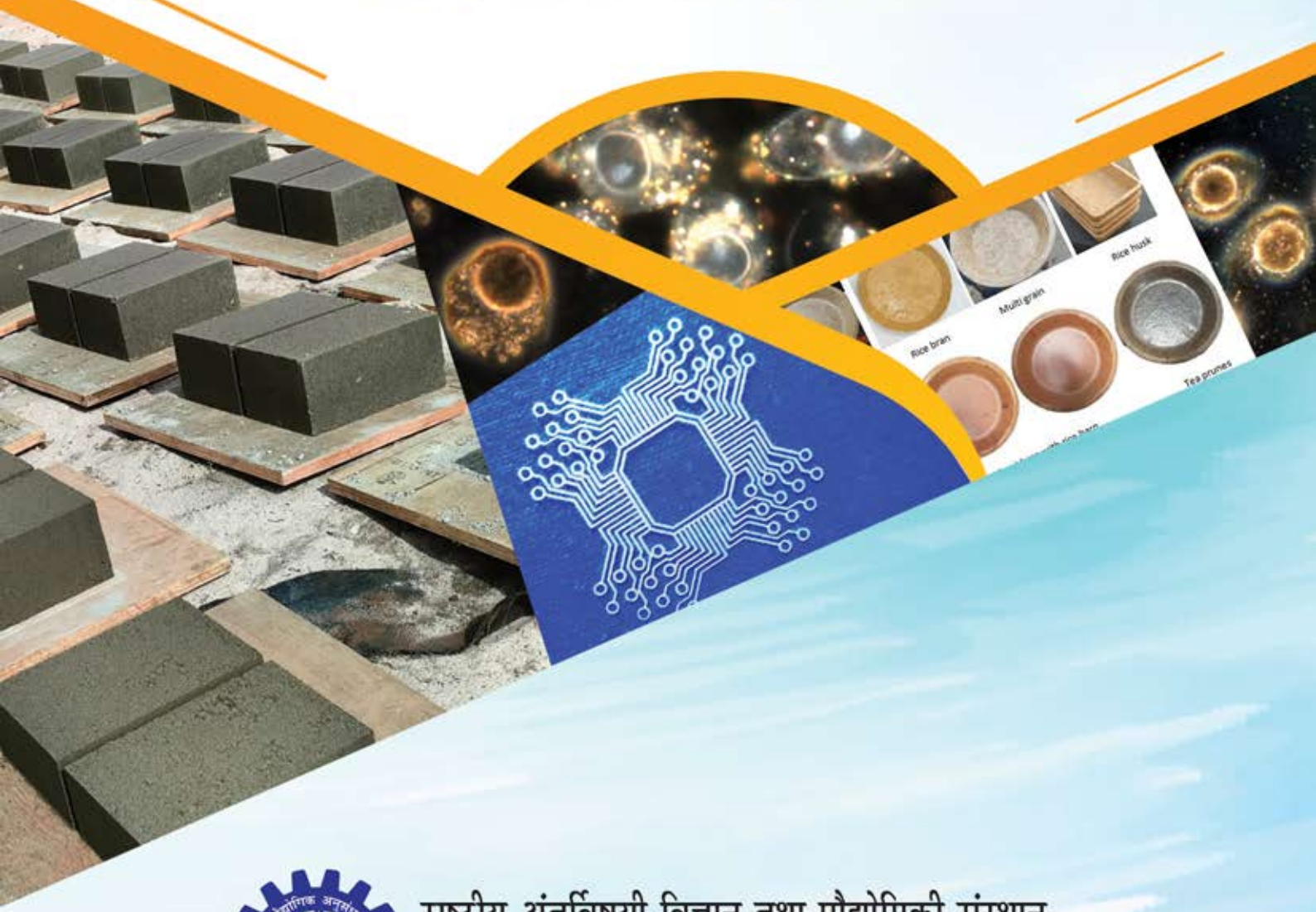
वार्षिक प्रतिवेदन
Annual Report
2021-2022



राष्ट्रीय अंतर्विषयी विज्ञान तथा प्रौद्योगिकी संस्थान
(वैज्ञानिक तथा औद्योगिक अनुसंधान परिषद्)
तिरुवनन्तपुरम, केरल, भारत

National Institute for Interdisciplinary Science & Technology
(Council of Scientific & Industrial Research)
Thiruvananthapuram, Kerala, India

वार्षिक प्रतिवेदन
Annual Report

2021-2022

सी एस आई आर - राष्ट्रीय अंतर्विषयी विज्ञान तथा प्रौद्योगिकी संस्थान

CSIR-National Institute for Interdisciplinary Science & Technology (NIIST)

(वैज्ञानिक तथा औद्योगिक अनुसंधान परिषद्)

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तिरुवनन्तपुरम / Thiruvananthapuram

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CSIR-National Institute for Interdisciplinary Science & Technology (NIIST)
(Council of Scientific & Industrial Research)

तिरुवनन्तपुरम / Thiruvananthapuram

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डॉ ए अजयघोष
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सचिव

डॉ के माधवन नंपूथिरी
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एनआईआईएसटी

प्रस्तावना

2021-22 के लिए सीएसआईआर-एनआईआईएसटी की वार्षिक रिपोर्ट प्रस्तुत करते हुए मुझे प्रसन्नता हो रही है। रिपोर्ट में सीएसआईआर एनआईआईएसटी द्वारा अंतर्विषयी अनुसंधान और विकास के सीमांत क्षेत्रों में सीएसआईआर और सार्वजनिक और निजी क्षेत्रों के अन्य हितधारकों के समर्थन के साथ केंद्रीय और राज्य सरकारों, उद्योगों और शिक्षाविदों, मंत्रालयों और विभागों सहित महत्वपूर्ण योगदान का विवरण दिया गया है। प्राप्त उपलब्धियां और सम्मान, उच्च प्रभाव कारकों वाले प्रकाशनों का विवरण, बौद्धिक संपदा (आईपी) सृजन, मानव संसाधन विकास, महत्वपूर्ण गतिविधियां और संगठित कार्यक्रम प्रस्तुत किए गए हैं।

इस अवधि के दौरान, संस्थान की प्रमुख उपलब्धियों में देश भर के एमएसएमई को सफल प्रौद्योगिकी हस्तांतरण शामिल है, विशेष रूप से रोगजनक चिकित्सा अपशिष्ट के सुरक्षित उपचार और निपटान के लिए स्थापित प्रणाली। एमएसएमई के लिए एक और महत्वपूर्ण औद्योगिक और सामाजिक रूप से प्रासंगिक प्रौद्योगिकी हस्तांतरण कृषि अपशिष्ट बचे हुए से बने बायोडिग्रेडेबल उत्पादों के लिए विनिर्माण संयंत्रों की स्थापना है। ये बायोडिग्रेडेबल सामान कृषि अपशिष्ट अवशेषों का पुन: उपयोग करते हुए एकल-उपयोग वाले प्लास्टिक की जगह लेते हैं। खाद्य ग्रेड पैकेजिंग के उत्पादन के लिए सतह कोटिंग के रूप में वनस्पति तेल आधारित पॉलिमर का उपयोग करना एक और महत्वपूर्ण प्रौद्योगिकी हस्तांतरण है। फाउंड्री रेत के कचरे को ईंटों में परिवर्तित करने की तकनीक को स्थानांतरित किया गया। खाद्य विज्ञान और प्रौद्योगिकी में प्रौद्योगिकियों के हस्तांतरण में कटहल का मूल्यवर्धित निर्माण और प्रोटीन युक्त खाद्य पदार्थों का निर्माण शामिल है।

सीएसआईआर-एनआईआईएसटी ने भारतीय मुद्रा को जालसाजी से बचाने के लिए फ्लोरोसेंट अणुओं और स्याही को सुरक्षा चिह्न के रूप में विकसित करने के लिए भौतिक विज्ञान (इंजीनियरिंग सहित) में सीएसआईआर प्रौद्योगिकी पुरस्कार 2021 (योग्यता प्रमाण पत्र) प्राप्त किया।एनआईआईएसटीवैज्ञानिकों को सीएसआईआर-युवा वैज्ञानिक पुरस्कार 2021, आईएसईईएस युवा वैज्ञानिक पुरस्कार,आईएसएएस - युवा वैज्ञानिक पुरस्कार2022,आईएनएसए युवा वैज्ञानिक के लिए पदक, और आईसीटीस्थापना दिवस युवा वैज्ञानिक पुरस्कार 2021 सहित कई पुरस्कार प्राप्त हुए हैं।

समीक्षाधीन वर्ष के दौरान, हमारे पास विभिन्न अनुदान देने वाले संगठनों और लाइन मंत्रालयों द्वारा वित्तपोषित कई सहायता अनुदान परियोजनाएं भी थीं। संस्थान के पास कई प्रतिष्ठित द्विपक्षीय कार्यक्रमों और उद्योगों द्वारा समर्थित परियोजनाओं के तहत कई कार्यान्वयन चरणों में परियोजनाएं भी हैं। सीएसआईआर-एनआईआईएसटी और सीएसआईआर की अन्य प्रयोगशालाएं कोविड के खिलाफ लड़ाई में शामिल हुईं और नई दवाओं की खोज के लिए सीएसआईआर के रणनीतिक समूह अभियान का भी हिस्सा थीं, जिसमें कोविड-19 के लिए दवाओं का पुनर्उद्देश्य शामिल है।

विभिन्न कौशल विकास कार्यक्रम, जिज्ञासा, विज्ञान दिवस, प्रौद्योगिकी दिवस, सीएसआईआर स्थापना दिवस, सीएसआईआर-एनआईआईएसटी स्थापना दिवस, आजादी की अमृत महोत्सव, और भारतीय स्वतंत्रता के 75 वर्ष समारोह इस अवधि के दौरान आयोजित कुछ आवश्यक कार्यक्रम थे।

मैं इस अवसर पर सीएसआईआर-एनआईआईएसटी के सभी सदस्यों को धन्यवाद देता हूं, जिन्होंने अपने समर्पित समर्थन के माध्यम से संस्थान की प्रगति में योगदान दिया है। मैं महानिदेशक, सीएसआईआर-मुख्यालय और अनुसंधान परिषद् सदस्यों को उनके समर्थन के लिए भी धन्यवाद देता हूं।

डॉ सी आनंदरामकृष्णन

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Dr K Madhavan Nampoothiri
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FOREWORD

I am pleased to present the Annual Report of CSIR – NIIST for the period of 2021 – 22, the report encompasses the details of the significant contributions made by CSIR NIIST on the frontier areas of interdisciplinary R&D, with the support of CSIR and other stake holders of public and private sectors comprising of the Ministries & departments of central and state governments, industries and academia. Achievements and accolades received, details of the publications with high impact factor, intellectual property (IP) generation, human resources development, major activities and programs organized are presented.

Major achievements of the institute during the period are successful technology transfer to MSME's across the country, including the system developed for the safe handling and disposal of the pathogenic medical waste. Another major industrial and socially relevant major technology transfer to MSME's is to setting up the manufacturing units of biodegradable products from agricultural waste residues. These biodegradable products replace the single use plastics and simultaneously utilizing the agricultural waste residues. The other major technology transfer is utilization of the plant oil-based resins as surface coating for the development of food grade packaging. Technology for the utilization of the foundry sand waste to bricks was transferred. Technologies transfer in food science & technology includes the value-added production from jack fruit and production of protein enriched dietary fiber from coconut floor.

CSIR – NIIST bagged the CSIR Technology Award 2021(Certificate of Merit) in Physical Sciences (including Engineering) for the development of the fluorescent molecules and ink as security markers for the protection of Indian currency and counterfeit activities. Scientists of NIIST have also won several recognitions including CSIR – Young Scientist Award 2021, ISEES Young Scientist Award, ISAS- Young Scientist Award 2022, INSA Medal for Young Scientist, ICT Foundation Day young scientist award 2021.

During this period under report, we also had significant number of grant – in – aid projects supported by various funding agencies and line ministries. The institute also has projects under various prestigious bilateral programme, projects sponsored by industries under various stages of execution. CSIR-NIIST joined the fight against COVID along with other CSIR laboratories and was also a part of CSIR's strategic group initiative to develop new therapies including the repurpose of drugs for COVID-19.

Various skill development programs, Jigyasa, Science day, Technology day, CSIR Foundation day, CSIR – NIIST Foundation day, Azadi ki Amrit Mahotsav, 75 years of Indian Independence celebrations were some of the important programs conducted during this period.

I take this opportunity to thank one and all of CSIR - NIIST, who have contributed to the progress of the institute through their dedicated support and also would like to thank DG CSIR, CSIR – HQ and RC Members for their whole hearted support.

Dr. C. Anandharamakrishnan

महत्वपूर्ण उपलब्धियां 2021-2022

2021-22 की अवधि के दौरान, सीएसआईआर-एनआईआईएसटी ने केंद्र, राज्य सरकार की एजेंसियों, शैक्षणिक संस्थानों, सार्वजनिक और निजी क्षेत्रों के हितधारकों से महत्वपूर्ण निवेश के साथ वैज्ञानिक, तकनीकी और जनशक्ति विकास में निरंतर वृद्धि हासिल करना जारी रखा। औद्योगिक, निजी और सार्वजनिक क्षेत्रों और प्रौद्योगिकी हस्तांतरण से जुड़े नए सहयोगों में वृद्धि ने बाहरी स्रोतों से राजस्व उत्पन्न करने में पर्याप्त वृद्धि किया है। रिपोर्टिंग अवधि के दौरान सीएसआईआर से वित्तीय सहायता के साथ-साथ बाहरी फंडिंग में लगातार वृद्धि ने सीएसआईआर-एनआईआईएसटी को उच्च गुणवत्ता वाले प्रकाशनों के साथ-साथ ट्रांसलेशनल अत्याधुनिक अनुसंधान और प्रौद्योगिकी विकास पर ध्यान केंद्रित करने में मदद की है।

2021-22 की अवधि के दौरान विभिन्न फंडिंग एजेंसियों द्वारा वित्त पोषित 148 परियोजनाएं थीं। इस साल में एनसीपी (आला बनाने वाली परियोजनाएं), एफबीआर (फोकस्ड बेसिक रिसर्च), एफटीटी (फास्ट ट्रैक ट्रांसलेशनल), एफटीसी (फास्ट ट्रैक व्यावसायीकरण), और मिशन मोड योजनाओं के तहत सीएसआईआर से 23 परियोजनाओं की सफल शुरुआत को निम्नलिखित विषयों के तहत चिह्नित किया है: 1. खनन, खनिज, धातु और सामग्री 2. रसायन (चमड़े और पेट्रोकेमिकल सहित) 3. ऊर्जा (पारंपरिक और गैर-पारंपरिक) और ऊर्जा उपकरण 4. पारिस्थितिकी, पर्यावरण, पृथ्वी विज्ञान और जल 5. कृषि, पोषण और जैव प्रौद्योगिकी और 6. स्वास्थ्य देखभाल। सीएसआईआर-एनआईआईएसटी ने ग्यारह प्रौद्योगिकी हस्तांतरण और अच्छी संख्या में निजी उद्योग के साथ अनुसंधान एवं विकास सहयोग समझौते किए हैं।

सीएसआईआर-एनआईआईएसटी एक एनएबीईटी मान्यता प्राप्त, श्रेणी ए सलाहकार संगठन है, जिसके दो क्षेत्रों में यानी 1) खनन और 2) पर्यावरण प्रभाव आकलन अध्ययन (ईआईए) करने के लिए बंदरगाह में मान्यता है। परियोजनाओं की वैधानिक मंजूरी के लिए अनिवार्य ईआईए सेवाओं का उपयोग सरकारी और निजी क्षेत्र द्वारा किया जाता है। सीएसआईआर-एनआईआईएसटी की परीक्षण और विश्लेषण प्रयोगशाला सुविधा को एनएबीएल द्वारा आईएसओ/आईईसी 17025: 2005 के अनुसार पानी, अपशिष्ट जल, डाइऑक्सिन, फुरान और पॉली क्लोरीनेटेड बाइफिनाइल्स (पीसीबी) के विश्लेषण के लिए मान्यता प्राप्त है। इसके अलावा, पर्यावरण, वन और जलवायु परिवर्तन मंत्रालय (एमओईएफसीसी), भारत सरकार द्वारा पर्यावरण मंजूरी के लिए डाइऑक्सिन विश्लेषण के लिए रेफरल प्रयोगशाला के रूप में सीएसआईआर-एनआईआईएसटी को सिफारिश की गई है।

वर्ष 2021-22 में कोविड-19 महामारी का प्रकोप और प्रसार के कारण सदी की सबसे चुनौतीपूर्ण स्थिति देखी गई। सीएसआईआर ने कोविड-19 से संबंधित गतिविधियों को कम करने के लिए 5 कार्यक्षेत्रों की पहचान की, अर्थात् 1. डिजिटल और आणविक निगरानी 2. तेजी से और किफायती निदान दवाओं और नई दवाओं के पुनर्प्रयोजन सहित नए उपचारों का विकास 4. अस्पताल सहायक उपकरण 5. आपूर्ति श्रृंखला और रसद। सीएसआईआर-एनआईआईएसटी भी अन्य सीएसआईआर प्रयोगशालाओं के साथ कोविड से युद्ध लड़ने में तुरंत उठ खड़े हुए। इसके अलावा, एनआईआईएसटी सीएसआईआर की रणनीतिक समूह पहल का एक हिस्सा था, जिसमें कोविड-19 के लिए दवाओं के पुनर्प्रयोजन सहित नए उपचार विकसित किए गए थे। सीएसआईआर-एनआईआईएसटी तीन शक्तिशाली दवा उम्मीदवारों के लिए व्यवहार्य और लागत प्रभावी सिंथेटिक रणनीति विकसित कर रहा है; गैलीडेसिविर (बायोक्रिस्ट फार्मास्युटिकल्स), नाइटाज़ॉक्सानाइड (रोमार्क लेबोरेटरीज), और ईआईडीडी 1931 और 2801 (एमोरी यूनिवर्सिटी)।

सीएसआईआर-एनआईआईएसटी ने इम्यूनिटी बूस्टर, स्मार्ट टच-फ्री स्वयंगतिशील हैंड सैनिटाइजर डिस्पेंसर (भीतर और बाहर), एयर सैनिटाइजर, यूवी-क्लीन डिसइंफेक्टिंग यूनिट, एकीकृत स्व-कीटाणुनाशक झिल्ली के साथ पुन: प्रयोज्य स्टॉपगैप फेस मास्क के क्षेत्र में सक्रिय रूप से उत्पादों और प्रक्रियाओं को वितरित किया और विभिन्न उद्योगों को प्रौद्योगिकियों को स्थानांतरित किया। कोविड 19 को कम करने वाली गतिविधियों के संबंध में विकसित अन्य प्रौद्योगिकियां कुशल रोगाणुरोधी सूत्रीकरण, पुन: प्रयोज्य पीपीई (मास्क / गाउन) के लिए सूती कपड़ों पर कोटिंग्स, प्राकृतिक उत्पाद-आधारित सेल्फ-सैनिटाइज़िंग कम्पोजिट कोटिंग्स - अयूरकोट, नॉवेल सॉलिडिफिकेशन/जेलेशन सिस्टम कीटाणुनाशक गुण, प्राकृतिक उत्पाद आधारित स्टीम इनहेलर ड्रॉप्स और हर्बल सैनिटाइज़र हैं।

संस्थान के पास एक पूर्ण उन्नत विश्लेषणात्मक सुविधा है जिसका उपयोग उच्च गुणवत्ता वाले बुनियादी और अनुवाद अनुसंधान के लिए पूरी क्षमता के साथ किया जा रहा है, साथ ही उद्योग और शिक्षाविदों से नमूनों के परीक्षण से राजस्व उत्पन्न किया जा रहा है। सीएसआईआर-एनआईआईएसटी ने सीएसआईआर कौशल पहल कार्यक्रम के माध्यम से विभिन्न खंडों के तहत अल्पकालिक पाठ्यक्रम शुरू किए। संस्थान उच्च गुणवत्ता वाले मानव संसाधनों का पोषण करना जारी रखता है, हर साल 30 से अधिक पीएचडी प्रदान करता है। एनआईआईएसटी उच्च प्रभाव कारक पत्रिकाओं में हर साल 200 से अधिक पत्र प्रकाशित करता है और इसका एक मजबूत पेटेंट पोर्टफोलियो है।

इस पृष्ठभूमि के खिलाफ, 2021-2022 की वार्षिक रिपोर्ट सीएसआईआर-एनआईआईएसटी द्वारा किए गए नवाचार, उपलब्धियों, प्रगति और प्रभाव को सीमांत अनुसंधान के गतिशील रूप से परिवर्तनशील और चुनौतीपूर्ण अंतःविषय वातावरण में अपनी योजनाओं के साथ संरेखित करती है। यह सभी और अधिक रोमांचक कहानियां वार्षिक रिपोर्ट 2021-22 में सामने आई हैं।

SIGNIFICANT ACHIEVEMENTS 2021-2022

During the period 2021-22, CSIR-NIIST continued to achieve sustained growth on Scientific, Technological and manpower development with significant investment from stake holders comprising of Central, State Government agencies, educational institutes, public and private sectors. The upsurge in new collaborations involving industrial, private and public sectors and technology transfers translated to a substantial increase in generating revenue from external sources. The funding support from CSIR during the reporting period along with a steady rise in external funding, have helped CSIR-NIIST focus on translational cutting edge research and technology development along with high-quality publications.

There were 148 projects funded by various funding agencies during the period 2021-22.The year also marked the successful initiation of 23 projects from CSIR under NCP (Niche creating projects), FBR (Focused Basic Research), FTT (Fast Track Translational), FTC (Fast Track Commercialization) and mission mode schemes under the following themes: 1.Mining, Minerals, Metals and Materials 2. Chemicals (including leather and Petrochemicals) 3. Energy (Conventional and non-conventional) and Energy devices 4. Ecology, Environment, Earth Sciences and Water 5. Agri. Nutrition and Biotechnology and 6. Healthcare. There were eleven technology transfers and a good number of private industries with which CSIR-NIIST entered into R & D collaboration agreements.

CSIR-NIIST is a NABET accredited, Category A consultant organisation with accreditation in two areas Viz., The 1) Mining and 2) Ports & Harbour for carrying out Environment Impact Assessment Studies (EIA). The mandatory EIA services are used by government and private sector for statutory clearance of projects. The Testing and Analysis Laboratory facility of CSIR-NIIST is accredited by NABL as per ISO/IEC 17025: 2005 for analysis of Water, Waste water, Dioxins, Furans and Poly Chlorinated Biphenyls (PCBs). In addition, CSIR-NIIST has been recommended by Ministry of Environment, Forest and Climate Change (MoEFCC), Govt. of India as a referral laboratory for Dioxin analysis for environmental clearances.

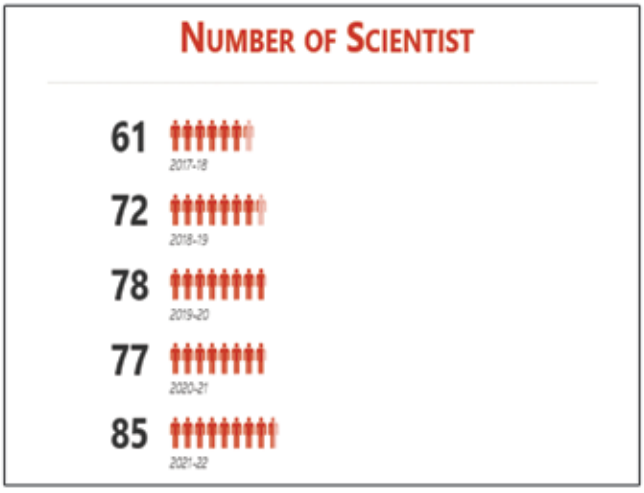
The year 2021-22 witnessed the century's most challenging situation as there was outbreak and spread of covid-19 pandemic. CSIR identified 5 verticals for mitigating COVID 19 related activities namely 1. Digital and Molecular Surveillance 2. Rapid and Economical Diagnosis Development of new therapies, including repurposing of drugs and new Drugs 4. Hospital assistive devices 5. Supply chain and logistics. CSIR-NIIST immediately rose up to the occasion in fighting the war with COVID along with other CSIR laboratories. Also NIIST was a part of CSIR's strategic group initiative to develop new therapies including the repurpose of drugs for COVID-19, CSIR-NIIST is developing viable and cost effective synthetic strategies for three potent drug candidates; Galidesivir (BioCryst Pharmaceuticals), Nitazoxanide (Romark Laboratories) and EIDD 1931 & 2801 (Emory University).

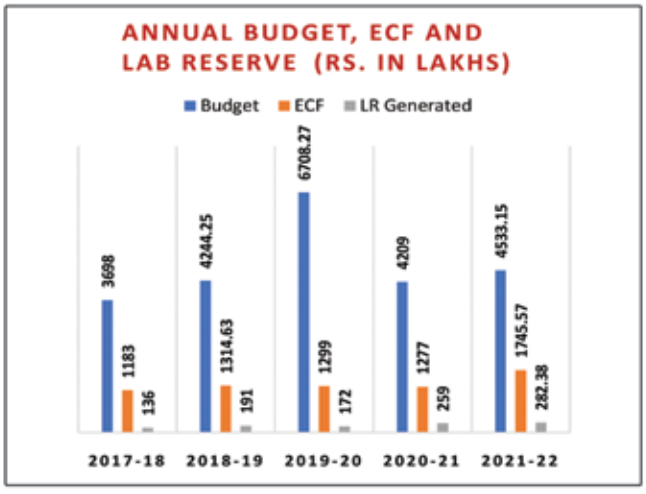
CSIR-NIIST actively delivered products and processes in the area of Immunity boosters, Smart Touch-Free Automatic Hand Sanitizer Dispenser (Indoor & Outdoor), Air sanitizer, UV-Clean Disinfecting Unit, Reusable Stopgap Face Mask with integrated self-disinfecting membrane and transferred the technologies to various industries.Other technologies developed in relation to COVID 19 mitigating activities are Efficient Antimicrobial formulations, coatings on cotton fabrics for reusable PPE's (masks/gowns), Natural Product based Self-Sanitizing Composite Coatings – Ayurcoat, Novel solidification/Gelation system disinfecting properties, Natural products based Steam inhaler drops and Herbal Sanitizer

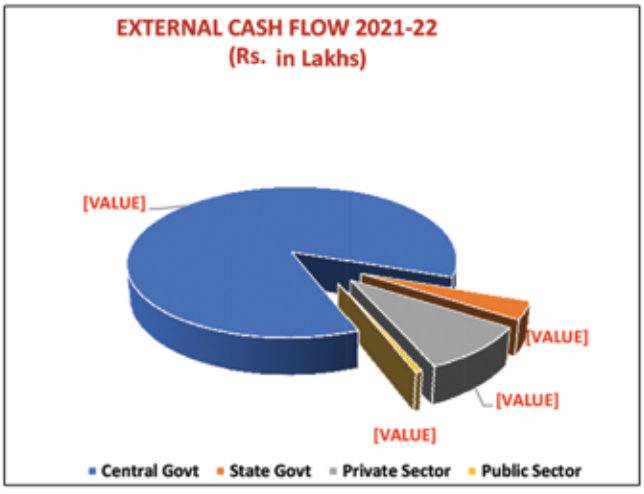
Institute has a full-fledged advanced analytical facility which is being utilized to the full capacity for high quality basic and translation research, besides generating revenue from testing of samples from industry and academia. CSIR-NIIST introduced short term courses under various segments through CSIR Skill Initiative programme. The Institute continues to nurture high quality human resources, awarding over 30 PhDs every year. NIIST publishes over 200 papers every year in high impact factor journals and has a robust patent portfolio.

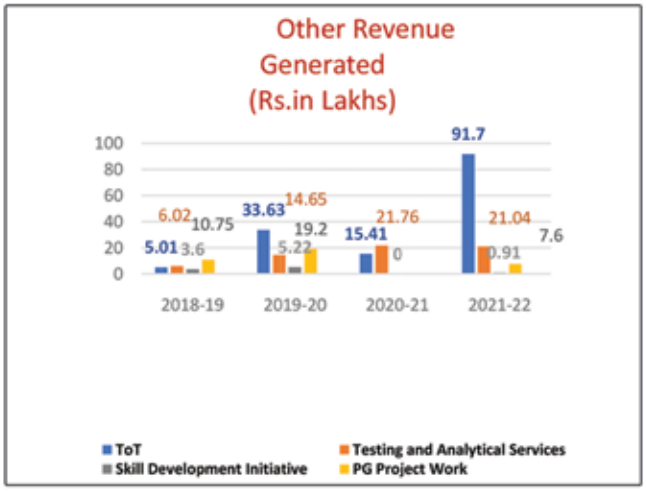
Against this backdrop, the Annual Report for the period 2021-2022 sets out the innovation, achievements, progress, and impact made by CSIR-NIIST aligning with its plans in a dynamically mutating and challenging interdisciplinary environment of frontier research. All this and more exciting stories unfold in the Annual Report 2021-22

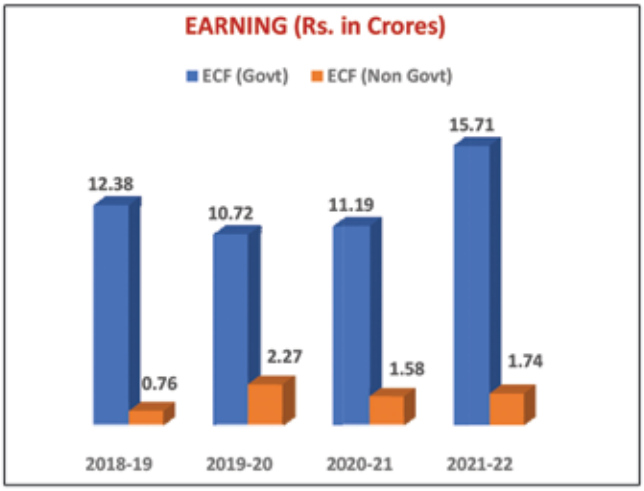
PERFORMANCE METRICS



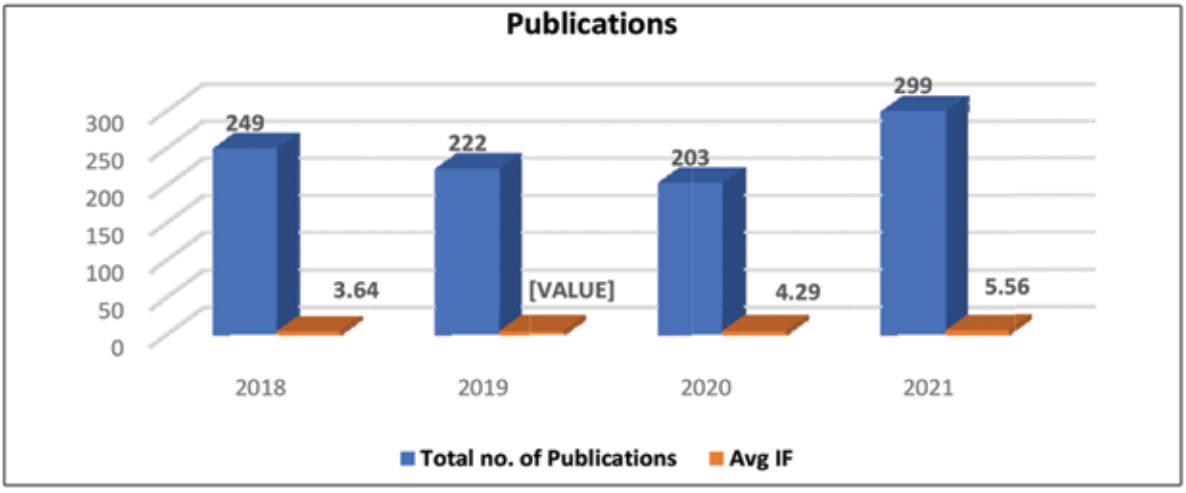


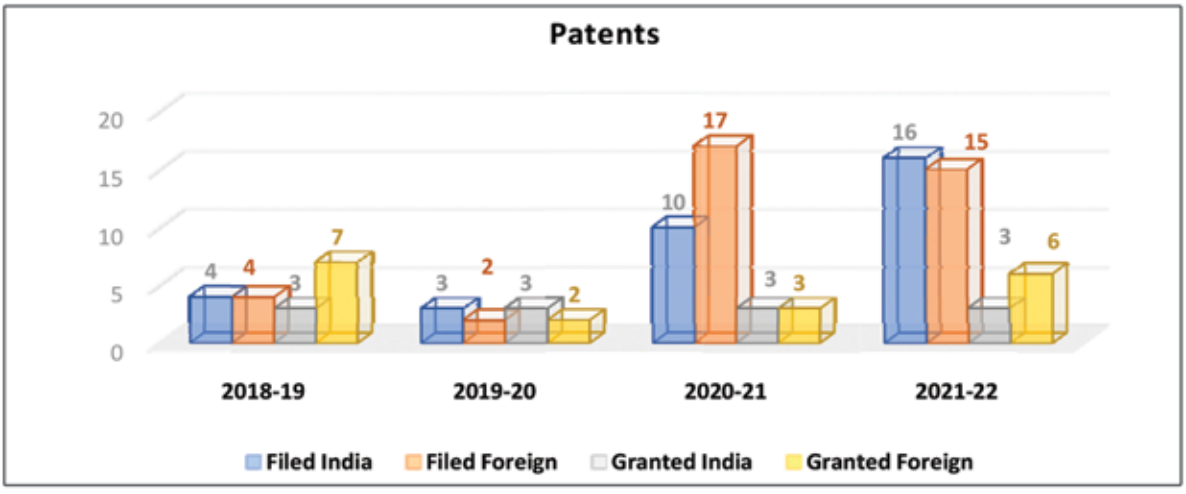


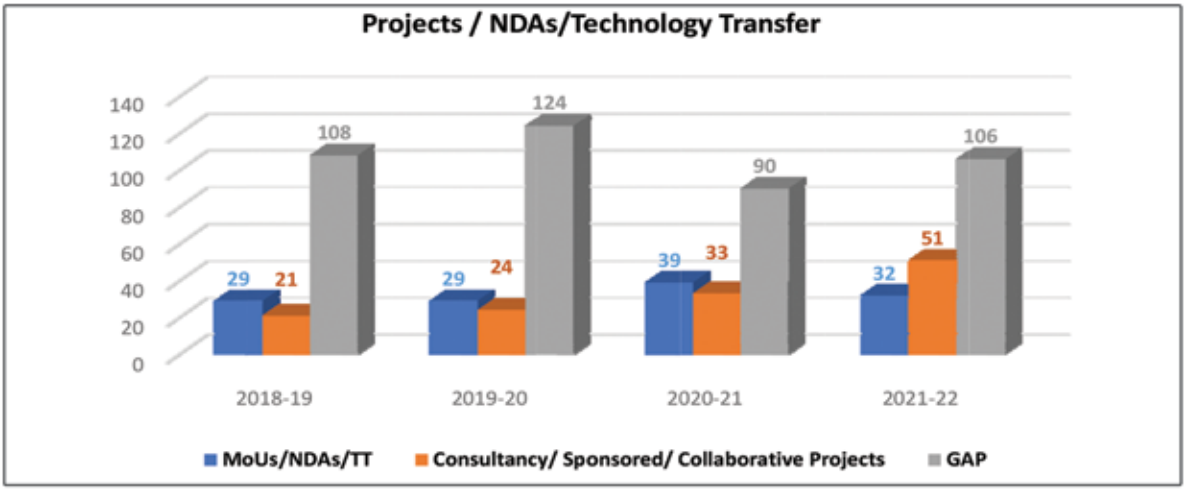




RESEARCH OUTPUTS







Success Stories

Manufacturing of Building Bricks from Foundry silica-sand

Prof. Dr. A. Ajayaghosh, Director NIIST exchanges the know-how transfer agreement with Mr. Thomas Mathew, Managing Director AUTOKAST in the presence of The Hon'ble Minister of Industries and Commerce, Govt. of Kerala

CSIR-NIIST has research activities on the utilization of industrial inorganic solid wastes, under the CSIR-themes, *'Waste to Wealth'* and *'Industrial wastes utilization'*. In the year 2021, CSIR NIIST developed a process to transform the waste foundry silica-sand into building bricks through a compression moulding technology involving reactive silicate binders. The process know-how was transferred successfully to the company Autokast Ltd, a Government of Kerala undertaking Public Sector company, producing metals and alloys components in its' foundry units. The company uses silica sand for making moulds using sodium silicate, bentonite and coal powders. After casting operations, the silica sand is treated as wastes and in fact, the storage of this used silica sand is a great revenue loss. Currently the company generates 20 to 40 T foundry silica sands per day. Hence CSIR NIIST conducted feasibility studies for making building bricks from the waste foundry silica sand.

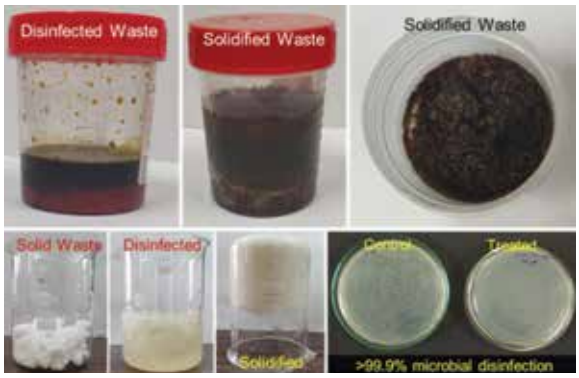
A process know-how, namely a cold-compression technology was identified and the techno-economic feasibility was successfully completed for manufacturing silica-sand bricks that are suitable for the construction applications. On October 7th 2021, CSIR NIIST entered an agreement with the Autokast company to transfer the Process Know-How. CSIR-NIIST extended the technical support to set-up the brick manufacturing plant and currently the plant is installed and started the manufacturing.

The plant is designed to produce nearly 750 to 800 bricks per day for 8 hrs duty. In a month 18000 bricks can be produced. Today the market price is about 36 rupees per brick and therefore a revenue of approximately 6.75 lakh can be generated in a month with significant employment and skill-development opportunities. The technology involves;

- Compression molding technique
- Strengthening by the addition of Hybrid Binders
- 50 to 60% Utilization of Foundry sand Waste
- No High-temperature Firing, only Sun drying and curing
- No Fire-Wood Firing and hence No CO_2 release
- Compressive strength >80 to 110 Kg/Cm^2
- Water Absorption < 15%
- Comparable Cost
- Only less than 6% cement

CSIR NIIST process has merits in a way that Foundry sand replaced the M-Sand which is produced from the Natural Resources. Bricks can also be shaped in aesthetically appealing colors for architectural interior design applications. CSIR NIIST technology is environmentally friendly process and directly help the Life-Mission Project of Govt of Kerala, which is committed to construct homes for nearly 1.6 lakh homeless people in Kerala.

Disinfection-Solidification Systems for Pathogenic Biomedical Waste Disposal



With the advent of Covid-19 and the emergence of harmful microbes, including virus, bacteria, fungi, etc., healthcare agencies across the globe have stressed the significance of effectively managing and disposing of biomedical waste as the first step toward preventing these infections from uncontrolled spreading. Mismanagement of infectious wastes such as biomedical test samples can cause the transmission of contagious and infectious diseases to a susceptible host upon contamination or occupational exposure. In this regard, adding a solidifying agent to liquid biomedical waste reduces the risk of spills and aerosolization. If the solidifying agent contains a disinfectant, it may be possible to dispose of the waste as non-regulated medical waste, which is less expensive than red-bagging. Solid wastes such as cotton, sharps, and tissues may also spread infections. Simple absorbers or hypochlorites are not always capable of treating such solid wastes. Acrylate-based gelators and super absorbent polymers are used to treat fluidic medical waste. Such materials are, however, not easily recycled and are non-biodegradable.

In an attempt to prioritize the R&D activities towards the national demand in mitigating the spread of the pandemic, CSIR-NIIST, Thiruvananthapuram, developed potential candidates for spontaneous disinfection and immobilization of pathogenic biomedical waste using a dual disinfection-solidification system. This system, with inherent antimicrobial activity, can disinfect both liquid and solid samples, resulting in gelation, flocculation, or complete solidification of the waste instantaneously upon mixing. >99.9% microbial disinfection was observed within 1 minute of contact, and the treated waste may be disposed of as non-regulated medical waste subject to regulatory approval. Segregation, transportation, and disposal of such disinfected medical waste are easier and safer with a significant reduction in cost for a healthcare facility. Premeasured containers can be used to handle any amount of waste and may be further incorporated in an all-in-one sample collection-disinfection-disposal device. The team has tested and validated several fluids and solid biomedical waste models, including aqueous waste with high salt and sugar concentrations, proteins, highly oxidizing and toxic metal salts, hospital chemicals such as iodine solution, models of urine, saliva, and blood, bacterial broths, cotton, tissues, swabs, needles, syringes, and mixtures in the laboratory. Accordingly, three families of patents have been filed to ensure IP protection. The antimicrobial action has been certified, and third-party validation is obtained. The non-toxic nature of the treated material has also been tested and approved by a third party.

The know-how has been transferred to a start-up in Kerala, Bio Vastum Solutions (BVS) Pvt. Ltd. (Angamaly) and was recently demonstrated in full-scale at the industrial facility. CSIR-NIIST, along with BVS, aims at an innovative solution for the safe and environment-friendly management of pathogenic biomedical waste. A completely biodegradable solidification system that would provide an innovative and sustainable solution to the pathogenic biowaste disposal issues in the country has also been developed. This technology is fully aligned with the government missions on AtmaNirbhar Bharat, Swachh &Swasthya Bharat, and Start-up initiatives.


APTD
CSTD
Research
Divisional
Details
ETD
MSTD
MPTD

AGRO PROCESSING AND TECHNOLOGY DIVISION

Agro Processing & Technology Division is a multifaceted centre with main focus on product and process development for post harvest value chain of agri produces, food/health food/functional foods/ vegan foods, nutraceuticals, Phytopharmaceuticals, bio-fertilizers & bio pesticides and biodegradable cutleries.

One of the thrust areas of division is the sustainable development of the agriculture sector by scientific and technological intervention and innovation in post harvest value addition and thereby ensuring the welfare of the sector. This division host a well-equipped pilot plant and sophisticated analytical laboratories in the area of agro-processing and food process/technology. Recently, the division is also actively involved in developing technologies for value addition of byproducts of agri/ food industries ensuring circular economy. APTD is also involved in the development and validation of nutraceuticals and phytopharmaceuticals exploring rich biodiversity, availability of abundant traditional knowledge in this region and available expertise in the division. The development of bio-fertilizers & bio-pesticides from endophytic microbes, mining of novel indigenous microbial strains capable of producing industrially important multiple enzymes for active ingredients isolation from spices and fruits are also one of the area of interest. The division is equipped with facilities for *in vitro* screening of compounds and mechanism Utilization of agri waste for development of eco-friendly and biodegradable cutleries and vegan leather have been initiated recently. Division also works with various MSME for product development and technology transfer for mutual benefits. The division has academic programmes (Ph. D) for human resource development in the field of food science & technology and biomedical sciences for meeting the needs of industries and academics institutes.

Research Highlights

- Technology development and commercialization for post-harvest value addition of agri crops such as spices, oil seeds, fruits vegetables etc
- Technology incubation activity for millets and herbs for the benefit of MSME's and agri entrepreneurs
- R&D, Industry interface programs (sponsored & consultancy) for product and process development, technology up-gradation and scientific validation of health benefits.
- Utilization of agricultural wastes/residues for the development of eco-friendly and biodegradable cutleries.
- Technologies for value addition of vegetable oil processing industrial by-products for sustainability
- Product and process development for Vegan and free from foods
- Activities for reviving traditional sectors like Jaggery processing units, palm neera processing units through various value addition programs which help in sustaining the biodiversity and providing employment for rural population.
- Value added products from traditional grains and underutilized fruits and vegetables.
- Pharmacological evolution of bioactive compounds from plants for metabolic disorder and cancer
- Bio-fertilizers and bio-pesticides from microbes with special emphasis on endophytic organisms
- Development of mitochondrial antioxidant through conjugation of triphenyl phosphonium with natural products
- Dietary fibre from agri/food processing spent materials as metabolic enhancers
- Biochemical, cellular and molecular level validation studies of specific treatment regiments employed in Ayurveda.
- Acrylamide in foods and mitigation strategies

1. Establishment of decentralized processing units for fruits and vegetable value addition

As a part of the ongoing activities on setting up decentralized processing units for the value addition of indigenous agricrops, processing units were set up for HORTICORP, Kayamkulam and BLFO, Ranni. These turnkey projects include establishing 500 kg per day processing unit for dehydration, preservation and value addition of regional fruits & vegetables and processing line for further value addition. These processing plants are expected to support the local farmer groups by providing value addition to the indigenous agricrops and also by preventing the post-harvest loss.

2. Development of biodegradable cutlery from agri-residue for alternative to single use plastic and boosting to farmers' utilization of agri income

Government of India and various states of India has recently proposed several restrictions and ban on usage of single use plastics. Government of India is planning for a three-stage ban on single use plastics (SUP) starting from 2020. Following this, various states

of India have also restricted the production, distribution and usage of SUP. Government of Kerala has banned the usage of SUP since January 1, 2020 vide **GO (MS) 6/2019-Envt dated 27.11.2019.** With view of above bans, we started working on developing alternative plastics from wide range of agro residues. As we know, India being an agricultural country with about 60% of people engaged in agriculture and related activities, huge volume of agro-waste/by-products are available. Burning of these stubble wastes poses severe air pollution. The utilization of these agro-wastes provides immense opportunities as an alternative to single-use plastics. Utilization of all the agro residues and by-products such as (Rice waste (straw, bran, husk), wheat waste (straw, bran, husk), coconut waste (de oiled cake, milk residue), sugarcane waste, tea waste (prunes, waste), apple waste (prunes), pineapple leaf waste, banana stem waste, water hyacinth waste, sea food waste, fruits and vegetable waste and corn waste) etc. For production of various agro residues will help in increasing the income of farmers through selling of these by-products. This initiative is in line with our honourable PM's mission of **"doubling the farmer's income by 2022".** So far, 8 technologies have been transferred to various companies from Kerala, Punjab and Himachal Pradesh.

3. Single step process for protein enriched dietary fiber and virgin coconut oil from coconut floor/ low fat desiccated coconut'

Virgin coconut oil, obtained from the milk of fresh and mature kernel of coconut (*Cocos nucifera* L.), is one of the fast-growing commodities owing to the health

benefits associated with medium-chain fatty acid (MCFA). Coconut residue obtained after the extraction of milk is a by-product of the coconut industry, and only a small part of it is being utilized as fertilizer or feed for cows. Large quantities of the coconut residue by-product are usually left to rot on the fields as waste material. The residue left after the cold pressing of coconut is having approximately 30-35% residual oil that is usually present in the pressed cake/residue. This residual oil can be further extracted to produce virgin coconut oil or coconut oil using appropriate technologies. This residue is an enriched source of the dietary fiber and protein which are the major nutritional components present in raw coconut. CSIR - NIIST has developed a process for making fiber/protein rich product free from residual oil and nutty flavour and virgin coconut oil using super critical fluid extraction method. The value addition of the coconut residue is very important for the related industries for sustainable development. The major highlights of the technology include complete extraction of oil from reside as virgin oil, protein enriched fibre, free from nutty flavour, scalability and can be retrofit for customer requirements. The technology has been successfully transferred to M/s Apex COCO Solar Ltd, Tirupur.

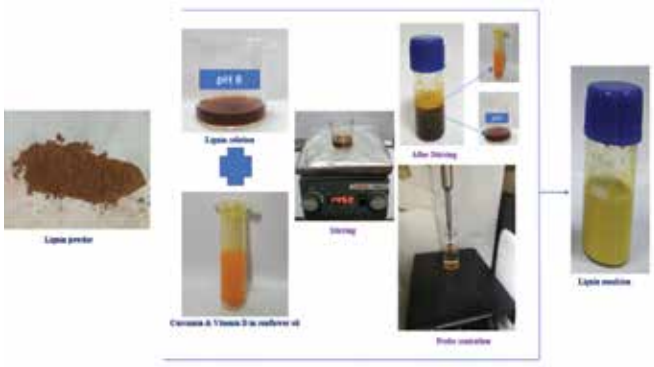
4. Value added products from jackfruit

Jackfruit is one of the most relished underutilized fruit which is rich in many nutrients and bioactives. The development of novel processed products and value chain for jackfruit for higher economic returns had always attracted scientific interventions. Jackfruit is gaining popularity all over the world due to emerging ethnic and mainstream marketing opportunities and recent research publications on its health benefits have generated renewed interest in this ethnic fruit. Several products are currently available in the market, mostly processed as a cottage industry with minimal processing techniques and involving manual operations. These products cannot be manufactured in a large scale processing facility because of the lack of scalability of processing operations. Thus, the products coming out of such processing facilities lack proper product optimization in terms of nutritional, chemical, microbial and sensory quality. In this context, CSIR NIIST has developed value added products out of jackfruit such as ready to cook tender and raw jackfruit and ripe jackfruit preserve and preserve in honey, which provided convenience, nutritional and health benefits to the consumers. The process is developed in such a way that it retains the freshness of the product after storage, rehydration, and cooking. The product is stable up to 9 months at ambient temperature (30±2 °C) without any

added preservatives, under vacuum package in flexible polyethylene bags. The major highlights of the system include, low energy consumption, extended shelf life, retention of sensorial properties, scalability and can be retrofit for customer requirements.

5. Phytochemical rich extract from the spent material generated from IndustrialDashamoola preparation (a medicinal Ayurvedic decoction)

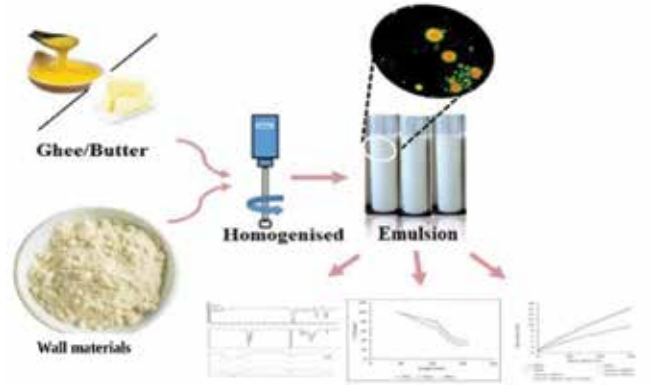
Dashamoola Arishta (DA), an age-old Ayurvedic formulation, is considered as panacea for inflammation-related ailments. The phytochemical rich 70% (v/v) ethanol extract was characterized and antidiabetic and anti-inflammatory capabilities were established earlier. The residue after extraction of phytochemicals were further utilized for extraction of cellulose and lignin. Isolation and characterization of nano lignin from Dashamoola spent materials and its application in Pickering emulsions for Curcumin and vitamin D delivery were attempted. A stable Pickering emulsion with nano emulsion was fabricated, characterized and



shelf life studies were conducted. It was found that the nano ligin could effectively form a highly stable Pickering emulsion, encapsulating curcumin and vitamin D, indicating its application in food systems.

6. Fabrication of fat encapsulates for food and health care applications

The optimization of process conditions for fabricating fat encapsulates for food and health care applications were undertaken as a part of 'lipid to powder' activity. In order to develop a fat substitute in the form of a powder, it is important to fabricate a stable emulsion without affecting the inherent properties of the fat. Hence studies were initiated with a focussed to develop a stable emulsion with higher oil payload. The optimization was carried out in terms of oil payload, wall material composition and homogenization conditions. The oil load was increased from 50% to 70% (dry basis) at a total soluble solid (TSS) of 30%. The optimized emulsions were kinetically stable even after 24 h of storage at ambient conditions (29 to 35°C). Bulk density of the emulsions were 1.007 g/mL, 1.04 g/mL, and 0.97 g/mLfor 50%, 60% and 70% oil payloads, respectively; whereas the corresponding viscosities were 50.9 cP, 49.8 cP, and 30.1 cP. The mean droplet diameters were 385.1 ± 131 nm, 404 ± 87.39 nm, and 410.6 ± 269.9 nm and, corresponding zeta potential values were -28.1 ± 4.42 mV,-27.2 ± 6.28 mV, and -26.0 ± 6.19 mV for 50%, 60% and 70% emulsions, which indicated high stability. Thermal analysis (DT-TGA) and FTIR of the emulsions indicated that core component (oil) was well protected when whey protein was used as wall material. This thermally and kinetically stable emulsions can be further taken for encapsulation studies.



7. Development vegan leather as a biomaterials substitute from various agri residues

Animal leather is the major raw material in the fashion industry catering to the textile, bags and footwear sectors. Animal leather processing causes serious environmentally detrimental issues such as toxic chemical release, excessive usage of fresh water leading to its scarcity, contribute to global warming, and antibiotic depilation. Consequently, processes for the development of alternative materials with environment friendly processing protocols and smaller carbon footprints can make significant impact on this sector. The synthetic leather market in 2020 was valued at over 30$ billion and by 2027, it is estimated to become 40$ billion. The leather industry market value in 2020, 394.1 $ billion, is 13 times more than its synthetic counterpart. The fashion industry is a multi-trillion business. The proposed project focuses on the development of Natural vegan leather that serves as a replacement for animal and synthetic leather. The government of India and various states of India have recently proposed several restrictions on synthetic leather production and animal slaughter for leather production. The government of India is planning for encouraging vegan products such as vegan meat and vegan leather. India is one of the biggest agricultural producers in the world. There is immense opportunity to use the natural vegan leather know-how as an alternative to animal and synthetic leather by the utilization of the agro-waste. Against this backdrop, CSIR-NIIST has developed at lab level, a process for making natural vegan leather from agro-residues to replace animal and synthetic leather for applications such as bags, foot wear, Garments and other goods

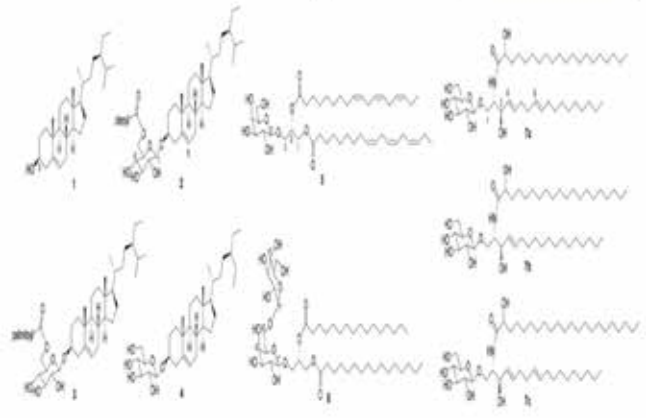
and accessories of leather/synthetic leather make. The process knowhow is at TRL - 4 (Technology readiness level). Further development studies need to be carried out for improving the quality and yield of the product and also to improve various parameters required for the multitude of applications. Based on the application requirement, different evaluations need to be.

The novelty of the process

1. The raw material used for the vegan leather manufacture is 100% biodegradable.
2. The process is free from hazardous chemicals and toxic discharge.
3. Minimal effluent generation,
4. Process developed is suitable for agro waste viz., corn husk, banana fibre, pineapple leaf fibre mango peels, papaya peels and water hyacinth
5. The developed process having less unit operation.
6. Dry process.
7. Excellent entrepreneurship development potential.
8. All agro-waste can be simultaneously used as a single raw material.
9. Utilization of all agro residues (waste to value addition)

8. Phytochemical investigation of unripe banana (Musa AAB) cv. Nendran and its novel 'Banana Grits

Novel 'Banana Grits' (BG) was prepared from the pulp of unripe banana (*Musa* AAB) cv. Nendran, and their detailed phytochemical investigation is described. The present work serves as a first report of isolation and identification of glycolipids by exhaustive NMR and HR-



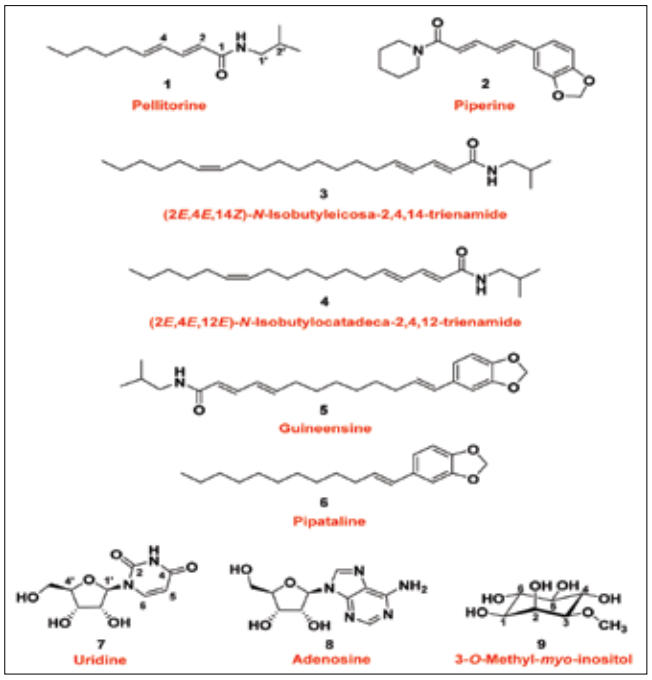
Structures of compounds 1-7. Compound 1 -β-Sitosterol, Compound 2 -Sitoindoside-II, Compound 3 - Sitoindoside-I, Compound 4 -β-Sitosterol β-D-glucopyranoside, Compound 5 -MGDG, Compound 6 - DGDG, Compound 7–Glucocerebroside

ESI-MS analysis from Nendran that include glycolipids viz. monogalactosyldiacylglycerols, digalactosyl-diacylglycerols, acyl steryl glycosides, glucocerebrosides, and sterylglycoside. Proximate analysis, estimation of total carotenoid content, and the resistant starch content in BG are also reported. *In vitro* starch digestion pattern indicated that out of 80% of total starch in BG, 2% is SDS and 42% is RS. The presence of SDS and RS indicates that they may contribute to gut health and glycaemic control. The technology of banana grit production and that of processed green gram was transferred to a Kochi-based company M/s. MOZA ORGANIC Pvt. Ltd. India on 1st January 2021.

9. NMR-based phytochemical profiling of a palatable spice-based immunomodulatory nutraceutical with palmyra palm syrup and a consortium of dry ginger, black pepper, and long pepper

A palatable spice-based nutraceutical comprising dry ginger, black pepper, and long pepper in palmyra palm syrup, named 'Trikatu syrup', was explored for

the phytochemical composition by chromatographic isolation from its organic fractions. The acetone fraction primarily contained the phytochemicals of *Piper* species *viz*. pellitorine, piperine, trienamides, guineensine, and pipataline. The acetonitrile fraction contained uridine, adenosine, and 3-O-methyl-*myo*-inositol, which were neither reported so far in any of the three spices nor palmyra palm. The current work demonstrates the

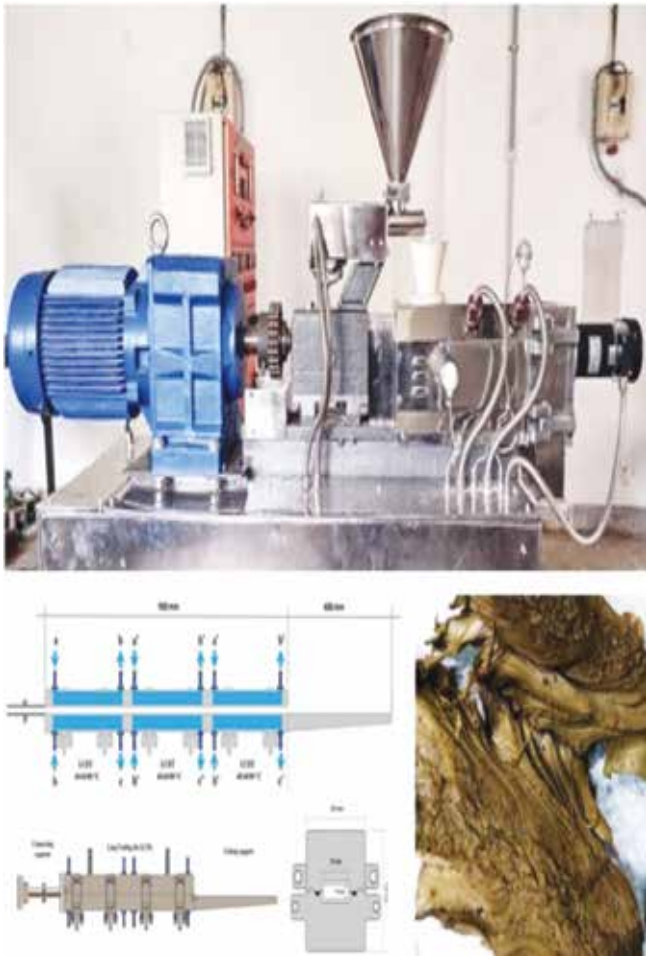


Structures of the phytochemicals from acetone and acetonitrile fractions of TS

utility of NMR that provides a precise phytochemical fingerprint of formulations of their organic extracts to ascertain their authenticity.

10. Development of plant-based animal food products

The global human population is expected to grow to 1000 crores in 2050. It is quintessential to produce almost 30-40% more food to feed the population and ensure food security. Food production systems demand huge resources such as agricultural land, water, energy and emit large volume of greenhouse gases (GHG), which is often underestimated and seldom gets attention. On an average, every year, 5 million hectares of tropical rain forest is cleared to produce more food for humans. It is devastating to the environment. UN



Intergovernmental panel on climate change (IPCC) singled out that, animal-derived foods such as meat and dairy require almost 10-100 times more area to produce similar quantity of plant-based foods (in terms of calories and proteins). It also emits 50-300 times more GHGs compared to most commonly consumed plant foods. Hence, it was suggested to immediately reduce meat and dairy products consumption obtained through industrialized animal farming and promote plant-based vegan food alternatives. Towards the cause, we have initiated R&D projects pertaining to the formulation and production of Plant-based dairy and meat alternatives such as plant-based yogurt and meat products. Above products are formulated with local ingredients which are alternative to conventional protein sources. Recently, SERB has funded a project on the fabrication of cooling die to produce plant-based meat analogs through extrusion cooking.

11. Design and development of an integrated solar dryer for spices dehydration and disinfection

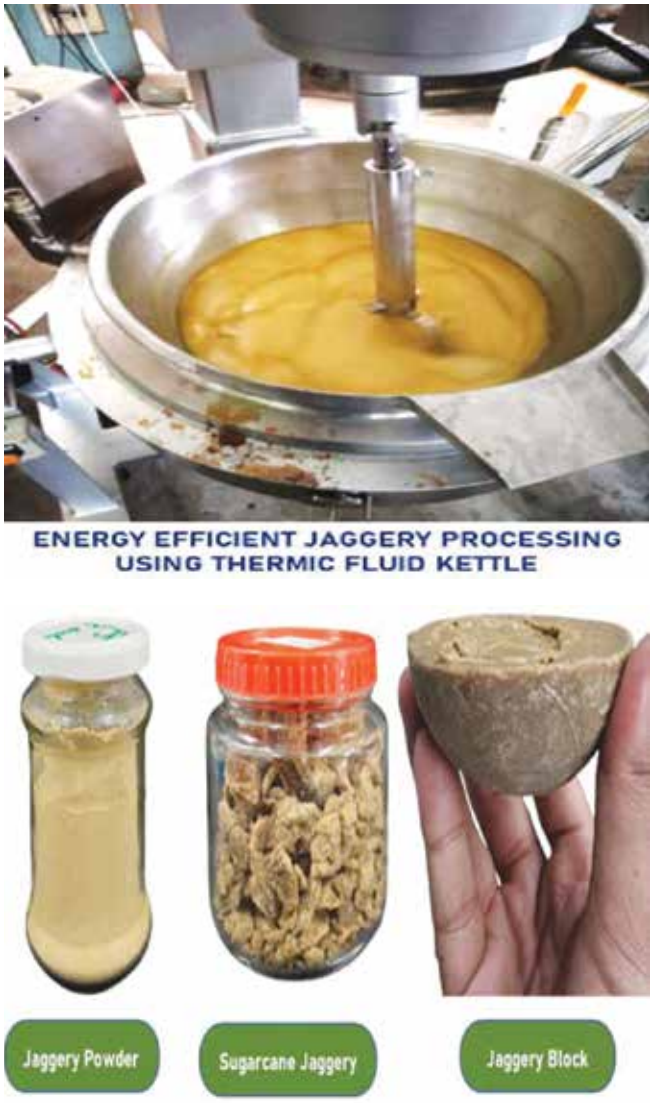
Drying assisted by renewable energy sourcesis the need of the hour for post-harvest agro processing. Under the context, the study was taken up towards development and evaluation of an integrated solar dryer for simultaneous dehydration and disinfection of agro produces, especially spices.

The objective of the project focused on the development of a solar dryer coupled with Ozonation for the above said purpose. The conceptualized design comprised of absorber plates that collect solar radiations propelled towards the drying chamber using a blower. The product is spread in trays, sequentially undergoing thin layer drying. The effectiveness of different materials, viz. galvanized iron, stainless steel wire mesh, and aluminium, were focused on to analyze the effectiveness of each material. The inclusion of an ozone generator and destructor along with the dryer has also been conceptualized, focussing on surface decontamination and microbial inactivation, which could further enhance the product's quality.

The conceptualized model was developed, as shown in the figure. The designed drying chamber could dry around 5-10 kg product at a time. The effectiveness of the newly developed solar dryer was tested by drying small cardamom. The newly developed solar dryer was observed to be efficient in drying cardamom in terms of bioactive retention, colour retention and energy savings. The developed model of solar dryer has the potential to be used in various food applications. The developed dryer could be effectively useful both commercially and quality-wise, particularly in the spices industries.

12. Modernization of jaggery production units – initiative towards energy-efficient hygenic jaggery production

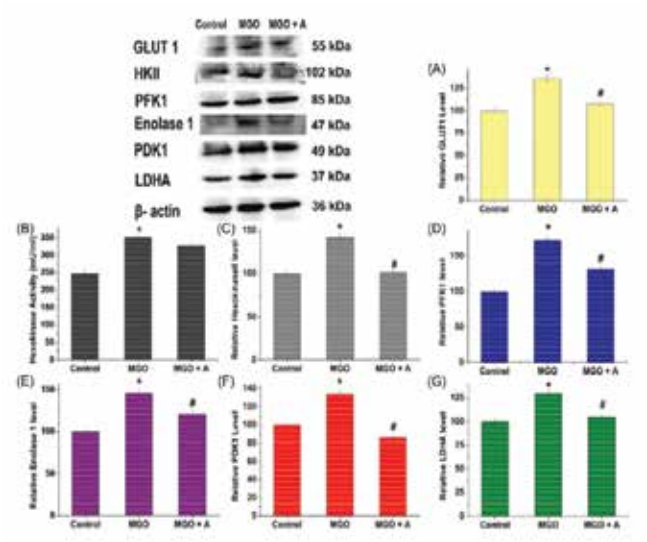
Major factors responsible for the jaggery sector downfall have been poor technological intervention for juice extraction, open pan furnace inefficiency, jaggery moulding and packaging, quality control and hygiene issues, lack of technical skill, and meagre financial support etc., Conventional jaggery making with an open pan furnace consumes all bagasse for evaporation of water, making the process energy intensive. Hot spots during the uncontrolled boiling of juice cause caramelization of sugar. It gives dark brown colour to jaggery, which has a low market value. Chemicals like lime, phosphoric acid and hydros powder are used as clarificant to enhance the colour of jaggery. Traces of these chemicals in jaggery are harmful to human health. Hence, a study was undertaken to modernizatethe jaggery production unit via controlled evaporative process. The processing parameters were optimised based on process temperature, pH of juice, total soluble solids and mixing time. Production of Jaggery powder and its analysis were also observed. Jaggery powder was prepared by heating the sample at a low temperature, followed by constant mixing and



powdering process. The effect of various clarification and solidification agents was also analysed for their effectiveness in operation as well as the optimized quantity required for obtaining better output was analysed. Field level trials were performed at Jaggery processing unit, Sugarcane seed farm, Pandalam. The energy efficiency of modernized Jaggery processing using a thermic fluid kettle were higher compared to traditional processing. The sensory attributes of the product were analysed and found suitable for usage in food applications. Product preparation in common beverages, including milk, tea and coffee, were tested, and the produced jaggeries were found acceptable at the consumer level. The developed product and process are of a satisfactory level, better than conventional processing methods, with better quality, which could be confidently implemented at the industrial level, and are expected to be implemented soon in jaggery sectors of Kerala, such as Marayoor and Pandalam.

13. Methylglyoxal causes cancer promotion in HepG2 cells via Warburg effect

The critical roles played by advanced glycation endproducts (AGEs) accumulation in diabetes and diabetic complications have gained intense recognition. Methylglyoxal (MGO) is one of the prime precursors for advanced glycation end products formation. The present research was performed to check whether MGO has any role in the promotion of cancer in HepG2 cells. HepG2 cells were incubated with MGO (50 µM) for 24 hrs and subjected to various analyses. Aminoguanidine (200 µM), was positive control. The various biochemical and protein expression studies, relevant to the MGO detoxification system, oxidative stress and glycolysis were performed. MGO caused reduction of expression of GLO 1 (27%) and GLO 2 (11%) causing weakening of the innate detoxification system. This is followed by an increase of RAGE (95%), AGEs or methylglyoxal adducts. We also observed hypoxia via estimation of oxygen consumption rate and surplus ROS (24%). To investigate the off-target effect of MGO we checked its effect on glucose transport, and its associated proteins. Glucose uptake was found increased (15 %) significantly with overexpression of GLUT 1(35%). We also found a significant increase of glycolytic enzymes such as hexokinase II, phosphofructokinase 1 and lactate dehydrogenase along with lactate production. Observation of surplus ROS and enhanced glycolysis led us to check the expression of HIF 1α which is their downstream signalling pathway. Interestingly HIF 1α was found to increase significantly (35%) along with c-Myc which is important in promoting aerobic glycolysis and tumour growth. It is known that enhanced glycolysis and oxidative stress are catalysts for the over-expression of HIF 1α which in turn create an ambience for the promotion of cancer. MGO also decreased the pYAP/YAP, which again supports the cell proliferation and survival. Aminoguanidine was able to prevent the adverse effect of MGO partially. MGO affected glucose metabolism

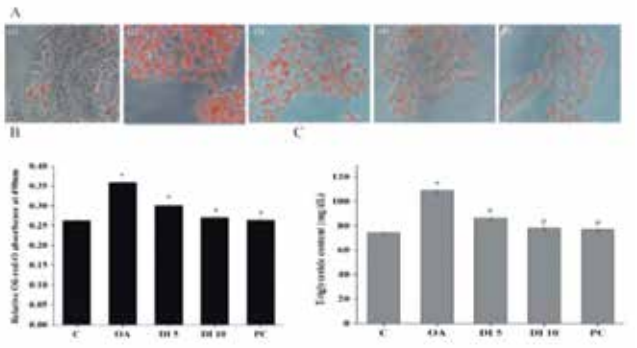


Effect of MGO on the expression of (A) GLUT 1, glycolytic enzymes (Hexokinase II (B) activity and (C) expression), (D) Phosphofructokinase 1, (E) Enolase 1, (F) PDK1, and (G) LDHA in HepG2 cells. Control, MGO – Methylglyoxal (50 µM), MGO+ A -Methylglyoxal (50 µM) + Aminoguanidine (200 µM). Values are expressed as mean ± SEM where n = 3. * indicates the mean value was significantly different from control cells ($p \leq 0.05$). # indicates the mean value was significantly different from MGO treated cells ($p \leq 0.05$)

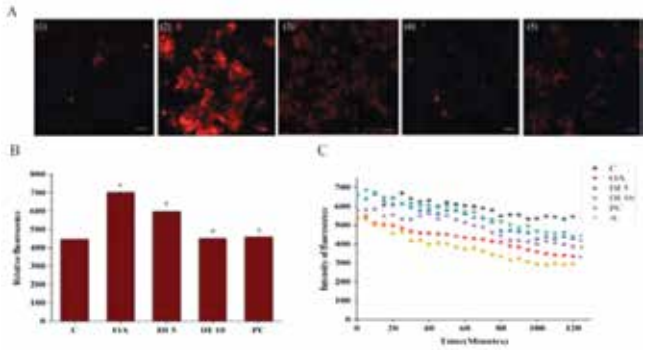
leading to enhanced aerobic glycolysis in HepG2 cells. Various enzymes relevant to cancer promotion like HKII, PFK1, LDHA, and PDK1 were also increased with MGO. It also caused overexpression of HIF1α. All these alterations contribute to the promotion of cancer via induction of the Warburg effect and glycation in HepG2 cells with MGO.

14. *Dillenia indica* L. is beneficial against NAFLD in *in vitro* model

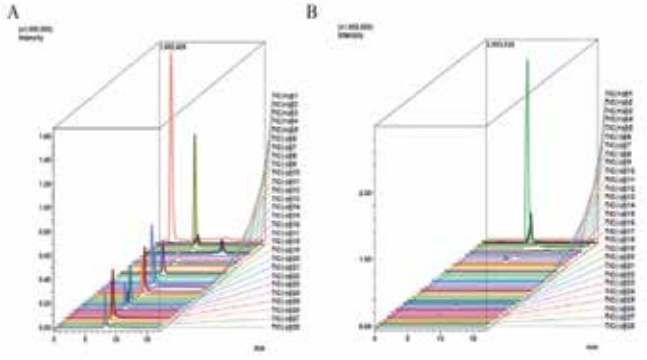
Non-alcoholic fatty liver disease (NAFLD) is a chronic liver disease characterized by excess fat accumulation in the hepatocytes, that affects a high proportion of the world's population. However, to date, no effective medical interventions exist that completely reversed NAFLD other than lifestyle changes, dietary alterations, and possibly, bariatric surgery. The increased rate of NAFLD in the world population, the absence of targeted medicine for NAFLD, and also the possibility of drug discovery based on Ayurvedic or traditional knowledge have driven this research. Here in this study we evaluated the effect of hydroethanolic extract of *Dillenia indica* leaf (DI-HET) against NAFLD. An *in vitro* model for NAFLD was employed in this study. For this HepG2 cells were incubated with 100 µM of oleic acid (OA) for 24 h. For evaluation of the effect of DI-HET, the extracts (5 or 10 µg/mL) were pretreated to the OA group. Fenofibrate was the positive control. Various parameters relevant to lipogenesis, β-oxidation of fatty acids, intracellular lipid accumulation, inflammation, glucose uptake, oxidative and mitochondrial stress, and key proteins were studied.DI-HET significantly reduced the intracellular lipid accumulation in OA-treated cells. It also substantially decreased the expression of lipogenic, inflammatory proteins and increased β-oxidation in the OA group. OA-induced ROS generation was reduced following treatment with DI-HET. Western blot analysis showed that the expression of LXR-α, SREBP-1C, SREBP-2, HMGCR, FAS, CD-36, and ACOX-1 were downregulated while that of SIRT-1, p-LKB, p-AMPK, p-ACC, CPT-1, and PPAR-α upregulated in DI-HET treatment. Treatment with DI-HET upregulated glucose uptake. LCMS/MS analysis showed the presence of polyphenols like naringenin, catechin, epicatechin, shikimic acid, syringic acid, vanillic acid, and kaempferol. These results suggested that DI-



Effect of DI-HET on oleic acid induced lipid accumulation in Hep G2 cells: (A)The lipid accumulation was assessed by Oil Red O staining. Representative phase-contrast microscopic images of Oil Red O stained HepG2 were presented, scale bar 50 µm. (1) Control (C) (2) Oleic acid 100 µM (OA) (3) Oleic acid + 5 µg/mL extract (DI 5) (4) Oleic acid +10 µg/mL extract (DI 10) (5) Oleic acid 100 µM + fenofibrate 20 Mm (PC). (B) Absorbance was read at 490 nm after Oil-Red-O staining (C) Measurement of intracellular triglyceride content in HepG2 cells. Absorbance was spectrophotometrically measured at 530 nm. Data are expressed as mean ± SEM; where n=6. * denotes significant difference from the control group ($p \leq 0.05$) and # denotes significant difference from the OA treated group ($p \leq 0.05$).



Effect of DI-HET on oleic acid induced mitochondrial superoxide generation and oxygen consumption rate in HepG2: A) The fluorescent microscopic images of cells stained with MitoSOXTM Red indicator, scale bar 20 µm. (1) Control (C) (2) Oleic acid 100 µM (OA) (3) Oleic acid + 5 µg/mL extract (DI 5) (4) Oleic acid + 10 µg/mL extract (DI 10) (5) Oleic acid 100 µM + fenofibrate 20 µM (PC). (B) Fluorescence intensity emitted by MitoSOXTM in control and treated cells. C) Effect of DI-HET on oxygen consumption rate. Control (C), Oleic acid 100 µM (OA), Oleic acid + 5 µg/mL extract (DI 5), Oleic acid + 10 µg/mL extract (DI 10), Oleic acid + fenofibrate 20 µM (PC) and Antimycin A (A). Data are expressed as mean ± SEM; where n=6. * denotes significant difference from the control group ($p \leq 0.05$) and # denotes significant difference from the OA treated group ($p \leq 0.05$).

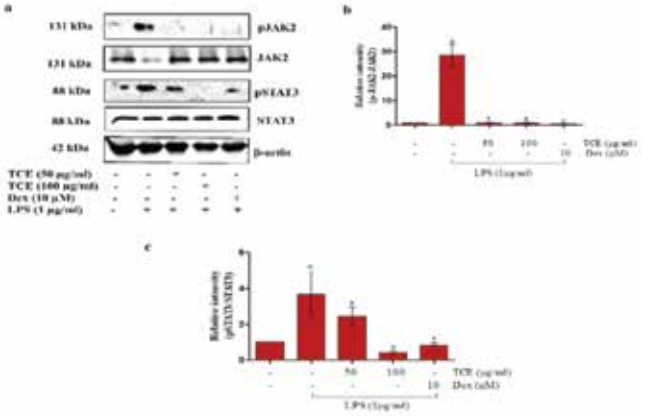


Phytochemical analysis of DI-HET by LCMS/MS method a) LCMS/MS Chromatogram of standard compounds with retention time in minutes 1) Catechol (1.87 min), 2), Catechin(6.75 min), 3) Quinine(6.88 min), 4) Naringenin(7.28 min), 5) Tocopherol (12.87 min) 6) Gallic acid (1.91 min) 7) Chlorogenic acid (6.81 min) 8) Epicatechin (6.77 min), 9) Syringic acid (7.20 min) 10) Vanillic acid (6.79 min) 11) Caffeic acid (6.91 min) 12) Epigallocatechin(2.01 min) 13) Ferulic acid(7.36 min) 14) Myricetin (7.65 min), 15) Quercetin (7.92 min), 16) p-Coumaric acid (7.34 min), 17) Luteolin (7.92 min), 18) Apigenin (8.18 min), 19) Kaempferol (7.83 min) 20) Rutin (7.34 min), 21) Diadzein (7.91 min), 22) Hesperetin (7.86 min) 23) Shikimic acid (1.76 min) 24) Ellagic acid (7.56 min), 25) Morin (7.74 min), 26) Genstein(7.81 min), 27) Cinnamic acid (7.93 min), 28) Chrysin (8.39 min) b) LCMS/MS Chromatogram of DI-HET showing corresponding peaks of polyphenols with retention time.

HET is effective against NAFLD by activation of the SIRT-1/p-LKB-1/AMPK signaling pathway via polyphenols present in the extract

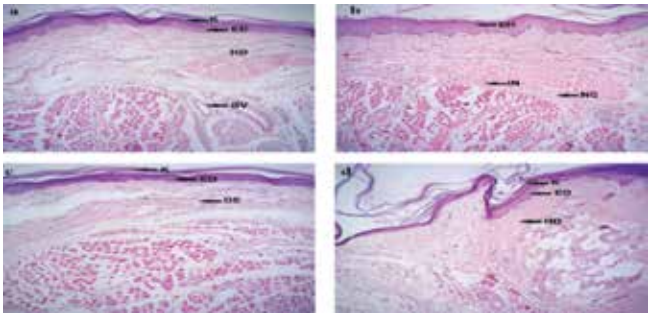
15. *In vitro* anti-inflammatory and *in vivo* anti-arthritic effect of *Tinospora cordifolia*

Rheumatoid arthritis (RA) is a chronic inflammatory disorder causing cartilage and joint degeneration. In spite of the availability of several robust drugs like biologics, most of the patients are unresponsive and reports of severe adverse effects following long term use are also there. Subsequently the usage of natural plant based products in RA therapy is broadening over the years. *Tinospora cordifolia* is a widely used medicinal plant in Ayurveda against various inflammatory disorders including RA. However, there is very limited knowledge regarding the actual molecular events responsible for its therapeutic effect and this has limited its acceptance among the professionals. Here in this study we explored the anti-inflammatory and antiarthritic effect of hydroalcoholic extract from *Tinospora cordifolia*. The rich polyphenol nature of the extract was elucidated using HPLC. LPS-stimulated murine macrophage cell line RAW 264.7 were used for *in vitro* studies and collagen induced arthritis (CIA) model was used for *in vivo* studies.

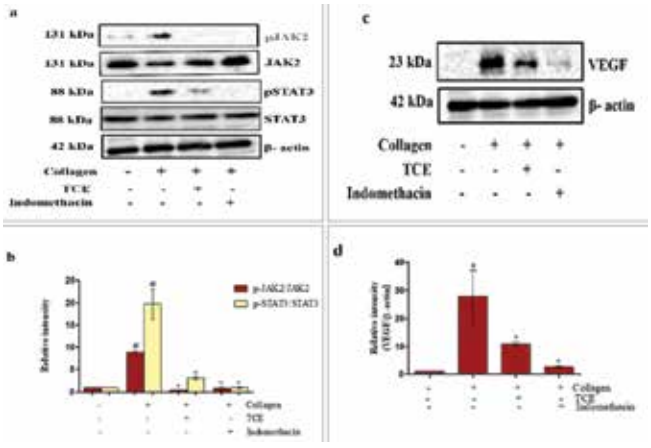


Effect of TCE on JAK-STAT pathway modulation. The total cell lysate was used for protein expression studies. (a) JAK2, pJAK2, STAT3, pSTAT3 expression against β-actin as an internal control. (b) The relative band intensity of pJAK2 against total JAK2 using densitometry. (c) The relative band intensity of pSTAT3 against total STAT3 using densitometry. Values are mean ± SD of three independent trials; # represents significant difference when compared to that of control group ($p \leq 0.05$) and * represents a significant difference when compared to that of the LPS treated group ($p \leq 0.05$).

The polyphenols in TCE were identified using HPLC. TCE effectively downregulated the level of proinflammatory mediators (IL-6, TNF-α, PGE2, and NO) in LPS-stimulated RAW 264.7 cells. Subsequently the upregulated expression of COX-2 and iNOS following LPS stimulation were also downregulated by TCE. Furthermore, TCE targeted the upstream kinases of the JAK/STAT pathway, a crucial inflammatory pathway. The expression of VEGF, a key angiogenic factor as well as an inflammatory mediator was also decreased following pretreatment with TCE. The anti-arthritic effect of TCE (150 mg/kg) was evaluated in the CIA model as well. From the results of histopathology, oral administration of TCE was found to be effective in reducing the clinical symptoms of arthritis including paw oedema, erythema and hyperplasia. *In vivo* results validated the *in vitro* results and there was a significant reduction in serum level of proinflammatory cytokines and mediators (IL-6, TNF-α, IL-17, NO, and PGE2). The phosphorylation of STAT3 and the expression of VEGF was also downregulated following TCE treatment. Our study provided a detailed insight into the molecular events associated with anti-inflammatory and antiarthritic effect of *Tinospora cordifolia*.



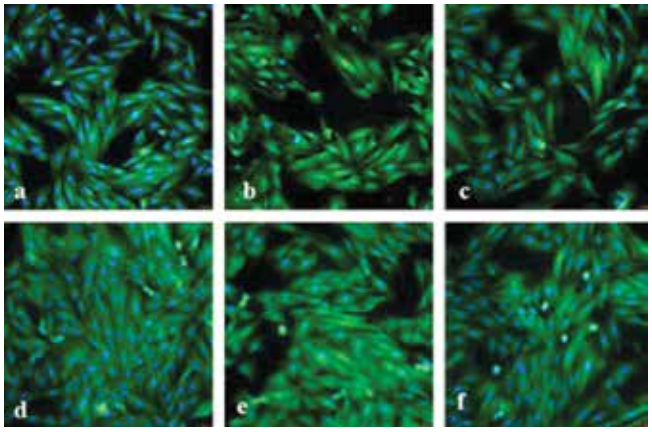
Histopathological analysis of paw tissue (H&E stain) in CIA model. (a) Normal (b) CIA model (c) TCE (150 mg/kg) (d) Indomethacin (3 mg/kg). K- keratin layer; ED- epidermis; HD- hypodermis; BV- blood vessel; EH- epidermal hyperplasia; IN- inflammation; NC- necrosis; OE- Oedema



Effect of TCE on modulation of JAK/STAT pathway and on expression of VEGF.The total protein from paw tissue was analysed for (a) JAK2, pJAK2, STAT3, pSTAT3 expression against β-actin as an internal control. (b) Relative intensity of pJAK2 against total JAK2 and pSTAT3 against total STAT3. (c) VEGF expression against β-actin as internal control. (d) Relative intensity of VEGF was evaluated against β-actin. Values are mean ± SD of three independent trials; # represents significant difference when compared to that of control group ($p \leq 0.05$) and * represents a significant difference when compared to that of the CIA group ($p \leq 0.05$).

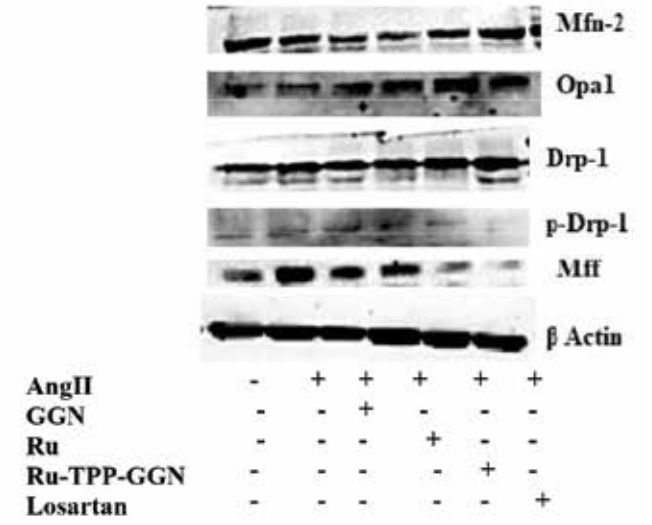
16. RutinTPP- functionalized guar gum nanoparticlesas mitochondrial antioxidants for cardiac hypertrophy: an *in vitro* study

Mitochondria are emerging as one of the essential druggable targets for managing cardiac hypertrophy and other associated complications. Mitochondrial dysfunction has been implicated in the development of heart failure.The ability to design mitochondrial targeting systems may therefore provide valuable alternative strategies to enhance therapeutic outcomes of mitochondrial-related diseases while at the same time minimizing side effects. Guar gum, a natural polymer derived from the seeds of *Cyamopsis tetragonolobus*, is used to prepare rutin (Ru) loaded triphenylphosphonium (TPP) functionalized guar gum (GG) nanoparticles (Ru-TPP-GGN). Ru, a bioflavonoid and an antioxidant, was loaded to TPP-GG nanoparticles to target its delivery directly to mitochondria. Ru-TPP-GGN increases rutin's solubility and improves its antioxidant activity in targeted mitochondria. The present study aimed to synthesize and characterize Ru-TPP-GGN. The characterization study showed that the prepared particles were of ~100 nm. In this regard, the effects of Ru-TPP-GGN against mitochondrial dysfunction in angiotensin II-induced hypertrophy in H9c2 cardiomyoblasts were evaluated. H9c2 cells with Ang II exhibited pathological hypertrophic responses and mitochondrial dysfunction, which was evident from ANP, BNP, MTT assays, cell surface area measurements, and mitochondrial specific parameters like alteration in mitochondrial transmembrane potential (ΔΨm), mitochondrial permeability transition pore



Effect of Ru-TPP-GGN on Ang -induced hypertrophy of H9c2 cells. Images of H9c2 cells from different experimental groups under phase contrast microscope (20x). (a) Control cells; (b) Ang -treated group, (c) AngII+5 µg GGN, (d) AngII+5 µg Ru (e) AngII+5 µg Ru-TPP-GGN (f) AngII+500nM losartan

opening (mPTP) in particular, its role in mitochondrial fission and fusion proteins. The treatment with Ru-TPP-GGN (5µg/ml) prevented Ang II-induced activity. These were comparable to the effects of the positive control losartan. These findings suggest that Ru-TPP-GGN protects against Ang II-induced cardiomyocyte

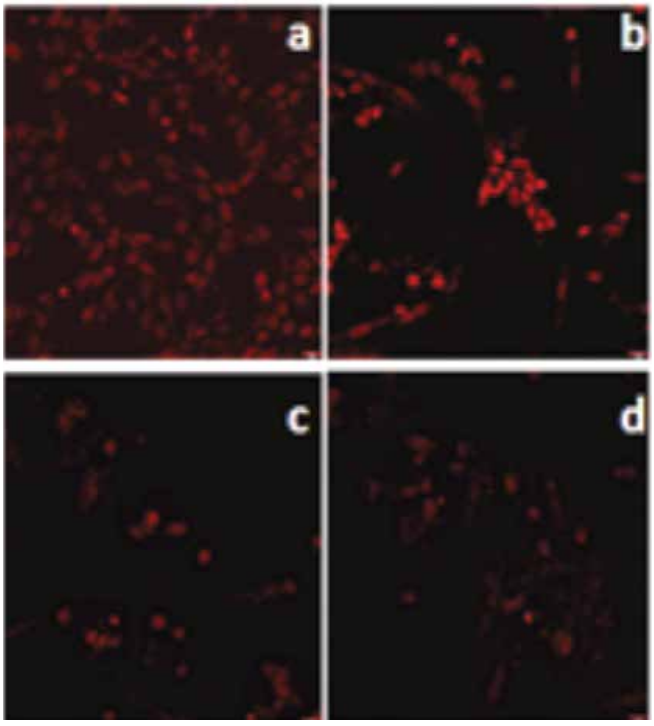


Effect of Ru-TPP-GGN on mitochondrial fission and fusion proteins

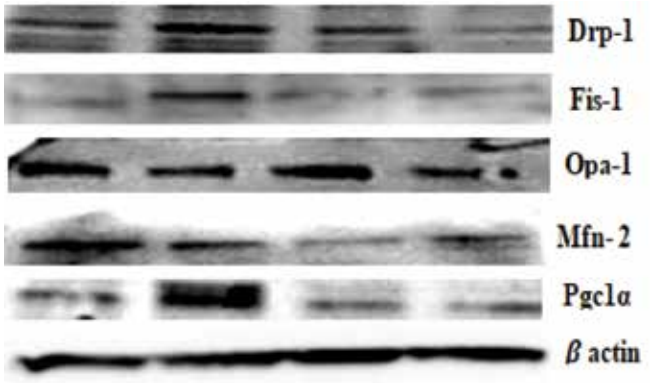
hypertrophy, compared to GGN and Ru (5 µg/ml). Overall results revealed the protective effects of Ru-TPP-GGN against mitochondrial dysfunction in cardiac hypertrophy *in vitro*, and the present findings may shed new light on the therapeutic potential of Ru-TPP-GGN.

17. Triphenylphosphonium-conjugated curcumin against D-galactose-induced cardiac aging: mitochondrial-targeted drug delivery in H9c2 cardiomyoblast

Aging-related cardiovascular disease has become the leading cause of death in older people. Therefore, understanding the causes and mechanisms associated with age-related cardiovascular diseases is particularly important. D-Galactose (D-gal) is a reducing sugar and is metabolized into glucose at normal concentrations. In addition, D-gal reacts with amines to form an unstable compound forming oxygen-derived free radicals and reactive oxygen species (ROS). Curcumin, a hydrophobic polyphenol, is a bioactive chemical constituent of the rhizomes of *Curcuma longa* Linn (turmeric), which has been extensively used for the alleviation of various human disorders. In addition to its pleiotropic effects, curcumin has been suggested to have antiaging features. In the present study, for selective targeting of the curcumin to the mitochondrion, we used triphenyl phosphonium conjugated curcumin(MC). The study showed that cotreatment with10 µg/ml of MC for 48 h enhances



Mitochondrial superoxide generetions in H9c2 on various treatments a) Control b) 50 µg Gal c) 50 µg Gal + 10 ug C d) 50 µg Gal + 10 µgMC

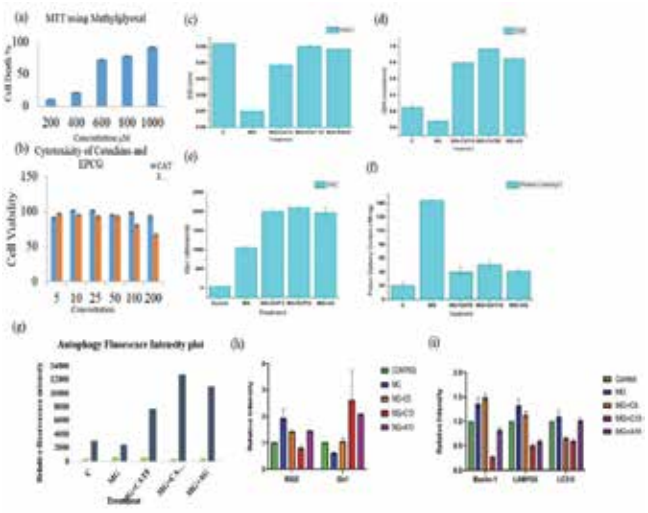


Effect of mitocurcumin on mitochondrial fusion and fission proteins in D-gal induced a ging treatments a) Control b) 50 µg Gal c) 50 µg Gal + 10 ug C d) 50 µg Gal + 10 µgMC

antioxidant activity and decreases the ROS production in D-gal-induced aging groups. MC alleviated D-gal-induced aging of the H9c2 cell line and significantly ameliorated mitochondrial function by rectifying the imbalance of fusion and fission in mitochondrial dynamics (Mfn2, OPA1, Fis1, Drp1, and PGC-1α). In summary, the results of this study revealed that MC showed substantial promise for improving the mitochondrial health in D-gal-induced aged H9c2 cells.

18. Role of catechins in ameliorating the effects of MG induced AGE formation and impaired muscle cell differentiation

Diabetes is slowly becoming the most prevalent disease affecting about 537 million adults (20-79 years) globally according to the latest reports (https://www.idf.org). Even worse are the complications associated with it of which advanced glycation end products are the main cause. AGEs are formed due to acumulation of α-dicarbonyls like Methylglyoxal(MG) which are primarily produced during intermediate hyperglycaemia. Our study focuses on trapping of methylglyoxal and thereby its downstream effects using Catechins. Catechins are natural polyphenols, their effect and toxicity is tested herein skeletal muscle cells induced with MG. We found that Catechins can reverse oxidative stress induced by MG with a concentration as low as 5µM. MG is degraded in the body by the glyoxylase enzyme system. Catechins were found to enhance its activity. Further, effect exerted by MG in muscle differentiation was reversed

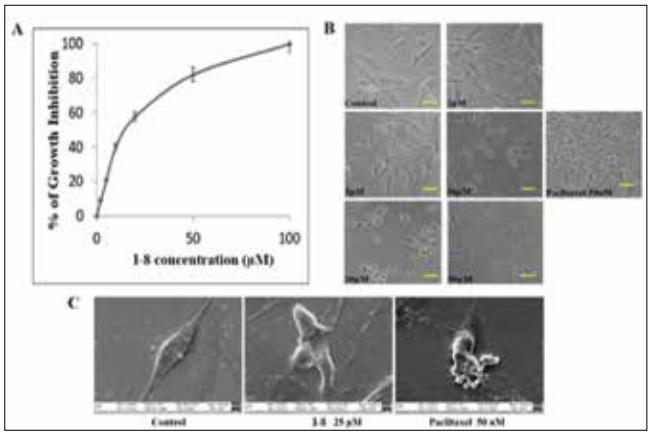


(a) MTT cytotoxicity assay of the MG; (b) MTT assay of Catechins and epigallectocatechin in MG induced cells; (c) SOD antioxidant enzyme status; (d) Glutathione enzyme estimation; (e) Levels of Glo1in various treatment conditions; (f) Protein carbonyl content estimation as a marker of oxidative stress; (g) Autophagy detection in L6 myotubes using fluorescent microscopy; (h)Western blot analysis-Cell lysates were examined for protein expression of RAGE and Glo-1 and autophagy marker proteins.

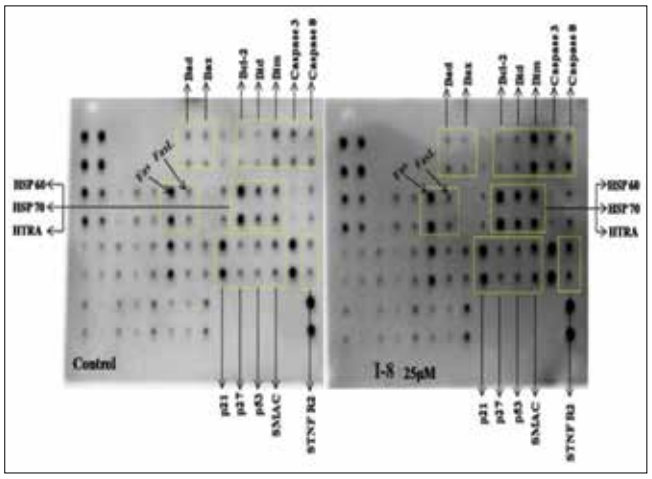
by Catechins which was confirmed by western blot of Myogenin protein. MG treated cells showed enhanced autophagy which was ameliorated by catechins. Overall we conclude catechins can be considered effective druggable candidate to curb diabetic complications as whole or diabetic myopathy specifically.

19. Identification of a novel pyrazole amide derivative against triple negative breast cancer cells

Triple negative breast cancer (TNBC) is a fatal breast cancer subtype with the overall survival rate around 77% due to high incidence of distant metastasis, especially in the brain. The 5-year overall survival of metastatic TNBC and metastatic non-TNBC is reported to be 10.81% and 33.46% respectively. A continuous chemotherapy regimen, preferentially with a single agent, is the only standard of care, for this group of patients. Paclitaxel is a major first-line chemotherapeutic agent for many solid cancers including TNBC and it have lot of side effects including metastatic promotion once the treatment stops. This warrants the urgent need for the development of therapeutic agents that can use in the chemo regimen for the interest of TNBC patients.



(A) *MTT assay results showing the growth inhibitory effects of I-8 in MDA-MB-231 cells after 24 h. Data represented here are a mean of three independent experiments performed in duplicate ± SD. (B) Representative phase-contrast images showing the morphological changes under treatment with I-8. Magnification, ×10. Scale bar = 100 µm. (C) Representative images of SEM analysis showing the morphological changes under treatment with I-8. Magnification, × 5k. Scale bar = 2 µm.*

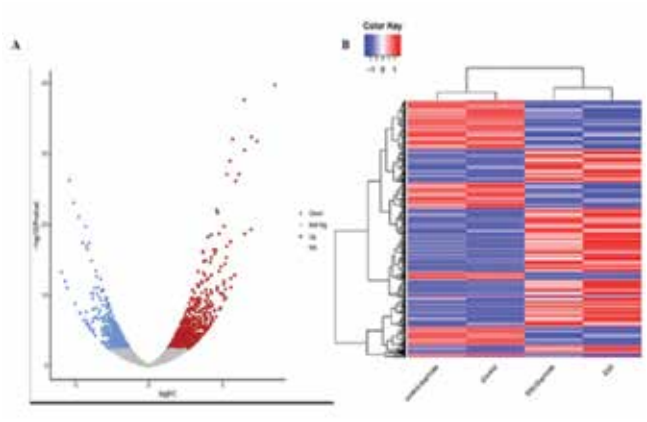


ChemiDOC image of human apoptosis antibody membrane array showing expression of pro-and anti-apoptotic proteins in the lysate of untreated (control) and I-8 (25µM) treated MDA-MB-231 cells. Relative differences in expression levels of each apoptotic marker protein (spots in yellow boxes) are compared.

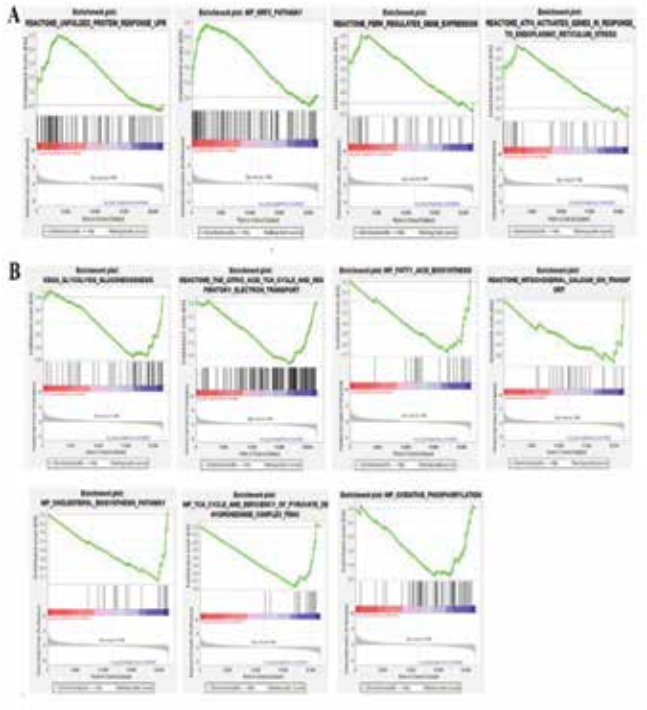
After screening more than 100 molecules, we have identified a potential pyrazole amide derivative (I-8) against TNBC which modulated the cell death through targeting diverse signalling pathways and signalling molecules. *In silico* investigations have proved that I-8 obeyed Lipinski rule with good oral bioavailability and synthetic accessibility. The GI_{50} value of I-8 in MDAB-231 cells was found to be 15.08 µM and it imparted apoptosis and anoikis forms of cell death. Another important feature identified for I-8 is that it can offer chemosensitivity to the standard drug paclitaxel. Co-treatment of 2µM of I-8 with paclitaxel reduced its GI_{50} value to ten times lower concentration, when it used alone. A patent has been filed on the identification of this molecule and their chemotherapeutic potential in breast cancer cells.

20. Whole transcriptome analysis (NGS) and identification of key genes involved in the apoptosis induction of Epoxyazadiradione in triple negative breast cancer cells

Epoxyazadiradione (EAD) is a pentacyclic triterpenoid present in neem seeds, and previously we have reported a remarkable cytotoxic effect of this compound in TNBC cell line MDA-MB-231 along with the mode of action. Here we have used a system biology approach to identify key genes and signaling pathways altered in EAD treated MDA-MB-231 cells through next generation sequencing. For this DNA was isolated from control and EAD treated cells and after quality checking and evaluation, the sequencing was done using HiSeq 4000 Illumina platform. The output from the sequencer (fastq files) were subjected to RNA-seq data analysis was done on the Galaxy Platform. DESeq2 tool was used for differential expression analysis of transcripts. After differential expression analysis using DESeq2 a total of 27979 genes (Downregulated-12482, Upregulated- 15497) were obtained. DEGs having significant expression variation were extracted by applying cutoff (p-value <0.05 and fold change >2) which resulted in 1838 genes out of which 752 are downregulated and 106 are upregulated. Enrichment of gene ontology and pathways were elucidated using Toppfun (Toppgene suite). On analysis of upregulated gene list, significantly enriched 25 biologicalprocesses and 17 molecular functions were obtained. Analysis of downregulated genes showed significantly enriched 107 biological processes and 8 molecular functions. Ranked DEGs (based on log fold change) were analysed using GSEA-Preranked tool (GSEA 4.1.0) against Canonical pathways (CP: a pre-defined collection of 2922 gene sets) of Molecular Signatures Database (MSigDB). The positively and negatively enriched pathways with FDR



(A) Volcano plot (Significance threshold 0.05 & LogFC threshold to color 1.0) Downregulated-12482, Upregulated - 15497. (B) Expression Heatmap showing the Euclidean distances between the samples as calculated from the r-log transformation of the count data . (p-value<0.05 and fold change >2)



Selected Enrichment plots showing:(A) Positively enriched 4 pathways related to ER stress(B) Negatively enriched 7 pathways related to cell metabolism

(qvalue) less than 0.25 were considered significant. Of the several positively and negatively enriched pathways, the notable ones were, positively enriched pathways related to ER stress, negatively enriched pathways related to cellular metabolism, negatively enriched pathways related to cell cycle an negatively enriched pathways related to cell adhesion and inflammation.

21. Immuno Modulatory Function of Nutritionals and Nutraceuticals for Health and Wellness

The herbal formulation with indigenous ethnobotanical approach especially from Himalayan Foot Hills, North East, and Western Ghats valley has a treasure of these to be dug out for this focussed approach.The proposed Immunity Mission has ten themes with activities defined as different Work Packages and one among them is **"Combination of Regional Teas for boosting immunomodulation"**. Tea is widely consumed all over the world. Tea contains abundant phytochemicals, such as polyphenols, pigments, polysaccharides, alkaloids, free amino acids, and saponins. Many studies have demonstrated that tea shows various health functions, such as antioxidant, anti-inflammatory, immuno-regulatory, etc.

In the present project, we are studying the immunomodulatory properties of tea from three different regions of India, Himalaya, Assam and Munnar. CSIR-IHBT, CSIR-NEIST and CSIR-NIIST are the labs involved in this work package. Munnar region in Idukki district of Kerala is very significant as tea is cultivated in an altitude of 1532 meters above sea water level. Hence, the tea varieties cultivated in this area gains a special attention to our proposed study as medicinal applications from the produced tea already reported. CSIR-NIIST is involved in the screening of different varieties from Munnar region for their abundance in polyphenol content and immunomodulatory potential.

CHEMICAL SCIENCES AND TECHNOLOGY DIVISION

The Chemical Sciences and Technology Division has been focusing on the development of molecules and functional materials and their applications in various device platforms and prototypes. Three priority areas of the Institute are coordinated by the Division – (1) Organic and Hybrid Electronics (Energy generation and storage, chromogenic coatings, conductive coatings, organic optoelectronics, computational chemistry); (2) Fluorescent Materials (Security applications, sensing, diagnostics and imaging probes and ultrafast kinetics); (3) Phytochemicals, and Drug Intermediates (Bio-evaluation of medicinal plants and advanced pharmaceutical intermediates). The Division leads various thematic activities of CSIR at the institute level, such as Energy (conventional and non-conventional) Materials and Devices, and Chemicals. The stand-alone vertical on "Coatings" under 4M theme is also being coordinated by the Division. Scientists in the division have also undertaken large number of important projects funded by various government agencies and industries. In addition to the involvement in technology development, division is also very active in knowledge generation as evidenced from 90 publications in internationally reputed peer-reviewed journals with high impact factor in 2021-22. The division has also got 15 patents filed or in the process of filing during this period.

The division has actively participated in the COVID-19 mitigation activities by developing processes for synthesis of antiviral drug molecules such as Molnupiravir,and developing new diagnostic platform for screening COVID-19 using label-free Raman scattering, developing flocculent materials for biomedical waste disposal, designing face masks, developing a herbal gel sanitizer, developing new formulations for steam inhalation and supplying hand sanitizer to the whole institute.

The highlights of the activities and achievements of the Division during the year 2021-22 along with brief abstracts of important developments are given below.

Highlights

- Signed an MoU with the Bank Note Press, Dewas (A unit of Security Printing and Minting Corporation of India, under the Ministry of Finance, Govt. of India) for the development of the fluorescent pigments suitable for Indian currency printing.
- Installed an indigenously made spary coating unit developed by an MSME unit for developing transparent conducting coatings.
- Signed MoU with Kerala State Drugs and Pharmaceuticals Limited for the development of knowledge base on 15 active pharmaceutical ingredients.
- Developed spray coated, high performance-electrochromic cells with assemblies of iron(II) based metallosupramolecular polymer network films using tetra-terpyridine ligands.
- Demonstrated a mixture of iron(II) chloride and bipyridine as a reversible color-to-colorless thermochromic switch.
- A lightweight all-organic nanocomposite of benzodithiophene-thienothiophene (BDT-TTE) based conjugated polymer and multi-walled carbon nanotube (MWCNT) was prepared for thermoelectric applications.
- Developed technologically important visibly opaque and near-infrared transmitting material based on perovskite nanocrystal/ squaraine dye composite.

- Singlet fission in pentacene dimers studied.
- Donor–π–acceptor (D–π–A) systems typically used in dye-sensitized solar cells (DSSC) have been studied for assessing the donating strength of various donors under the influence of substituents.
- High performance supercapacitors reported with heterostructured MoS_2-RuO_2nanocomposite based electrode.
- Developed MSN-Chitosan core-shell targeted theranostic nano-delivery system with self-destruction and immunostimulatory features to circumvent drug resistance and wipe-out tumour reinitiating cancer stem cells.
- Established differential recognition of the grades of cervical cancer by label-free surface enhanced Raman fingerprints and Chemometrics.
- Developed cost-effective and industrially viable processes for the synthesis of the antiviral EIDD 2801 (Molnupiravir) and its active pharmaceutical intermediate EIDD 1931.
- Developed an herbal gel sanitizer for prevention and spread of COVID-19, "CLEANiiST".
- Developed a novel sustained release liquid formulation for steam inhalation, "NiiSTEAM". Indian patent has been filed for the developed technology.
- Developed topical antibiotic cream using the phytomolecules against multidrug-resistant strains.
- Development of BODIPY-based 2D supramolecular polymers showing excited-state cascade energy transfer mediated multiple emission.
- Development of a new pentacyclic pyrylium fluorescent probe that responds to pH imbalance during apoptosis.
- Silicon shadow mask technology for aligning and *in situ* sorting of semiconducting SWNTs for sensitivity enhancement of NO_2 gas sensing.
- Identified potential semi-synthetic leads from *Curcuma amada* against obesity and hyperlipidaemia.
- Base-enabled access to diastereoselective Spirofuran oxindoles and γ-Functionalized allenoates.

1. Significant S & T Activities

A. Dye-sensitized solar cell for indoor photovoltaic and underwater photovoltaic applications

Capturing and recycling all kinds of light (indoor and outdoor) to realize self-powered devices is our goal in the expertise area of third-generation molecular light-harvesting technology - Dye-sensitized solar cells/Dye cells (DSCs). Conventional solar technologies are too bulky, rigid, or inefficient for use in remote/indoor locations under artificial lighting. The significant interest in DSCs is also related to the ease of sourcing materials used for their fabrication and the possibility of indigenous manufacturing and recycling. DSCs have already proved to be the best technology for harvesting energy from indoor/ambient lighting, with efficiencies up to 34.5%. Also, with more solar and less power consumption, the time between battery replacements can even be longer, or possibly, never. At CSIR-NIIST, we custom-designed and optimized these indoor light harvesters. Our initiatives are currently being streamlined towards indigenizing DSC technology in the country and globally for indoor photovoltaics. At NIIST, we have realized PCE >30% under standard indoor illumination using LED & CFL lighting [100 μW/cm^2@ 1000 lux] with the use of newly designed dyes and electrolytes and by using innovative device engineering protocols. We are also exploring unique applications where DSCs have been tested for underwater photovoltaic applications (under submerged conditions) and proved to be superior to

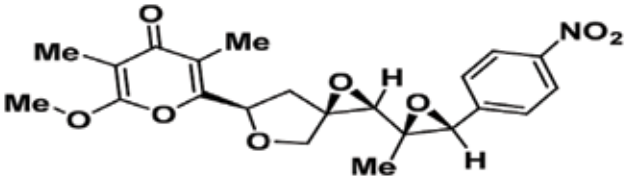
silicon and thin films,displaying the capability of DSCs to harvest indirect/diffused lights in comparison with conventional photovoltaics. Through our initiatives, we emphasized the importance of Indoor Photovoltaics and the dire need for harvesting all forms of light, particularly from artificial sources (LED/CFL).

B. Developing large-area dynamic windows for indoor energy-saving and aesthetic facades

With the evolving work culture, the smart windows/ glass market is exponentially growing (projected to $700 million by 2024). One concern is the energy wastage in commercial buildings that consume ~40% of the supplied power, and >30% is wasted through the windows. The "Energy and Buildings" (Centre for Science and Environment, India) has identified the rapid increase of glass usage in buildings and the glazing of glass to be the most viable pathway for saving a substantial amount of energy. We have developed an indigenous technology for smart materials and dynamic window prototype fabrication. The smart glass technology further assists in efficient energy management and utilization, net-zero energy buildings, indoor temperature regulation, and glare reduction while adding aesthetics (tunablecolor and color neutrality) to building architecture. Highly expensive imports restrict the current smart glass market in India. Smart glasses represent the largest global market, and market penetration in India is assured via the demonstration of high-performance, cost-effective, dynamic windows with smart attributes and facile processability.

C. Isolation of a novel microbial natural product alloaureothindiepoxide from *Streptomyces sp*. NIIST-D31 strain

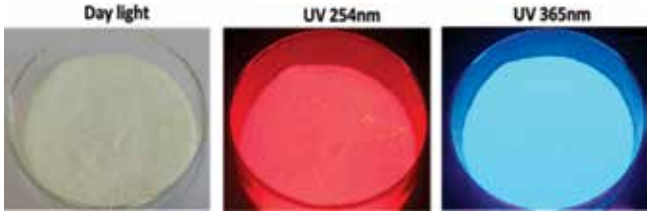
A novel vicinal diepoxide of alloaureothin was isolated from *Streptomyces sp*. NIIST-D31 strain along with three carboxamides, p-aminobenzoic acid and 1,6-dimethoxyphenazine. Exhaustive 2D NMR analysis and analysis of experimental, theoretical CD spectra aided in establishing the structure of the compound. The vicinal diepoxide formation can be postulated as epoxidation of 1,3-diene of alloaureothin by monooxygenases. This work was published in the *Journal of Antibiotics* **2022**. DOI: 10.1038/s41429-022-00547-1.



alloaureothin diepoxide

D. Fluorescent Materials for Security Printing

Counterfeiting of currencies, documents, pharma products, and consumer goods is a global problem resulting in substantial economic losses to the nation and companies associated with it. Incorporating fluorescent markers through random distribution (fibers) or printing (ink formulations) is among the most critical anti-counterfeiting measures used worldwide. These materials are currently imported at inflated costs from various countries, which threatens national security and results in forex depletion. In this context, the indigenous development of these materials and technologies that are difficult to duplicate is indispensable. CSIR-NIIST addressed this challenge by developing fluorescent



Dual fluorescent pigment emitting red and blue colors under different wavelengths of UV excitation.

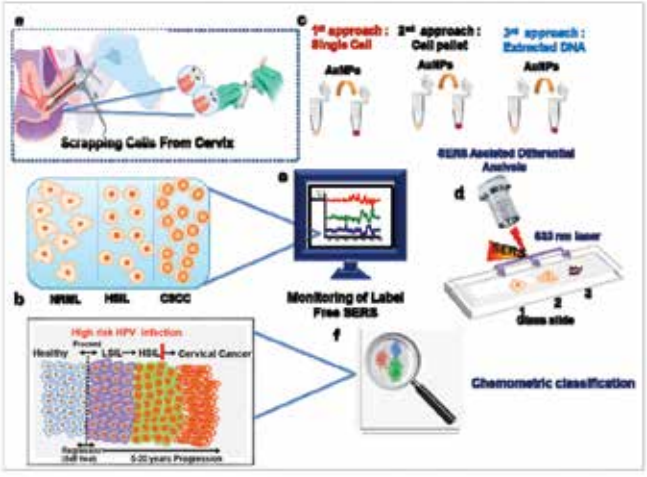
molecules and pigments with appropriate fluorescence characteristics suitable for security printing. These products would help the existing players (public and private) reduce the expenses in terms of import costs and enable their competence in fluorescence-based security solutions.

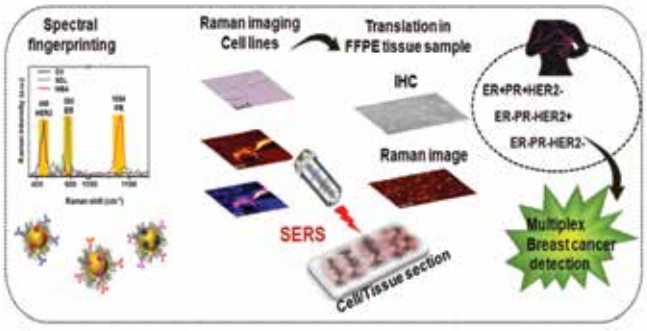
E. Cancer Diagnostic Research Based on Raman Spectroscopy

A new spectroscopy-based diagnostic modality has been developed by utilizing label-free ultra sensitive surface-enhanced Raman scattering (SERS) technique to generate a differential spectral fingerprint for the prediction of normal (NRML), high-grade intraepithelial lesion(HSIL), and cervical squamous cell carcinoma (CSCC) from exfoliated cell samples of cervix. Three different approaches, i.e., single-cell, cell-pellet, and extracted DNA from the oncology clinic as confirmed by Pap test and HPV PCR, were employed. Gold nanoparticles as the SERS substrate favored the increment of Raman intensity and exhibited signature identity for AmideI II/ Nucleobases and carotenoid/glycogen, respectively, from clinical samples for establishing the empirical discrimination. Moreover, all the spectral invention was subjected to Artificial Intelligence (AI) tool, which included a Support Vector Machine (SVM) and furnished an average diagnostic accuracy of 94%, 74%, and 92 % of the three grades. The current discovery with the combination of SERS readout and AI in field trials promises its potential to reduce the incidence in low-resource countries.

Background of the diagnostic kit (SERS-Nanotags) for Multiplex detection of Breast Cancer Biomarkers

Breast cancer is the most common cancer among women. Hormone receptors, including Estrogen receptor (ER) and Progesterone receptor (PR) status, are critical biomolecules in breast cancer. Over-expression of HER2/ Neu gene is associated with breast cancer patient's prognosis and therapy, and Ki67 is a proliferative marker. ER, PR, HER2, and Ki67 panelsare essential in the estimation process of breast cancer prognosis, which plays a significant role in treatment choices for breast cancer worldwide. Multiplexed detection is an attractive strategy in cancer diagnosis where multiple biomarkers can be evaluated simultaneously at a particular time. Recognition of relevant biomarkers in heterogeneous breast cancer facilitates clinicians in improving treatment strategies. Although the current gold standard immuno histochemistry can detect a single biomarker at a time, its subjective nature, the inability of multiplexing, and time-consuming nature make it a hurdle leading to delayed results. In the current strategy, an alternative multiplex-detection technique has been developed for conventional IHC and FISH analysis by sequential addition of diagnostic SERS-nanoprobes with unique Raman reporters having multiplexing capability for the ultrasensitive and rapid detection of differential biomarkers, ER, PR, and HER2 in breast cancer. Initially, the SERS-tags were validated in differential biomarker expressed cell line models, and later the study was extended for diagnosis in clinically confirmed retrospective formalin-fixed paraffin-embedded (FFPE) breast cancer tissue samples in single-plex, duplex as well triplex manner. Multiplexing SERS was compared critically in terms of time required for the analysis and found to be an excellent technique that minimizes the processing and experiment time to around 5-6 hr, unlike IHC for covering a 5 x 5 mm tissue area. Additionally, HER2 biomarker grading, which is executed conventionally using time-consuming IHC and expensive FISH analysis,

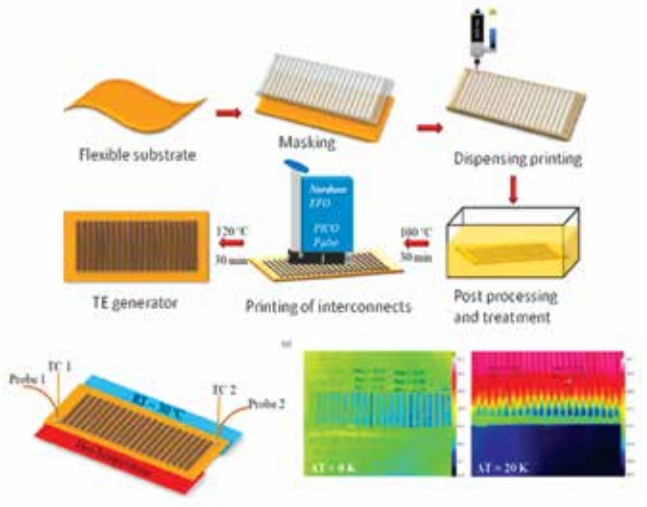




was also proved by SERS spectral analysis showing the potential of SERS to be applied in clinics. Simultaneous detection of these biomarkers enabled us to achieve a sensitivity of 95% and a specificity of 92% for single-plex analysis, 88% and 85% for duplex analysis, 75% and 67% for triplex analysis, respectively. Combined diagnosis of these biomarkers enabled SERS-tags-based detection to be turned out as an accurate, inexpensive, reliable, and facile technique that can simultaneously identify the biomarkers variations in different breast cancer subtypes semi-quantitatively.

F. Developing printable thermoelectric (TE) composites and module fabrication

We developed a process where flexible thermoelectric generators could be manufactured with a high degree of automation using dispenser printing. The process works for different materials in paste form (metals, polymers, composites). The paste-like material is squeezed with a defined quantity through a fine capillary and deposits onto the two- or three-dimensional substrate. The process advantages become especially obvious when producing individual thermoelectric modules that fit a given contour. Vertical orientation allows for many thermocouples to be packaged as a stack. The length of the TE legs and the resulting temperature gradient can be adjusted to the requirements of a given application.



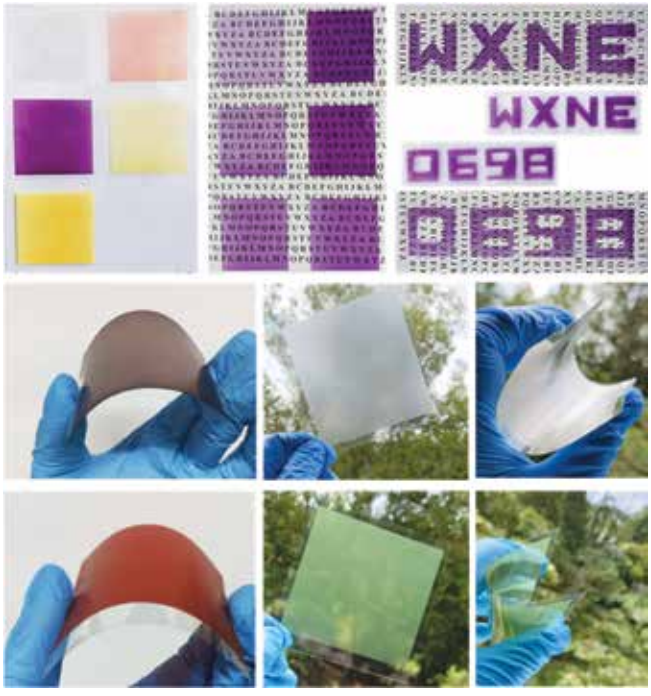
2. Area and Theme Wise Significant S & T Contributions:

A. Indigenous Fabrication of Transparent Conducting Oxide (TCO) Coatings by Spray Pyrolysis for Dye-Sensitized Solar Cell Application

Through this project, we intend to indigenously develop a unique spray pyrolysis system with plasma cleaner to develop high-quality FTO substrates which can be used for various optoelectronic applications like solar cells, LEDs, etc. By indigenizing the coating technology by employing the scalable spray pyrolysis technique, we are confident of achieving a cost reduction of equipment. With this, we will be able to supply both equipment and FTOs developed at a much lower price tag to educational institutions, thereby promoting research in various optoelectronic sectors in a much more efficient way. Indigenization of FTO coating technology, once developed with cost reduction, will lead to a paradigm shift in research taking place with the supporting optoelectronic areas where FTO is being used extensively.

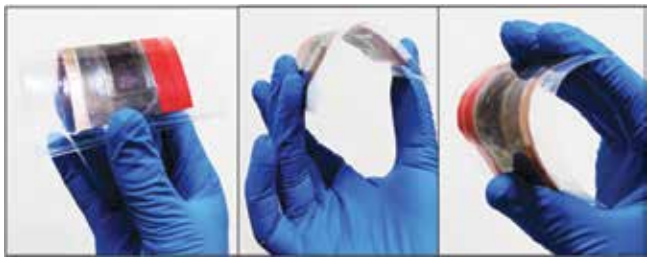
B. Advanced Materials Mission on Composite Materials for Flexible Electrochromic Devices

Flexible electrochromic technology has a good market potential for displays as both high and low-resolution non-emissive flexible/wearable devices could be fabricated with improved ambient visibility and energy efficiency. Organic-inorganic hybrid systems offer superior prospects in all the above-mentioned applications if they could be designed to extract synergistic benefits from both systems. These materials constitute a new class of functional materials with big potential for all kinds of smart coatings applications. The mission will impact non-emissive displays, wearable devices, flexible electrochromic paper signage applications, etc. The developed technology will cater to the high demand for low-cost and energy-efficient hand-held gadgets that arose with the advent of the cashless economy and Digital India/Make in India initiatives. The huge market potential coupled with a minimal number of filed patents on ECD-based display systems makes an ideal case to initiate exploring this area and becoming globally competitive.



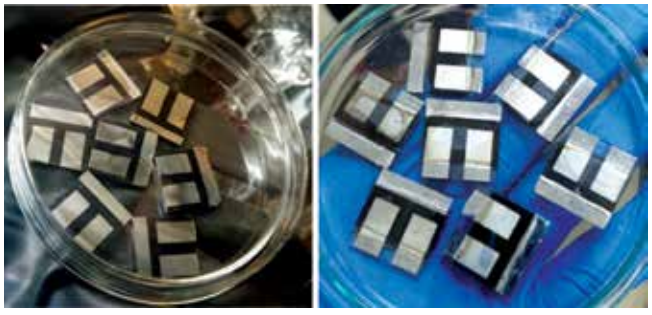
C. Engineering Flexible Dye-sensitized Solar cells/ Modules for Self-powered Wearable/portable Electronics

With increasing demand and deployment of portable electronics, the need grows for independent, constant power sources capable of driving these gadgets. Flexible photovoltaic devices capable of harnessing all forms of light (natural/artificial), which can be covered on non-planar or bendable surfaces, is an area that needs to be strengthened and developed to support this power demand. With the growing demand for economical, eco-friendly, easy-manufacturing, and renewable portable power sources, flexible photovoltaic devices with the capability of harnessing all kinds of light (natural/artificial) stand out as a promising candidate to be integrated with portable power sources. However, moving towards flexible substrates leads to low conversion efficiency and poor stability, which limits its applications. Among flexible photovoltaic devices, dye-sensitized solar cells (DSCs) occupy a prominent position due to its ease of manufacturing, use of abundant materials, low product cost, higher efficiencies (up to 32%) in indoor light, capability to harness more voltage from a single junction device and excellent flexibility as it can be made on metal and plastic substrates. But moving to flexible substrates leads to issues with sealing and poor mechanical stability. Therefore, optimizing the properties of the substrate, semiconductor film, sensitizers, electrolyte, and the counter electrode is highly required in a way to accelerate the market penetration of flexible dye-sensitized solar cells (DSCs). Through this project, we indent to indigenously develop flexible dye-sensitized solar cells/modules for self-powered wearable/portable electronics



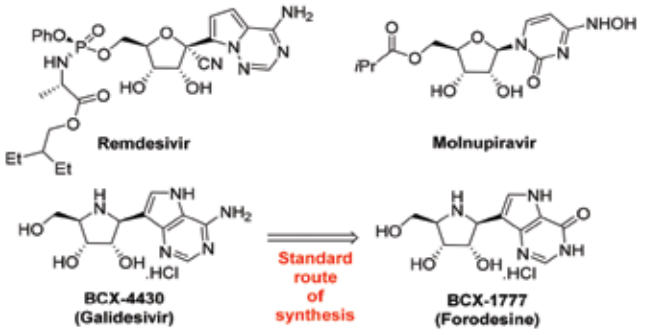
D. Perovskite Materials for Solar Cell (PSC) Applications

Considering the huge potential for perovskite solar cells for commercialization, it is high time that in India, we do extensive research on this class of solar cells and create the necessary intellectual property portfolio, which would be crucial for near future commercialization. In our effort, we are aiming a step forward to develop chemical processes to make the perovskite solar cells stable and maintain their performance for a reasonably long time in ambient working conditions. We also propose establishing processes for large-area manufacturing of perovskite solar cells compatible with the solution phase and low-temperature processing, which are critical for low-cost manufacturing. Given the novelty of our proposed ideas, we are highly optimistic that our research will lead to critical technological advancements in the field and generate a crucial patent profile, knowledge development, and a trained workforce, which may lead to the spin-off or commercialization of the technology. To achieve a breakthrough in next-generation perovskite technology, the team will integrate unique advances in complementary areas of material research and development, various deposition methods of large area perovskite absorber layers, advanced charge transport layers, carbon layers, and barrier encapsulating layers, thereby leading to the development of small area devices with >20% efficiency.



E. Development of processes for active pharmaceutical ingredients towards COVID-19

Nucleoside analogs are the mainstay of therapeutic modalities in treating viral infections. SARS-CoV-2 or COVID-19 infection led to a global endeavor in repurposing nucleoside-based drugs that resulted in remdesivir and molnupiravir as FDA-approved drugs, and many more are at various stages of developmental studies as potential hits for novel antivirals. BCX-4430 (aka galidesivir or immucillin A, a C-nucleoside analogue, is a broad-spectrum antiviral agent that disrupts viral RNA-dependent RNA polymerase. BCX-4430, initially intended for hepatitis C virus, displayed in vivo antiviral activity against several serious pathogens, including Ebola, Marburg, Zika, Yellow fever, Rift Valley fever, and in vitro against more than 20 RNA viruses. BCX-4430 was repurposed for COVID-19 by BioCryst Pharmaceuticals. Though the Phase I clinical studies displayed promising results with a dose-dependent decline in viral levels, and the drug was found to be safe and well-tolerated, it was not pursued further for COVID-19. However, BCX-4430 is in advanced clinical development to treat Marburg viral disease, the same family as Ebola with high fatality. A related adenosine analogue, BCX-1777 (aka Forodesine or immucillin H, serves as a purine nucleoside phosphorylase inhibitor that produces selective suppression of T-cells, inducing apoptosis. In Japan, BCX-1777 is sold under the brand name Mundesine® for the treatment of relapsed or refractory peripheral T-cell lymphoma. We reported a novel process for synthesizing BCX-1777 and BCX-4430 in an expedient manner that is advantageous over the reported routes that rely on the synthesis of an advanced common intermediate. The overall yield of BCX-1777 and BCX-4430 was 38% in 10 steps and 32% in 11 steps, respectively, from 2,3,5-tri-O-benzyl-D-ribonolactone. A process patent Indian Patent Application No. 202111061664 (Date of filing: 29/12/2021) was applied.



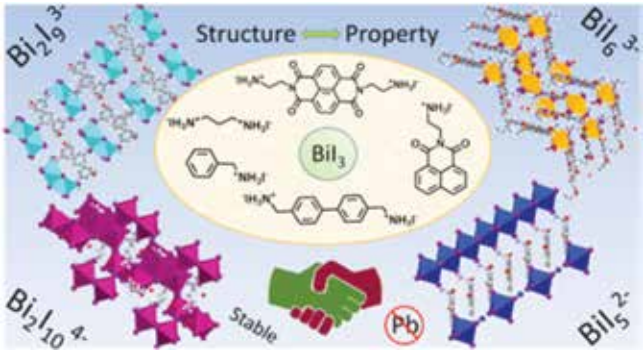
3. Contribution to Government of India Mission

A) Make in India

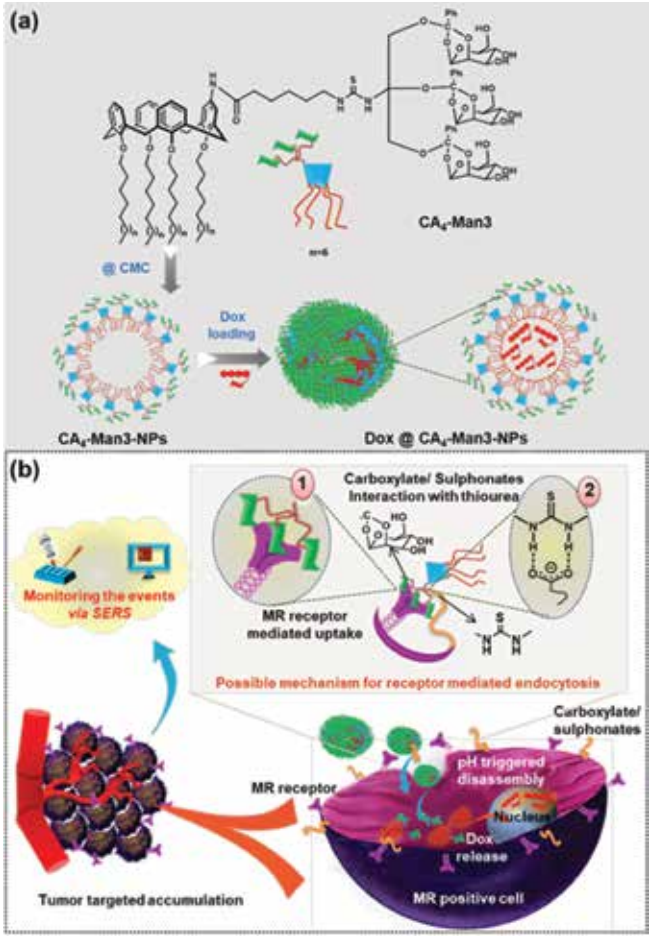
Developed indigenously spray pyrolysis system with plasm a cleaner to be used for development of high quality FTO substrates which can be used for various optoelectronic applications.

4. Important Scientific Achievements-Academic Impact

1. Lead halide perovskites are under the spotlight of current research due to their potential for efficient and cost-effective next-generation optoelectronic devices. The unique photonic and electronic properties of these solution-processable materials brought them to the forefront of materials science. However, the toxicity and instability of lead-based perovskites are the major hurdles to their commercialization. These issues initiated a strive for the development of environment-friendly, lead-free perovskites. In this context, bismuth halide perovskites (BHPs) were ideal rivals for lead-based congeners due to their excellent chemical stability, less toxicity, and structural versatility. Understanding the crystal structure and optoelectronic properties of BHPs is crucial for designing them for specific, tailor-made applications. We have made several research progress on the role of functional organic spacer cations in modulating the electronic confinements, optical properties, and photoconductivity of BHPs. We have employed a comprehensive experimental and theoretical investigation to probe these materials' intriguing optical and electronic properties. Our findings on the structure-optoelectronic property correlations will be valuable guidelines for the rational selection of organic spacer cations in designing BHPs featuring low exciton binding energy, narrow optical bandgap, enhanced visible light absorption, and high photoconductivity. One of our key findings is that by increasing the electron affinity of the organic spacer ligands, photoconductivity and visible light absorption of BHPs could be significantly enhanced. (Acc. Chem. Res. 2022, *55*, 275-285; Impact factor: 22.38)



2. Targeted Drug Delivery System

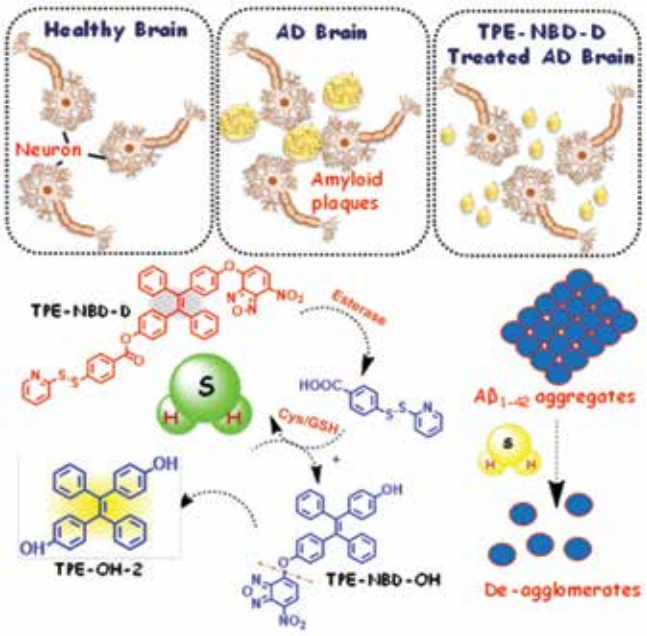


Dynamic self-assembly of mannosylated-calix[4] arene into micelles for the delivery of hydrophobic drugs; Padincharapad Sreedevi ,Jyothi B. Nair, Manu M. Joseph, Vishnu Priya Murali, Cherumuttathu H. Suresh, R. Luxmi Varma, Kaustabh Kumar Maiti* ***Journal of Controlled Release;*** 2021, 339, 284–296 (Impact Factor: 11.46)

Carbohydrate–lectin interactions and glycol-molecule-driven self-assembly are powerful yet challenging strategies to create supramolecular nanostructures for biomedical applications. Herein, we develop a modular approach of micellization with a small molecular mannosylated-calix[4]arene synthetic core, CA4-Man3, to generate nano-micelles, CA4-Man3-NPs, which can target cancer cell surface receptors and facilitate the delivery of hydrophobic cargo. The oligomeric nature of the calix[4] arene enables the dynamic self-assembly of calix[4] arene (CA4), where an amphiphile, functionalized with mannose units (CA-glycoconjugates) in the upper rim and alkylated lower rim, afforded the CA4-Man3-NPs in a controllable manner. The presence of thiourea units between calixarene and tri-mannose moiety facilitated the formation of a stable core with bidentate hydrogen bonds, which in turn promoted mannose receptor targeted uptake and helped in the intracellular pH-responsive release of antineoplastic doxorubicin (Dox). Physiochemical features, including the stability of the nanomicelle could circumvent the undesirable leakage of the cargoes, ensuring maximum therapeutic output with minimum off-targeted toxicity. Most importantly, surface-enhanced Raman scattering (SERS) was utilized for the first time to evaluate the critical micelle concentration during the formation, cellular uptake, and intracellular drug release. The present study not only provides an architectural design of a new class of organic small molecular nanomicelles but also unveils a robust self- assembly approach that paves the way for the delivery of a wide range of hydrophobic chemotherapeutic drugs.

3. SERS Based Diagnostics:

An Efficient Molecular Luminophore based on Tetraphenylethylene (TPE) Enabling intracellular



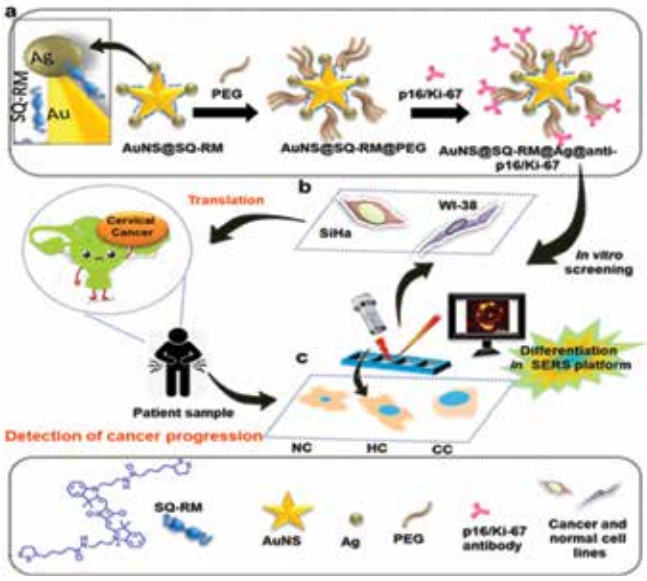
Detection and Therapeutic Benefits of Hydrogen Sulfide in Alzheimer's Disease; Adukkadan N. Ramya, Manu M. Joseph, Varsha Karunakaran, ChekrainValappilShihas Ahammed, Animesh Samanta, Kaustabh K. Maiti* ***Sensors and Actuators B: Chemical***; 2021, https://doi.org/10.1016/j.snb.2021.131118; (IF : 9.22)

Hydrogen sulfide (H2S), an essential neurotransmitter, regulates physiological processes, including brain function. Lower endogenously produced H2S may lead to Alzheimer's disease (AD), a progressive neurodegenerative disorder characterized by the deposition and aggregation of amyloid-beta (Aβ) peptides in the brain tissue. Developing a molecular probe enabling sensing and visualizing of Aβ-disaggregates caused by H2S would be a potential therapeutic benefit for Alzheimer's disease. Herein, we report a rational design and synthesis of an orthogonally substituted tetraphenylethylene (TPE) dual functional turn-on molecular luminophore TPE-NBD-D. The current strategy centers on a TPE-core appended with an ancillary H2S sensing unit i.e., 4- chloro-7-nitrobenzofurazan (NBD) and a disulfide linked donor (D: 4-(pyridin-2-yldisulfaneyl)-benzoate) as a source of H2S in presence of bio-thiols. The disulfide-linked H2S-donor is cleaved off from the TPE by esterase and its counterpart exhibited a turn-on

fluorescence response after releasing NBD ligand in bio-thiol environments. Molecular probe TPE-NBD-D, showed a marked efficiency in detecting H2S in solution state (LOD 0.1 μM) through AIE phenomenon and featured its aqueous solubility, cell membrane permeability, low cytotoxicity, and high selectivity towards H2S. The probe enabled to detection of intracellular H2S in neuroblastoma cell line SHSY-5Y as reflected by the turn-on fluorescence. Further, the TPE-NBD-D has been employed *in-vivo* mice model where the probe is capable of releasing H2S in thiol abundant colorectal area and opens up a new insight to understand the involvement of H2S releasing molecules in the management of Alzheimer's disease (AD). Eventually, the H2S production by TPE-NBD-D has been demonstrated to induce the Aβ1–42 de-agglomeration, which is meticulously monitored by the AFM, SEM, and Raman fingerprint analysis of the model agglomerated form of Aβ1–42 protein. This is the first time we revealed a TPE-structured molecular probe enabling as H2S donor and utilized for amyloid beta de-agglomeration without imparting any cytotoxicity. Therefore, this probe may be a potential chemical tool for the diagnosis and treatment of AD

4. **Elucidating Raman Image-Guided Differential Recognition of Clinically Confirmed Grades of Cervical Exfoliated Cells by Dual Biomarker-Appended SERS-Tag**; Varsha Karunakaran, Valliamma N. Saritha, Adukkadan N. Ramya, Vishnu Priya Murali, Kozhiparambil G. Raghu, Kunjuraman Sujathan,* and Kaustabh Kumar Maiti*, ***Analytical Chemistry***; 2021, 93, 32, 11140–11150, (Impact Factor: 8.00)

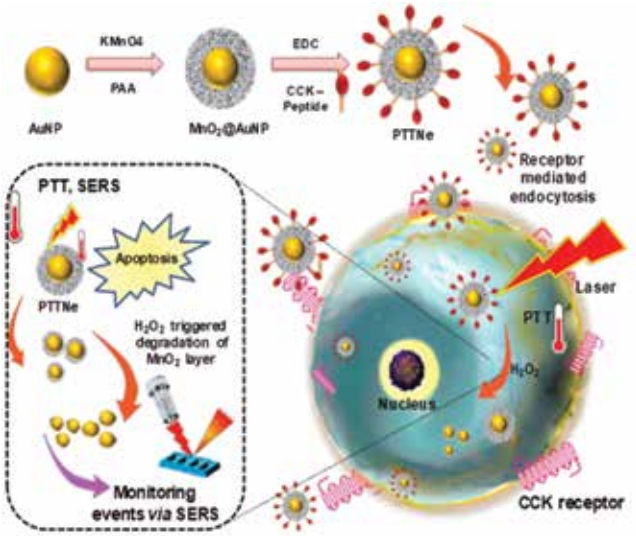
Ultrasensitive detection of cancer biomarkers via single-cell analysis through Raman imaging is an impending approach that modulates the possibility of early diagnosis. Cervical cancer is one such type that can be monitored for a sufficiently long period toward invasive cancer phenotype. Herein, we report a surface-enhanced Raman scattering (SERS) nanotag (SERS-tag) for the simultaneous detection of p16/K-i67, a dual biomarker persisting in the progression



of squamous cell carcinoma of the human cervix. A nanoflower-shaped SERS-tag, constituted of a hybrid gold nanostar with silver tips to achieve maximum fingerprint enhancement from the incorporated reporter molecule, was further functionalized with the cocktail monoclonal antibodies against p16/K-i67. The recognition by the SERS-tag has first validated in cervical squamous cell carcinoma cell line SiHa as a foot-step study and subsequently implemented to different grades of clinically confirmed exfoliated cells, including normal cell (NC), high-grade intra-epithelial lesion (HC), and squamous cell carcinoma (CC) samples of the cervix. Precise Raman mapped images were constituted based on the average intensity gradient of the signature Raman peaks arising from different grades of exfoliated cells. We observed a distinct intensity hike of around 10-fold in the single dysplastic HC and CC samples compared to the NC specimen, which clearly justifies the prevalence of p16/Ki-67. The synthesized probe can map the abnormal cells within 20 min with high reproducibility and stability for 1 mm × 1 mm mapping area with good contrast. Amidst the challenges in Raman image-guided modality, the technique was further complemented with the gold standard immunocytochemistry (ICC) dual staining analysis. Even though both are time-consuming techniques,

tedious steps can be avoided, and real-time readout can be achieved using the SERS mapping, unlike the immunocytochemistry technique. Therefore, the newly developed Raman image-guided SERS imaging emphasizes the approach of uplifting of SERS in practical utility with further improvement for clinical applications for cervical cancer detection in the future.

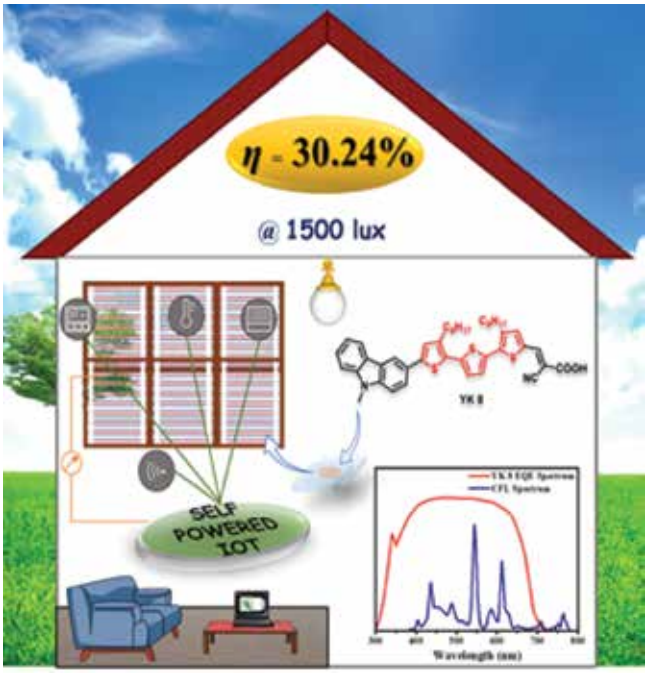
5. Elucidating Gold–MnO2 Core–Shell Nanoenvelope for Real-Time SERS-Guided Photothermal Therapy on Pancreatic Cancer Cells; Palasseri T. Sujai, ShanmughanShamjith, Manu M. Joseph, and Kaustabh Kumar Maiti* ***ACS Appl. Bio Mater***.; 2021, 2021, 4, 6, 4962–4972



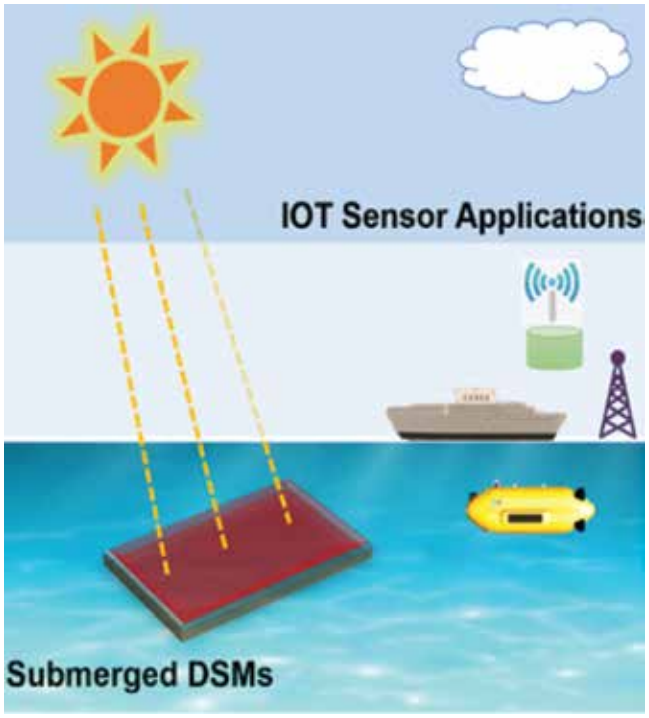
Pancreatic cancer represents one of the most aggressive in nature, with a miserable prognosis that warrants efficient diagnostic and therapeutic interventions. Herein, a MnO2 overlaid gold nanoparticle (AuNPs) based photothermal theranosticnanoenvelope (PTTNe:MnO2@AuNPs) was fabricated to substantiate surface-enhanced Raman spectroscopy (SERS) guided real-time monitoring of photothermal therapy (PTT) in pancreatic cancer cells. A sharp enhancement of the fingerprint Raman signature of MnO2 at 569 cm−1 exhibited as a marker peak for the first time to elucidate the intracellular PTT event. In this strategic design, the leftover bare AuNPs after the degradation of the MnO2 layer from the nanoenvelope in intracellular H2O2 enabled real-time tracking of biomolecular changes of Raman spectral variations during PTT. Moreover, the surface of the as-synthesized nanoenvelope was functionalized with a pancreatic cancer cell targeting peptide sequence for cholecystokinin fashioned the PTTNe with admirable stability and biocompatibility. Finally, the precise cell death mechanism was explicitly assessed by SERS spectral analysis as a complementary technique. This targeted phototheranostic approach demonstrated in pancreatic cancer cells presented a therapeutically viable prototype for futuristic personalized cancer nanomedicine.

6. Successfully realized the highest indoor dye-sensitized solar cell (DSSC) efficiencies through proper device optimizations. We achieved a record efficiency of 28.7% under standard 1000 lux CFL illumination and 30.24% under 1500 lux without co-sensitizers using iodide/triiodide electrolyte

Materials Advances, 2, **2021**, 7773-7787.



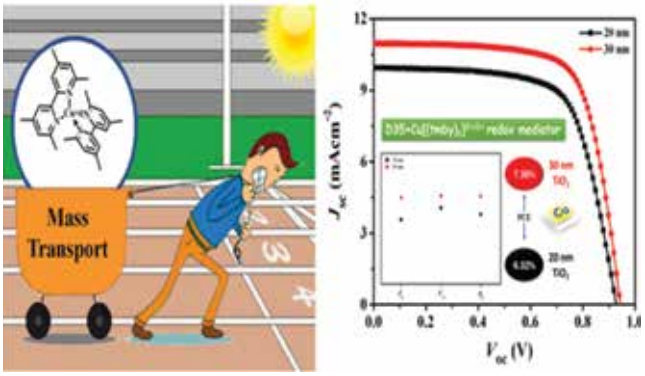
7. For the first time, dye-sensitized solar cells (DSSCs) have been tested for underwater photovoltaic applications (under submerged conditions) and



proved to be superior to silicon and thin films clearly displaying the capability of DSSCs to harvest indirect/ diffused lights in comparison with the conventional PVs

Prog Photovolt Res Appl.2022, 1-8. **(IF: 8.490)**

8. Copper redox shuttles, particularly $[Cu(tmby)_2]^{2+/1+}$ proved to be among the best electrolytes for dye-sensitized solar cells (DSCs), realizing higher power conversion efficiencies both under full sun and indoor illumination. The copper metal complex is bulky and is limited by mass transport. Understanding mass transport in these solar cells will enable further improvements in the performance of such copper-based DSCs. We systematically explored the role of illumination intensity on the photogenerated current and its relationship to mass transport using the best co-sensitized dye (D35:XY1) and $[Cu(tmby)_2]^{2+/1+}$combination. Furthermore, a comprehensive analysis of various charge transfer processes at discrete interfaces in these devices reveals collective enhancement in light-harvesting, dye regeneration, and charge collection efficiency that ultimately contributed to achieving a 16% improvement in PCE using 30 nm TiO_2 particles.



ACS Appl. Energy Mater., 5, **2022**, 2647−2654. **(IF: 6.959)**

Journal of Materials Chemistry C, 10, **2022,**3929. **(IF: 8.067)**

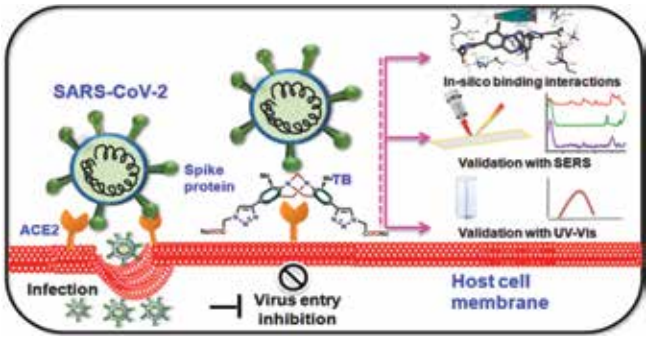
9. Introduced a new natural rubber (Hevea Brasiliensis)-based quasi-solid electrolyte as a potential candidate for arresting recombination and improving performance in aqueous dye-sensitized solar cells for the first time.

Journal of Materials Science: Materials in Electronics, 32, **2021**, 14207. **(IF:2.779)**

10. De novo design and synthesis of boomerang-shaped molecules and their in silico and SERS-based interactions with SARS-CoV-2 spike protein and ACE2.

Amrutham Linet, Manu M. Joseph,Haritha M, Shamna K, Sunil Varughese,Saurabh Sakhre, P. Sujatha Devi,* C. H. Suresh,* Kaustubh Kumar Maiti,* **Ishita Neogi***

New J. Chem., 2021, 45, 17777. (IF= 3.59)

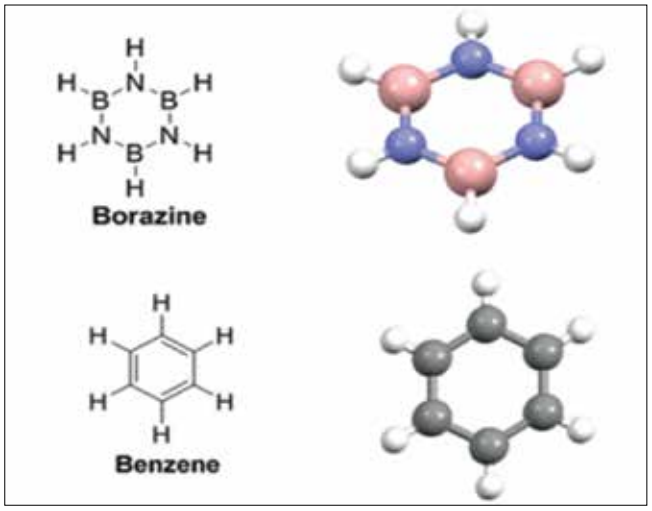


The recent outbreak of the COVID-19 pandemic is caused by severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2), which infects human epithelial tissue by the interaction of the receptor-binding domain of its spike protein (S-protein) with angiotensin-converting enzyme 2 (ACE2). Herein, we synthesized suitably configured Tröger's bases (TB-1/2/3) and investigated molecular docking of TBs at the interface of SARS-CoV-2 S-protein and ACE2, which revealed a high docking score indicating strong binding. Detailed analysis of docking highlights strong binding of TB-2 into the interfacial domain of SARS-CoV-2 S-protein and ACE2. Further, for the first time, we explored surface-enhanced Raman scattering (SERS) modality to assess intermolecular interactions between TB and SARS-CoV-2 S-protein and ACE2.

11. Synthesis and Reactions of Borazines.

Ishita Neogi,*Alex M. Szpilman*

Synthesis, 2022, 54, 1877. (IF =2.86, Selected for Cover page)



Given the wide array of current applications of borazine-based materials, synthetic access to these compounds is of importance.This review summarizes the many ways of preparing borazines and their carbo-substituted analogs. In addition, the functionalization of borazines is covered. The synthesis of molecules incorporating more thanone borazine unit as well as aspects of unsymmetrically substitutedborazines are not included. The literature has been covered comprehensively until the end of 2020.

12. Dioxirane: A Half-Century Journey.

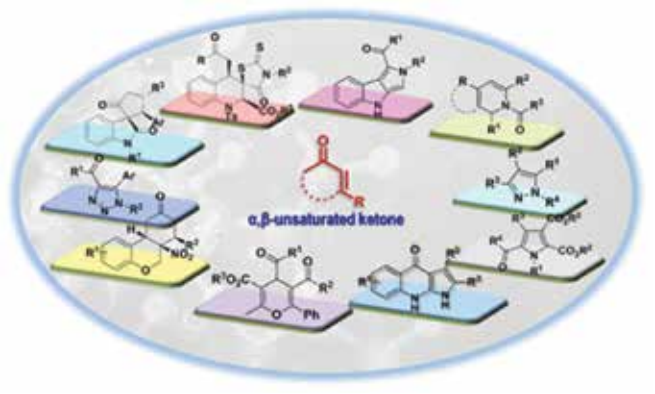
Tarek El-Assaad,Jayden Zhu,Anjitha Sebastian,Dominic V. McGrath,*__Ishita Neogi,__*Keshaba N. Parida*

Organic Chemistry Frontiers,2022, DOI: 10.1039/D2QO01005D. (IF = 5.28)

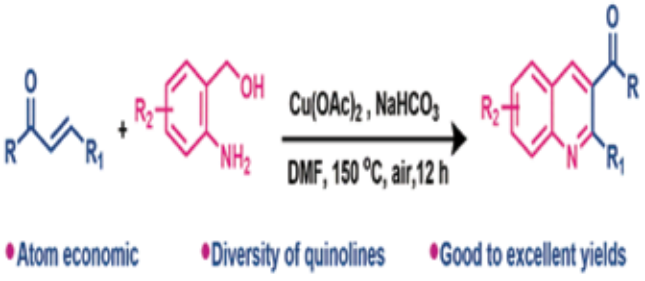
Dioxiranes are multi-tasking reagents inheriting mild and selective oxygen transfer attributes. These oxidants are accessed from the reaction of ketones with an oxidant and are employed stoichiometrically or catalytically (in situ) for numerous transformations such as oxidations, epoxidations, C–H hydroxylation, etc. The oxidations involve a broad spectrum of substrates such as alcohols, amines, phenols, silanes, phosphines, etc. Similarly, the epoxidation of olefins, alkynes, allenes and arenes is achieved efficiently, where the alkene epoxidation can be regioselective, chemoselective, stereoselective, and stereospecific. Furthermore, C–H hydroxylation using dioxiranes

proceeds in both inter- and intramolecular fashion producing a variety of potent molecules difficult to access using other means. Dioxiranes are used for the synthesis of various natural products, drugs, and biomolecules. This review covers all the aforementioned aspects of dioxirane chemistry along with the historical development, characteristics, and reaction mechanisms of dioxirane-mediated transformations established over the last five decades.

13. Recent Advances in the Transition Metal-Free Synthesis of Heterocycles from α, β-Unsaturated Ketones. Kizhakkan Thiruthi Ashitha, Ajay Krishna M S, Basavaraja D and Sasidhar Balappa Somappa, *Org. Chem. Front.*, **2022**, DOI: 10.1039/D2QO00278G. ***(IF: 5.8)***

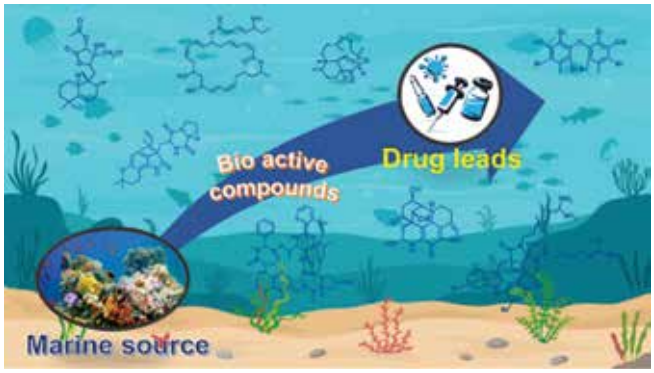


14. Cu(OAc)2 Catalyzed Aerobic Oxidative 2-Aryl-3-acylquinoline Synthesis via Aza-Michael Addition and Aldol Condensation of α,β-Unsaturated ketones and 2-Aminobenzyl alcohols. Athira C S, Basavaraj D, Praveen K.Valmiki, Shridevi D, Sasidhar B. Somappa. *Tetrahedron Letters,* **2022,** 104, 154043*https://doi.org/10.1016/j.tetlet.2022.154043****(IF: 2.5)***



15. Marine Based Natural Products: Exploring the Recent Developments in the Identification of Antimicrobial Agents. Sangeetha Mohan, Ajay Krishna, Sasidhar B Somappa, *Chemistry and Biodiversity,* **2022,** e202200513**,** https://doi.org/10.1002/cbdv.202200513***(IF 2.8)***

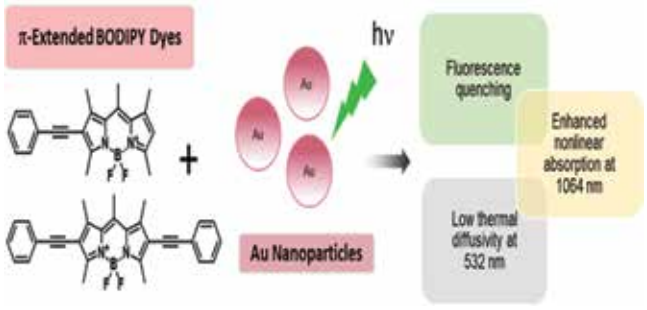
Special issue: Unlocking the Biomedical Potential of Marine Natural Products.



16. Effect of Laser Ablated Gold Nanoparticles on the Nonlinear Optical Properties of π-Extended BODIPY Dyes

Dipyrromethene boron difluoride (BODIPY) and its derivatives have attracted considerable interest due to their remarkable photophysical properties beneficial for developing fluorescent sensors, biolabels, photodynamic therapy agents, photonic materials, and so on. In this work, we report gold nanoparticles (AuNPs) induced modulation of nonlinear optical properties of π-extended BODIPY derivatives **BPA** and **BDIPA**. The spherical gold nanoparticles with an average particle size of 11 ± 3.5 nm were synthesized by pulsed laser ablation technique and characterized by transmission electron microscopy and dynamic light scattering. The interaction of AuNPs with the dye molecules was confirmed by UV/vis absorption and steady-state emission spectroscopy studies. Further, the dual-beam thermal lens technique was used to validate dye-nanoparticle interaction. The thermal diffusivity values of the samples at an excitation wavelength of 532 nm were measured, and found that the overall heat diffusion was slower in the AuNPs added samples than that of the dye alone sample, corroborating dye-nanoparticle interaction. The third-order nonlinear optical absorption properties of the samples were investigated by using the Z-scan technique in the infrared region (1064 nm).

The open aperture configuration shows significant reverse saturable absorption characteristics for all the samples. Determination of the nonlinear absorption coefficient for the dye samples at different input intensities identified two-photon absorption as the critical mechanism that produces reverse saturable absorption. The AuNPs incorporated dye samples showed a substantial enhancement in the nonlinear optical behavior. The nonlinear absorption coefficient of the AuNPs incorporated dye samples (10 cm/GW) was enhanced almost two times than that of dye-alone samples (5 cm/GW). The enhanced nonlinearity is attributed to the intense local field effect of AuNPs.

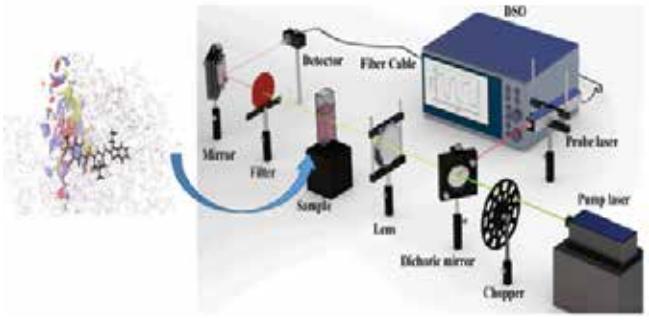


A. Prakash, J. C. Janardhanan, A. Padmakumar, V. K. Praveen, P. Radhakrishnan and A. Mujeeb, Effect of Laser Ablated Gold Nanoparticles on the Nonlinear Optical Properties of π-Extended BODIPY Dyes, ***J. Photochem. Photobiol. A Chem.*, 2022**, *431*, 113997.

17. Optical Probes and Sensors

HexamethineHemicyanine Dye as a Thermo-Optical Probe forSerum Albumin

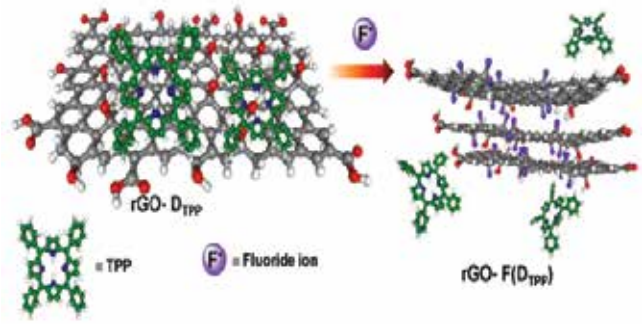
In the present work, we demonstrate the usefulness of a hexamethinehemicyanine dye as a thermo-optical probe for serum albumin, an abundant transport protein in the circulatory system, and its optimum concentration is often considered as an indicator of good health. For this purpose, the interaction of near-infrared (NIR) hemicyanine dye, LDS 821 (Styryl 9M) with bovine serum albumin (BSA) and human serum albumin (HSA) has been investigated using various spectroscopic techniques and molecular docking method. The gradual red-shift in UV-vis absorption and an increase in the emission intensity of the hemicyanine dye upon incremental addition of serum albumin indicate the binding of the dye with the protein. The circular dichroism spectroscopy studies revealed an increase in the *α*-helix content of protein with an increase in dye concentration specifying enhanced stability of proteins upon binding with the dye. The results of these studies imply that the binding of hemicyanine dye to the hydrophobic pockets of serum albumin considerably alters its optical properties by reducing the mobility and structural flexibility of the dye. Based on this understanding, thermo-optical properties of the dye in the absence and presence of serum albumin have been analyzed using a dual-beam mode matched thermal lens technique, which measures a rise in temperature due to the nonradiative relaxation of the excited state energy of the dye. A considerable decrease in the thermal diffusivity of the dye (1.39 x 10^{-3} cm^2/sec) in the presence of 0.1-0.7 µm HSA (1.30 - 0.99 x 10^{-3} cm^2/sec) and BSA (1.33 - 0.97 x 10^{-3} cm^2/sec) has been observed owing to the change in the heat diffusion capacity of the dye bounded with protein. The low fluorescence yield and the ability to bind in the interior of protein molecules make NIR emissive hemicyanine dye LDS 821 a potential thermo-optical probe for detecting serum albumin, an aspect unexplored for this class of dyes. The present study demonstrates that the thermal lens method with a suitable thermo-optical probe can be used as a sensing method for serum albumin.



S. Udayan, D. Elizebath, D. R. Sherin, V. K. Praveen, S. Sunny, P. Jayamurthy, T. K. Manojkumar, V. P. N. Nampoori, and S. Thomas, HexamethineHemicyanine Dye as a Thermo-Optical Probe for Serum Albumin, ***Optics & Laser Technology*2021**, *143*, 107351.

18. Fluoride-Philic Reduced Graphene Oxide–Fluorophore Anion Sensors

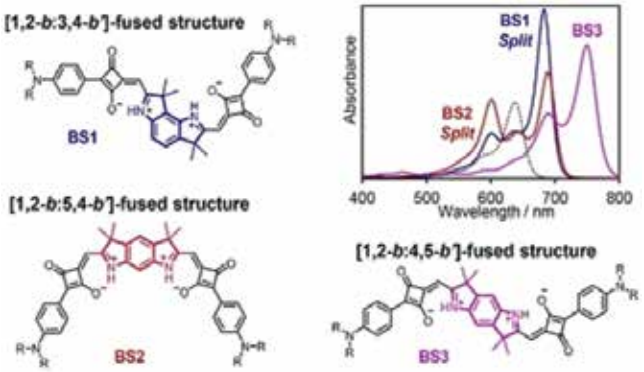
The detection and quantification of the fluoride ion, one of the most significant anions, have attractedmuch research interest because of its striking role in oral/bone health and clinical treatment ofosteoporosis. In this work, a set of F^- ion sensors that operate through the fluorescenceturn-on response of reduced graphene oxide (rGO)–fluorophore noncovalent conjugatehas been reported. The developedsensing systems perform well at neutral pH in aqueous solutions, and the response towards F^- ions wasinitiated within seconds. The high specificity for these optical sensors towards F^- ions, among a setof significant competing anions, was notable. For the three fluorescent organic dyes selected for study,tetraphenylporphyrin ($\mathbf{D}_{TPP}$), curcumin ($\mathbf{D}_{CURN}$), and coumarin ($\mathbf{D}_{CMN}$), the low-level detection (LOD) ability increased with an increase in π-interactions between rGO and the fluorophore. A fall in LOD tothe attomolar level could be achieved for the **rGO-$\mathbf{D}_{TPP}$** system. The turn-on fluorescence strategy wasextended further to develop solid-state sensor strips for F^- ion detection at the attomolar level. Thefluoride-philic nature of rGO–fluorophore systems were traced by systematic investigations using FT-IR,XRD, and XPS techniques, which revealed that the interaction between the most electronegative F^- ionand the rGO in the sensor unit leads to the formation of the stable compound graphite fluoride, and thisconversion in turn switches on the quenched fluorescence of the fluorophore.



A. A. Kumaran, A. Chithrambattu, B. Vedhanarayanan, S. B. A. Rajukrishnan, V. K. Praveen and R. N. Kizhakayil, Fluoride-Philic Reduced Graphene Oxide–Fluorophore Anion Sensors, ***Material Advances*2022**, *3*, DOI:10.1039/D2MA00393G.

19. Synthesis, Photophysical and Electrochemical Properties of Bis-Squaraine Dyes Fused on Isomeric Benzodipyrrole Central Units

Exciton interactions are not only observed in assembled molecules but also in compounds with multiple chromophores, referred to as superchromophores. We have developed isomeric bis-squaraine dyes as superchromophores in which two squaraine chromophores are fused onto the isomeric benzodipyrrole skeleton so as to regulate conformations and to reduce distances between two chromophores. The dyes with benzo[1,2-*b*:3,4-*b*′] dipyrrole and benzo[1,2-b:5,4-b′]dipyrrole moieties exhibited split electronic absorption originating from the intramolecular exciton interaction.The intensity of the split absorption bands varies in correlation with the orientation of chromophores. The isomeric dye with benzo[1,2-*b*:4,5-*b*′]dipyrrole moiety exhibited a near-infrared absorption associated with the resonance throughout two chromophores. Their electrochemical and spectroelectrochemical properties are distinct from those of monomeric dyes owing to electronic interactions between the two chromophores. Thus, the structural isomerism of the central skeleton significantly affects its optical properties as well as its electrochemical properties.

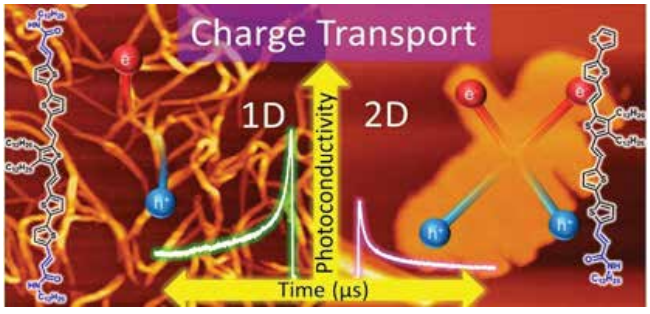


R. Sawada, T. Maeda, Y. Oda, S. Yagi, V. Karunakaran, H. Fujiwara and A. Ajayaghosh, Synthesis, Photophysical and Electrochemical Properties of Bis-Squaraine Dyes Fused on Isomeric Benzodipyrrole Central

Units. ***Chem. -Asian. J.*2022**, *17*, e202200227. (**VIP article, Part of Editors' Choice: Spotlights**).

20. Structurally Directed Thienylenevinylene Self-Assembly for Improved Charge Carrier Mobility: 2D Sheets vs. 1D Fibers

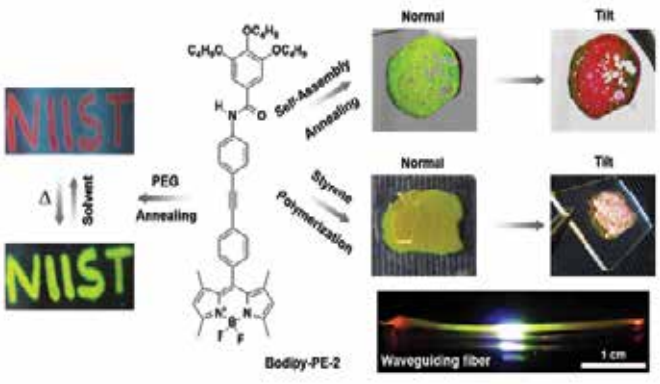
High charge carrier mobility is a prerequisite for organic electronics for which molecular arrangement and morphology play a vital role. In this work, we report how the self-assembly of thienylenevinylenes**T1** and **T2** can achieve morphologically distinct nanostructures with improved charge carrier mobility. Morphological analysis revealed that **T1** forms 2D nanosheets that further extend to an array of hierarchical pseudo-1D assemblies, whereas **T2** results in 1D nano-fibers. Flash photolysis–time-resolved microwave conductivity and transient absorption spectroscopy (FP-TRMC and TAS) revealed that 1D fibers of **T2** show 1.75-fold higher charge carrier mobility (9.2 x 10^{-2} $cm^2V^{-1}s^{-1}$)when compared to the array of 2D sheets obtained from **T1**(5.0 x 10^{-2} $cm^2V^{-1}s^{-1}$). This simple approach can be extended to design self-assembled organic photoconducting materials for optoelectronic applications.



S. Ghosh, S. Prasanthkumar, S. Das, A. Saeki, S. Seki, and A. Ajayaghosh, Structurally Directed Thienylenevinylene Self–Assembly for Improved Charge Carrier Mobility: 2D Sheets vs 1D Fibers, ***Chem. Commun.*2022**, *58*, 6837.

21. π-Extended Bodipy Self-Assembly as SupramolecularPhotonic Security Ink and Optical Waveguide

Iridescent photonic materials have wide-ranging applications in securityprinting and optical devices. While the commonly used photonic materials are based on polymers or inorganic colloidal particles, self-assembled small molecules are rarely exploited. Herein, a Bodipy (**Bodipy-PE-2**) self-assembly is reported that forms a layered photonic structure upon thermal annealing, exhibiting angle-dependent iridescence of green and pink with a luminescence shift from yellow to red. The micro- and nano-periodicity associated with the layered structure and the phase transformation due to the annealing are responsible for the observed properties. The single-crystal analysis reveals the critical role of weak dispersive interactions (C–H···π, C–H···O, and N–H···F) in the crystal packing and a possible phase change in the formation of the layered structure. A stimuli-responsive ink prepared with the annealed powder using polyethylene glycol as a vehicle medium exhibits reversible emission change between red and yellow upon heating and solvent exposure, respectively. A composite gel of the annealed **Bodipy-PE-2** and polystyrene displays angle-dependent color change and optical waveguiding properties. The self-assembled **Bodipy-PE-2** obtained from toluene exhibits active and passive waveguiding properties when excited with 532 and 633 nmlaser sources.



S. Cherumukkil, G. Das, R. P. N. Tripathi, G. V. PavanKumar, S. Varughese and A. Ajayaghosh, π-Extended Bodipy Self-Assembly as Supramolecular Photonic Security Ink and Optical Waveguide. ***Adv. Funct. Mater.*2022**, *32*, 2109041.

ENVIRONMENTAL TECHNOLOGY DIVISION

The Environment Technology Division (ETD) at CSIR-NIIST focuses on three core areas of R&D activities such as -

1. **Environment clean-up technologies**
2. **Environment management services, and**
3. **Centre for excellence in DIOXINs like POPs.**

The major activities in the field of environment clean-up technologies include design development and field implementation of solutions for solid, liquid and gaseous odour pollutants. This division is known for its expertise in biological treatment systems, especially in anaerobic treatment systems. Some of the unique technologies from this division such as the BFBR (US 6592751), Gas biofilter (US6,696,284), Solid-state AD system, and Perchlorate remediation (US 2021147269A1) have already been implemented in the field, and several full-scale treatment systems are working in the different states of India.

The environmental management group at ETD is working towards environmental sustainability using state of the art techniques like environmental remote sensing and geographic information system and tools like ArcGIS ®, Erdas imagine, Fugitive dispersion model etc. The group has major activities in the areas of Environmental Impact Assessment and sustainable management of sediment resources (Sand replenishment studies). The group is also involved in other environmental management services like E-waste inventory, geo-spatial analysis and ecological damage assessment. Clients include Kerala minerals and metals Ltd., IREL (INDIA) Ltd., Kerala state pollution control board, Institute of Land and Disaster Management (ILDM), revenue department, government of Kerala etc.

CSIR-NIIST has established a Centre of Excellence in Dioxin-like POPs Research & Monitoring. The unique national facility is well equipped with state-of-the-art sampling, sample preparation and quantification tools which has been recommended by MoEF& CC for environmental clearances and accredited by NABL as per ISO/IEC 17025:2017 for environmental, food and feed analysis. Currently, the upgradation of the facility is being undertaken as part of the Pradhan Mantri Kisan Sampada Yojana- Food Testing Laboratory (PMKSY-FTL) scheme of Ministry of Food Processing Industries, Govt of India to cater the growing needs of food & feed exporters to comply with international regulations. The facility has been involved in addressing the unmet R & D needs in the emission characterization & control measures, food safety, human health risk assessment etc. The Centre has expertise and facility to undertake health risk assessment using the prediction of health risk through metadata analysis, validated health risk prediction equations for dioxin contamination in environment and food samples. Further, the validation of risk prediction will be undertaken using preclinical tests and clinical studies.

Significant S & T Activities

Implementation of a sustainable bioenergy based model effluent treatment plant for desiccated coconut industries.

The Kerala State Pollution Control Board (KSPCB) has brought to our notice the environmental issues caused by the improper management of wastewater effluents generated by desiccated coconut (DC) industries. We have taken it up as a priority item based on the demand. CSIR-NIIST plans to set up a model demonstration effluent treatment plant for the DC Industry sector in one of the suitable sites. The Department of Science

& Technology, Govt. of India will provide the financial support for the implementation under the "Integrated Technology Interventions for Sustainable Environment" scheme, Technology Division Mission. The plant will be a permanent setup, and the user industry can operate it upon completion of the project period and allowed to visit the other stakeholders to see the technology. The technology which will apply to treat the DC wastewater in this project is based on CSIR-NIIST developed a high-rate anaerobic called "Buoyant Filter Bioreactor" (BFBR). Apart from the wastewater treatment, the process generates biogas and can be used as fuel in the industry.

M/s. Vittal Agro Industries was identified through the Coconut Development Board (CDB), Government of India, to set up a model demonstration unit based on its technical capability and interest in carrying out the project. Necessary wastewater parameter was analyzed to design the model demonstration plant, and a customized demonstration effluent treatment plant was designed according to the site conditions. The basic design of the plant and process flowsheet development was completed, and the same was shared with solution providing supporter agency M/s. Galaxy Environ (**NIIST technology license**) inviting offer for fabrication, supply and installation of plant and machinery, discussion under progress.

Table. 1 Typical wastewater Characteristics taken for the model plant Design

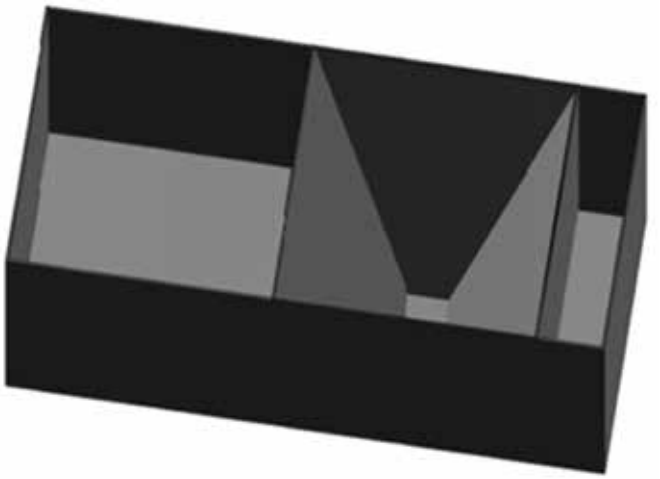
S.NO.	Parameter	value	Unit
1	pH	4.5 – 6.5	
2	Oil & Grease	1- 1.5	g/L
3	Biological Oxygen Demand (BOD_5)	7– 9	g/L
4	Chemical Oxygen Demand (COD)	13 – 15	g/L
5	Total Suspended Solids (TSS)	3 - 4	g/L
6	Total Kjeldahl Nitrogen (TKN as N)	2 - 4	g/L
7	Total Phosphorous (TP as P)	2- 2	g/L

The success of one such demonstration unit will encourage other DC units to establish similar treatment unit and thus sustain the desiccated coconut industry. It will also comply with the Government of India's initiatives and stress on "Waste to Wealth.

Secondary sludge (biosolid) minimization during aerobic wastewater treatment

Excess sludge management is a major issue faced by aerobic wastewater treatment plants. A typical STP working at 30 MLD produces as high as 10 tonnes of waste sludge per day. Disposal of waste sludge accounts even up to 30-40 % of the operating costs of STPs. Disposal methods like landfills may not be practical because of other issues like secondary pollution and the non-availability of land. Minimizing the production of sludge at the source can resolve the issue of excess sludge generation and buildup to a great extent. In aerobic biological wastewater treatment, operational parameters such as Food to Microorganisms (F/M) ratio, Sludge Retention Time (SRT) etc. play an important role in sludge generation and buildup. By proper optimization of these operational parameters, excess sludge generation and buildup can be reduced to a significant extent. Once the sludge generation is reduced, the residual sludge (sludge remaining after process optimization) can be valorized by suitable digestion methods for the recovery of bio-energy and organic manure. In this context, the ongoing project at the ETD division focuses on strategies for reducing the excess secondary sludge generation in aerobic treatment systems. The studies will be conducted in a prototype aerobic wastewater treatment system having 1000 L/day capacity, thereby (1) operational cost shall be cut down by 30-40 % (2) negative environmental impact due to sludge accumulation can be reduced and (3) recovery of bio-energy and organic manure by the valorization of residual sludge through digestion methods. A schematic diagram of a prototype aerobic wastewater treatment

system designed for the minimisation of secondary sludge is shown in the Figure.

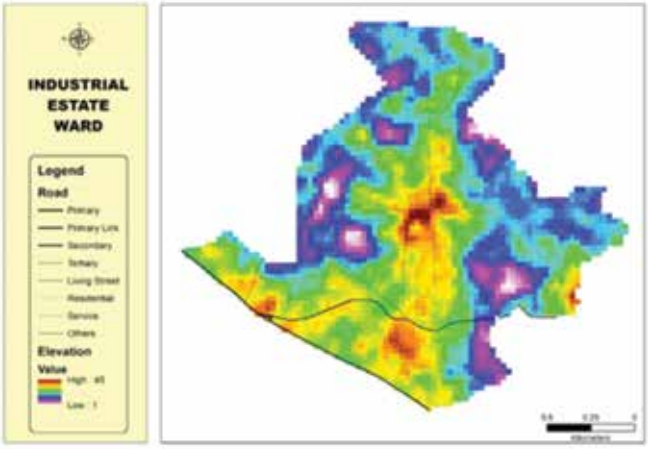


Schematic design of a prototype aerobic waste treatment system

Resource-oriented treatment of urban wastewater, faecal sludge and septage (CSIR-BMBF collaborative project)

The class I and class II Indian cities generate 72,368 MLD of sewage of which only 28 % is being treated (CPCB 2021). Approximately 63% of India's urban population is dependent on onsite sanitation systems such as septic tanks, twin pit latrines, etc. Around 36% are dependent on off-site systems such as sewer networks, open or covered drains, etc. and less than one per cent is still defecating in the open. Faecal sludge treatment and management are one of the biggest challenges that low- and middle-income countries are facing today. When onsite treatment technologies like a septic tank and pit latrines become full, the overflow is usually disposed of untreated into surface water, irrigation fields, open lands and drains. The high concentration of pathogens in the faecal sludge poses a serious public health risk. It is worth mentioning that a 5m^3 of faecal sludge disposed of untreated in the environment is equivalent to 5000 People practising open defecation. It is worth mentioning here that the baseline data to understand various aspects of FSM in India is also missing. Since India is a very diverse country, the food habits of people, topography, ambient environment, resources etc., vary significantly with time. The task can be accomplished by dividing the area into model regions and carrying out the survey.

In this context, the ongoing collaborative project under CSIR-BMBF (Indo-German) scheme focuses on the development of a resources-oriented treatment of urban wastewater, faecal sludge and septage, with a suitable business model. NIIST has selected one of the wards in Thiruvananthapuram corporation (Industrial estate ward) as model region for the study. The unique feature of this model region is that it is without any sewerage network. Primary data collection and identification of a sustainable treatment approach are currently progressing with technical input from the German side.



Digital elevation of the model region (Industrial estate ward)

Process Development for VOC and Odour Emissions Control

Large amounts of organic solvents are used in automotive painting booths. On an average, more than 6 kg of volatile organic compounds (VOCs) are used as paint solvents per vehicle in typical automotive plants with solvent-based coatings. The metals and plastics used for automobiles have been painted for both decoration and protection against corrosion. The paints used contain organic polymers and solvents. These compounds can be photo-chemically reactive and can negatively affect local air quality. In India, there are several MSME industries which are relevant to the Indian economy for which no data related to the emission factor is available in open source. Automobile spray painting units and cause VOC and odour emission in several parts of the state. Odour and volatile organic compound emissions are

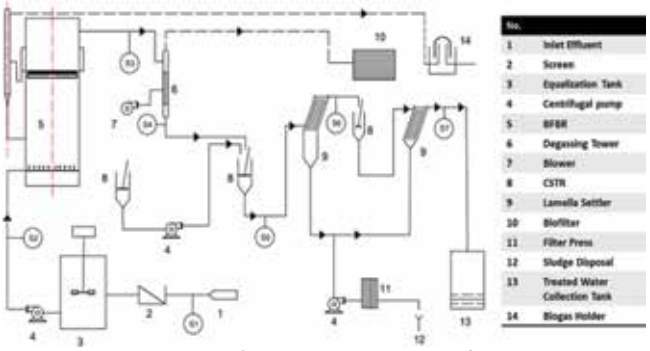
potent air pollution issue, particularly affecting public perception process industries. The control of VOC and odour emissions will become an increasingly important issue. Biological waste air treatment is the best for this as it is cost effective as well as environment friendly in comparison with conventional techniques such as chemical or thermal. Therefore, a hybrid bio-physico-chemical process termed as "Gas Bio-trickling filter" has been developed through R&D project financially supported by CPCB and KSPCB. The biological treatment utilizes microbial consortia to treat contaminant emitted in the air. The system is equipped with the continuous recirculation of the aqueous phase containing the essential inorganic nutrients. A counter current gas liquid flow distribution has been designed for efficient treatment and subsequent removal of VOC form polluted air stream. The trickling liquid is circulated from the top of the filter bed by a pump and is homogenously distributed on the top surface of the porous bed by head spray system. The liquid medium is trickled on the filter bed from the top of the bed at a certain fixed rate and VOC enriched gaseous stream is entering from the bottom of the reactor. Physicochemical and biological phenomena occur simultaneously during the pollutants degradation in biotrickling filtration system. Biotransformation occurs along with adsorption, absorption and diffusion to remove contaminants from the gaseous stream. In the presence of microbial consortia in packed media biofilm will aerobically degrade the VOCs (targeted pollutants).

Modular VOC Emission Control Unit-Gas Bio-trickling filter


Air sampling from a spray-painting unit along with KSPCB authority and subsequent odour & VOC analysis

Performance evaluation and intensification of novel buoyant filter bioreactor with associated secondary treatment process for rice processing industries

Rice being the staple food of a larger population in general and to the India in particular and most of the industries are adapting the parboiled process. Rice production by parboiled process required large amount of water and discharging huge amount of wastewater to environment. Thus, most of the rice industries were falling under red or orange category of highly polluted industry. In this context the present study was undertaken to evaluate the performance of an ETP at rice processing industry. The ETP employed a primary high-rate anaerobic treatment system called Buoyant filter bioreactor (BFBR) followed by secondary chemical treatments, to meet the effluent standards. The overall percentage removal efficiency of ETP observed is COD (90%), Colour (93%), Iron (100%), phosphate (100%), turbidity (94%), TSS (50%) and BOD (99%). A sharp reduction of BOD from 1500 to 10 mg/l was observed upon BFBR treatment indicating the excellent working condition of BFBR. The final effluent coming out from ETP meets the criteria for Permissible Limit as

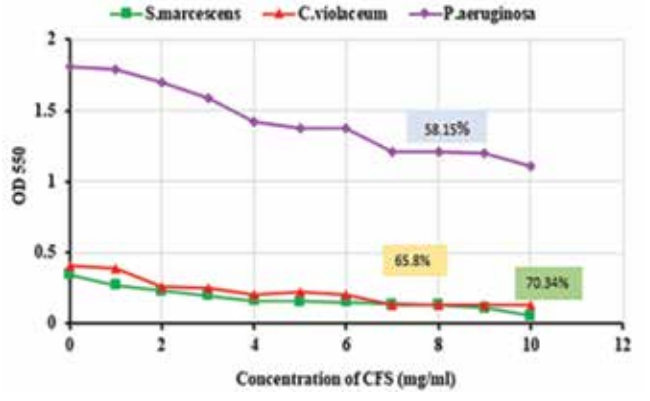


Schematic diagram of BFBR assisted modified ETP. (Source: https://doi.org/10.1016/j.cep.2021.108619)

per ISI,1977 (On land of irrigation) and Permissible Limit as per ISI 1974 (In land surface water) which indicates the performance of the developed ETP is satisfactory.

Quorum Quenching Mediated Biofilm Control

The quorum quenching enzymes are envisaged as an alternative mechanism for biocidal agents as well as traditional biofouling control methods.In the present study, a novel strain of *Bacillus velezensis* PM7 exhibiting extracellular quorum quenching (QQ) activity against gram-negative bacteria is reported for the first time. Analytical studies of the AHL degradation using LC-MS as well as biomarkers revealed the mechanism of QQ as homoserine ring hydrolysis. Using molecular techniques, the presence of aiiA homologue gene-specific for acyl homoserine lactonase enzyme was confirmed in the bacterium. A biofilm inhibitory activity in the range of 58.15 to 70.34% was achieved by the PM7 against three different gram-negative bacteria. Moreover, a significant reduction ($p<0.05$) in the quorum-sensing controlled traits such as violacein production in



Antibiofilm activity of CFS against selected gram -ve bacteria

3D structure of the $AiiA_{PM7}$ enzyme

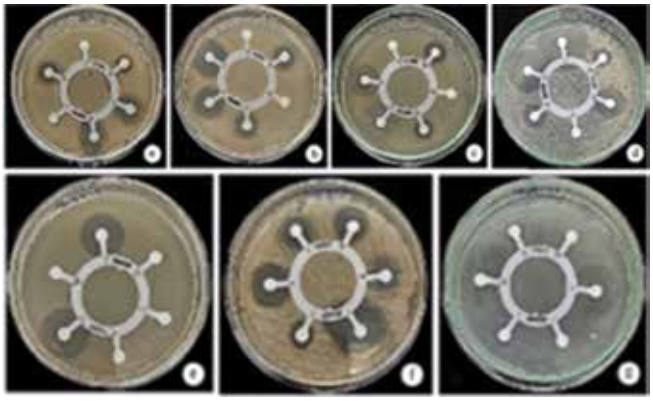
Chromobacteriumviolaceum (73%), swarming motility and prodigiosin production (67.2%) in *Serratia marcescens*, exopolysaccharide production (97.9%), in *Pseudomonas aeruginosa,* was also observed. The protein modelling and subsequent docking analysis also revealed broad spectrum substrate specificity of the lactonase enzyme. The extracellular, as well as the broad spectrum activity of this novel strain, can be beneficial for its use in quorum quenching applications.

Antibiotic resistance of pathogens in STP-treated water:

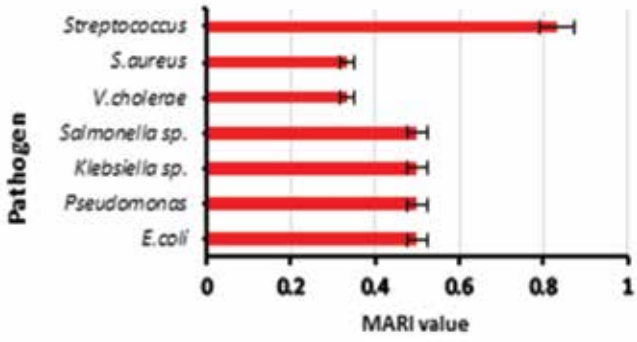
Understanding the fate of the pathogens upon disinfection and continuous monitoring of the efficiency of microbial disinfection is crucial for the optimal management of an STP. In this scenario, an assessment of the disinfection efficiency and antibiotic susceptibility profile of major pathogenic bacteria in chlorine-disinfected water from a full- scale sewage treatment plant for the co-treatment of sewage, septage and faecal sludge was conducted.

Seven bacterial pathogens were selected for the study. Selective plate based culture methods were adopted for the study which employed fast detection of the pathogens using either chromogenic substances or species specific biocidal agents. At a residual chlorine level of 0.26 ± 0.08 ppm, a significant reduction in bacterial

load was observed only in the case of *Klebsiella* with a Log Reduction Value (LRV) of 0.92 and *Staphylococcus aureus* (LRV 0.8), while *Vibrio cholera* showed an increase in the number of colony-forming units in the treated discharge water. The resistance pattern of these residual pathogenic bacteria against first-line antibiotics was also remarkable (Fig. 1) with all the isolates showing a Multi Antibiotic Resistance Index (MARI) value higher than 0.3, indicating the probability of a high antibiotic residue exposure (Fig. 3) These observations suggest the requirement of continuous surveillance initiatives concerning the disinfection efficiency and antibiotic susceptibility profile in urban wastewater treatment plants that ensures the safety of treated water for its many reuse application.



Antibiotic susceptibility profile of the tested pathogens



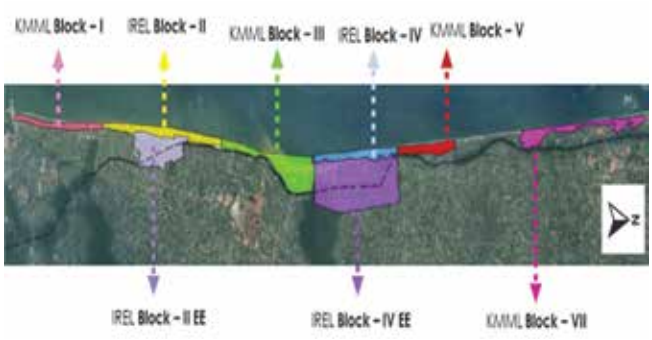
Multiple Antibiotic Resistance Index of the tested pathogenic

Testing and analysis facility for Biodegradability of alternative single-use plastic materials and biodegradable items for MSMEs.

As per the G.O. No. 128/2019/ENVT, Govt. of Kerala, Environment Department, identified CSIR NIIST as the Nodal lab for Certifying the Biodegradability of single-use plastics items in Kerala. In this regards biodegradability facility (as per the standard ISO 14855-2:2018) has been developed to assess the biodegradability of alternative materials against single-use plastic materials. This facility is helping various MSMEs in this sector. CSIR-NIIST has expertise in method standardization, protocol and methodology development for determination of biodegradability of alternative plastic materials and different kind of biodegradable items. Environmental regulatory authority (i.e., KSPCB) and various MSMEs in paper, packaging, and biodegradable items are benefiting by this facility.

EIA Study for renewal of KMML Block III mining lease and enhancement of production; Client: KMML, Kollam

Kerala Minerals and Metals Ltd. (KMML) has appointed CSIR-NIIST to evaluate the environmental aspects and their possible associated impacts that would arise due to the proposed heavy mineral sand mining operations and to work out environmental management plans and environmental monitoring programme to prevent, control, minimize/eliminate the adverse environmental impacts envisaged from the mining activity. Kerala Minerals and Metals Ltd. (KMML) are mining atomic minerals of strategic importance to the Government. This project's main objective is to renew the mining lease and enhance mineral sand production from 2,50,000 TPA to 7,50,000 TPA in Block III and physical separation of minerals at the Mineral Separation Plant (MSP). The spatial extent of this project is 88.119 Ha. Natural and Community Resource Augmentation (NCRAP) study was further recommended as additional study.



Neendakara-Kayamkulam (NK) belt, Kollam district, Kerala

The Project is now recommended for Environmental Clearance.

(i) EIA for NK block IV of IREL (India)

IREL has been granted renewal of mining lease to collect heavy mineral sand from NK Block IV (Panmana and Karunagapally) in Kollam district for an area of 40.566 Ha respectively. For obtaining EC for mining activities, IREL entrusted NIIST to carry out the EIA studies. Based on the study and project presentation, the project has accorded Environmental Clearance.

(ii) Expansion of mining quantity from 2,37,150 TPA to 7,50,000 TPA (ROM) in IV EE

Total mine lease area is 180 hects (Block IV EE). This project has a EC based on the study done by NIIST in 2011. But now the project proponent wishes to go for expansion and to increase the production capacity from 2**,37,150 TPA to 7,50,000 TPA (ROM).** CSIR-NIIST has carried out the study and the project has accorded Environmental Clearance from the Central government (MoEF&CC)

(iii) EIA Study for renewal of mining lease for KMML Block I

This project proposal deals with the Environmental Impact Assessment (EIA) study of KMML NK Block I. The project is for the renewal of the mine lease. The spatial extent of the mine lease is 34.285 Ha. The proposed renewal is for inland mining only. The mining plan for the first two years is 2,00,000 TPA, and for the next two years is 2,50,000 TPA, and 3,00,000 TPA for the last year. Studies were carried out in order to determine the effect of mining on various environmental ecosystems, and mitigation measures were suggested to reduce the impact of mining. An environmental Management Plan was also suggested for the above project. The Public was very supportive which was reflected in public hearing conducted at site.

(iv) EIA study for NK block IIEE of IREL (India)

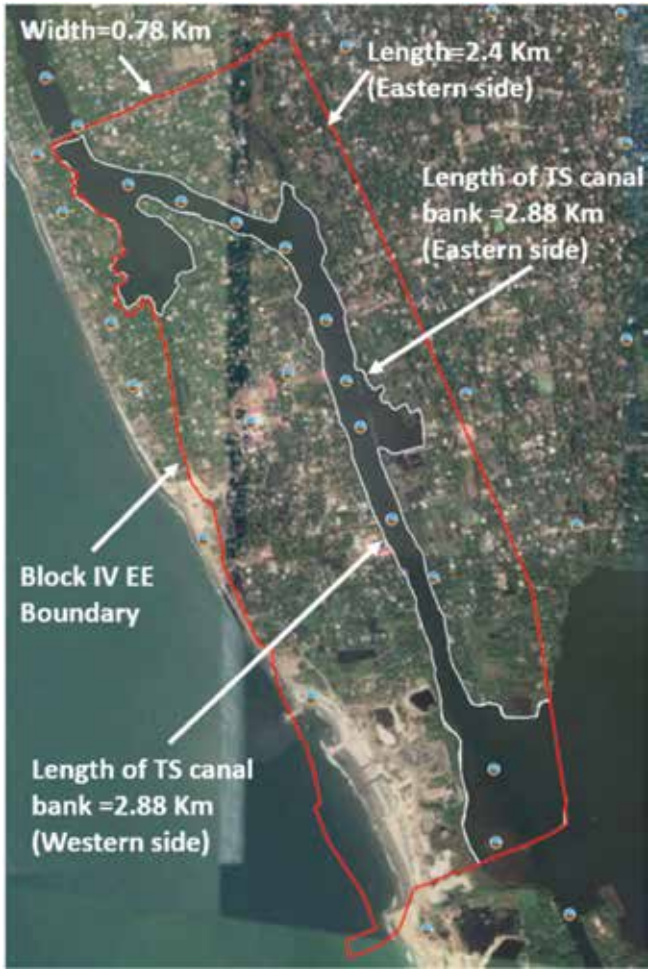
NK block IIEE is an extension to IRE NK block II and the area is of 67Ha.This block will be mined only by DWUP (inland mining). IRE has awarded the job of carrying out the EIA study to us. We have completed the Public hearing and now based on the presentation to State EIA committee, the project is recommended for Environmental Clearance to SEIAA.

(v) NCRAP Study for KMML Block –III operating under violation and regularization of Environmental Clearance

NCRAP (Natural and Community Resource Augmentation Plan) studies were conducted as per the Notification S.O 804(E) dated 14.03.17, and regularization of this project which is under violation. NCRAP refers to the estimation of ecosystem damages and their monetary equivalents. The total mine lease area of KMML Block-III is 88.119 Ha. In this project, the equivalent cost for ecosystem damages was worked out, and mitigation measures were suggested for the reclamation of land. The significant impact envisaged is on the land environment and coastal erosion followed by hydrogeology, air, noise, socio-economic and occupational health, and safety. NIIST has also carried out studies through Remote sensing and Geographical Information System (GIS) to measure the status of erosion and accretion happening 5 km upstream and 5 km Downstream of the project site. The change detection study enabled us to work out the net erosion / accretion that has happened due to beach washing and other activity. The project is now recommended for Environmental Clearance.

(vi) EIA Study for the stability of TS Canal and Impact on Aquatic Fauna

Environmental clearance for IREL Block IV EE (Eastern Extension) was granted based on our EIA report to IREL (INDIA) Ltd. for a capacity of 2,37,150 TPA with certain compliance conditions. One of the compliance conditions (Specific condition no (iii)) was "50 meters all along the canal shall be maintained as a buffer and shall not be disturbed at all". For amendment of EC condition NIIST carried out a study considering the hydrostatic pressure up to 3 m depth from the sand. A ecological survey was also carried out to identify if there are any rare or endangered species. Based on the report submitted by NIIST, the committee recommended the mining on both sides of TS canal, leaving 10m buffer zone on both sides of TS canal. The outcome of the study enabled the company to collect highly concentrated



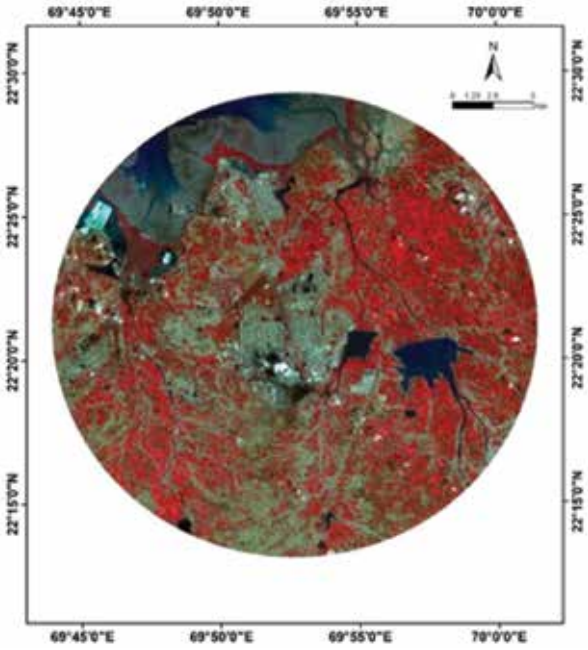
TS canal Boundary and surrounding areas

sand from the banks of the canal and to increase the production capacity of these rare earths.

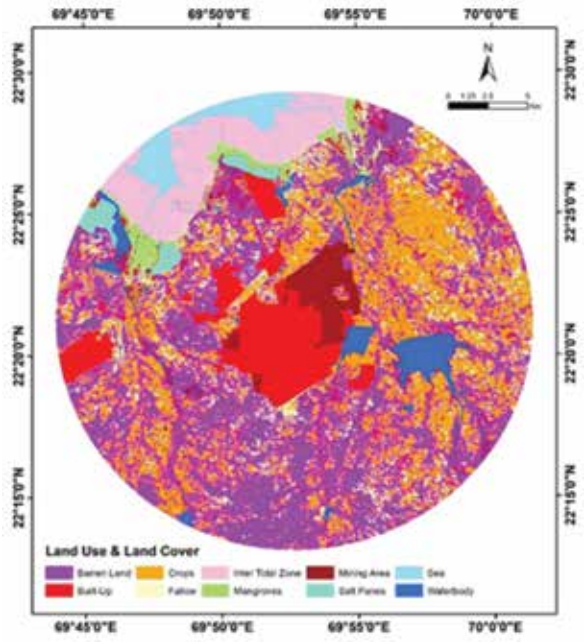
(vii) Land Use Land Cover (LULC) studies for Jamnagar, Gujarat Industrial Area

In this project, Land Use land cover (LULC) analysis of Jamnagar Gujarat Industrial Area is done with the help of high resolution satellite imagery and state of the art GIS software. Land use refers to "man-made or anthropogenic" activities and various uses which are carried on land. Land cover refers to "natural vegetation, water bodies, rock/soil, artificial cover and other resulting due to transformation". The LULC analysis helped to identify the extent of land in the project area into various categories viz. built up area, barren land, mining area, agriculture, waterbodies, etc. and changes over a period of time.

(viii) Inventory of Electronic and Electrical Equipment's



False color composite image of the area



Land use land cover analysis

(EEE) under guidelines on implementation of E-waste (Management) Rules, 2016

The primary objective in the project was to estimate the generation of E-waste in coming years in the state of Kerala. The methodology consists of collection, compilation, bifurcation, statistical analysis and representation of GST data for various electrical

and electronic items (EEE items). The output consists of predicted values of E-waste generation in the state of Kerala. The outcome of the report will help the Kerala State Pollution Control Board (KSPCB) for formulation of polices related to collection, reuse and resource recovery from E-waste.

Implementation of Pradhan Mantri Kisan Sampada Yojana – Food Testing Laboratory (PMKSY-FTL) funded by Ministry of Food Processing Industries

Considering the growing requirements in food processing industries for NABL accredited testing facilities for dioxins, furans and PCBs as well as for other contaminants such as antibiotics, veterinary drug residues, mycotoxins, heavy metals, VOCs etc a project has been sanctioned by Ministry of Food Processing Industries (MoFPI), Govt. of India under the PMKSY-FTL scheme for upgrading the existing food testing laboratory at CSIR-NIIST In February 2021. The total funding for the project is Rs. 523.31 Lakhs, out of which Rs. 376.48 Lakhs will be provided by MoFPI and the remaining Rs. 146.83 Lakhs has to be met by CSIR-NIIST. The first instalment of Rs. 181.33 Lakhs has been sanctioned by June 2021 and the procurement of a state of art instruments such as Dioxin Analyzer (GC-MS/MS), Headspace/Thermal Desorption System (HS/TD), Microwave Digester has been done and its installation and commissioning was completed on August 2022.

In order to facilitate the project, Director General, CSIR has sanctioned a funds of ₹ 81.25 Lakhs for the vertical extension of ETD building for housing the instruments and other sample preparation accessories on 19th February 2021. The Engineering Sub Division of CSIR-NIIST has carried out the work a great pace and the laboratories for housing the PMKSY-FTL was inaugurated by Dr. A. Ajayaghosh, Director, CSIR-NIIST on 31st December 2021.

Dioxin Analyzer (GC-MS/MS)

MoFPI has also provided part funding for technical civil works (TCW) and furniture & fixtures (F & F) which has enabled us to furnish the laboratory with Instrument tables, UPS, Air conditioners, Fume cupboards, Spot extractors, chemical storages etc.

Inauguration of PMKSY – Food Testing Laboratory by Dr. A Ajayaghosh, Director, CSIR-NIIST

Application for NABL re-accreditation as per ISO/ IEC 17025: 2017

In order to enhance the business potential of the PMKSY-FTL and support the food processing industries in the region for regulatory compliance, CSIR-NIIST has applied for NABL reaccreditation for the testing of various parameters in food and feed sectors. It includes dioxins and PCBs analysis in Aquaculture/marine food products such as fish, shrimp, prawn, crab and its products, Residue analysis in food product such as milk & dairy products, meat and meat products, poultry and poultry products, edible oils and fats, Animal food and feeds such as fish oil, fish/shrimp feeds, guar meal etc. The accreditation for dioxins and PCBs for the above mentioned sectors can empower the industries to meet the regulatory requirements in foreign market and save huge foreign exchange by providing accredited services in India. The

application process was initiated during October 2021 and after several rounds of scrutiny the reaccreditation assessment was held during 9-10th April 2022.

CSIR-Mission Mode Programme on Advancing Technological Leads for Assuring Safety of Food (ATLAS) - Affordable method development for confirmatory analysis of dioxins & PCBs in animal origin food materials in Indian market & human risk prediction

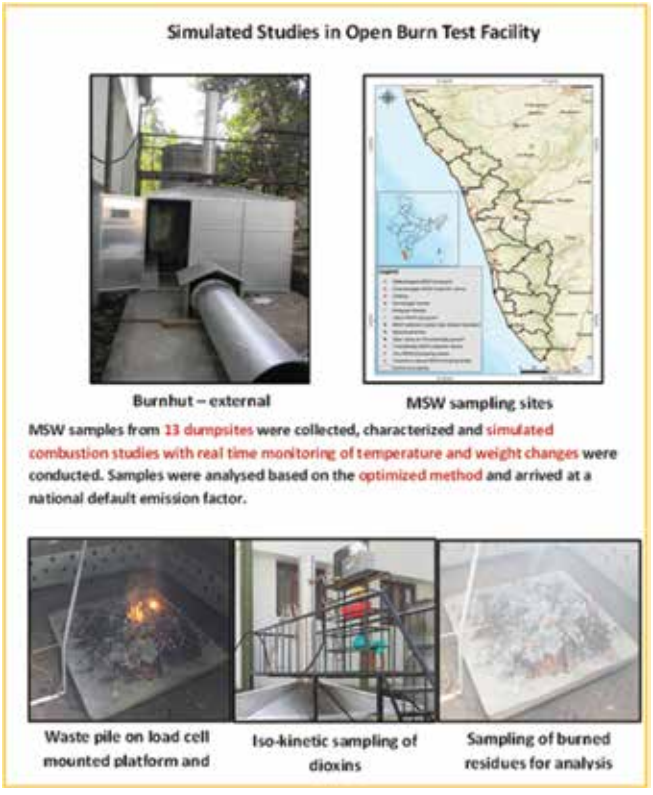
The project focussed to develop cost effective methods for the quantification of dioxins and PCBs in animal origin food samples such as fish, milk, egg, meat etc, carry out surveillance of levels in food samples in the vicinity of identified emission sources and conduct human health risk assessment/prediction. The sample preparation and quantification methods were developed and validated for fish and milk samples during the first year. An inline cleanup enabled Accelerated solvent extraction procedure followed by multi column (silica, alumina and reversible carbon) based semi automated clean up method was optimized. Further, the sampling of fishes/sediments from Eloor-Edayar region, which is one of the identified industrial hotspots in India and its analysis, was carried out. The study showed relatively higher levels of 2378 TCDD, 23478 PeCDF, 12378 PeCDD, 2378 TCDF. PCB 126, PCB 153, PCB 138, PCB 180 congeners in fish & sediment samples and strong positive correlation was observed between the congener patterns in fish & sediment samples.

Similarly, milk samples from a non-ferrous metal industrial region were collected and the levels of dioxins and PCBs were assessed.

The global metadata analysis for the levels of dioxins and PCBs in animal origin food samples were carried out by PRISMA guidelines as part of the risk assessment studies.

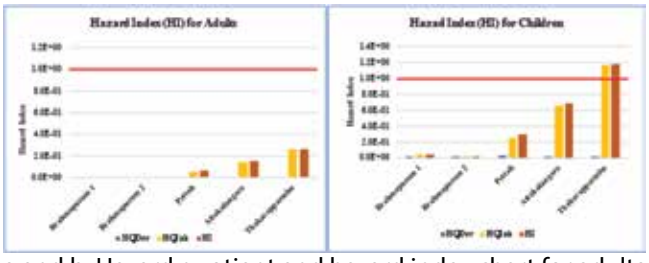
Studies on the open burning of municipal solid wastes and its inhalation/dermal exposure risk

The study reported an update to the polychlorinated dibenzo-p-dioxins and furans (PCDD/Fs) and dioxin-like polychlorinated biphenyls (dl-PCBs) annual emission inventory of India from open burning of municipal solid wastes (MSW) through the generation of nation-specific emission factors for air (EF_{air}) and burned residue (EF_{land}) vectors. The MSW characteristics and modes of disposal practiced in Indian cities exhibits subtle variations from that of developed nations due to differences in food habits, living standards and climatic conditions. The annual emission calculations based on EFs from hitherto studies simulating conditions prevailing in developed countries can lead to anomalous accounting of emission levels. It is the first experimental study reported from Indian subcontinent to determine EFs of dioxins and dl-PCBs from MSW open burning by simulated combustion experiments conducted in a custom fabricated Open Burning Test Facility (OBTF) - "Burn Hut", using real dumpsite waste samples. Iso-kinetic sampling and coning and quartering methods were employed for the sampling of air and land emissions from combustion experiments. The PCDD/F's EF_{air} ranged from 3 to 675 µg toxicity equivalence (TEQ)/ton of waste with a geometric mean (GM_{air}) of 67.0 µgTEQ/ton and EF_{land} ranged from 10 to 2531 µgTEQ/ton waste (GM_{land}– 100.0 µgTEQ/ton). The EF_{air} and EF_{land} of dl-PCBs ranged from 0.5 to 46 µgTEQ/ton (GM_{air} 7.0 µgTEQ/ton) and 0.5 to 96 µgTEQ/ton of waste (GM_{land} 6.0 µgTEQ/ton) respectively. A detailed

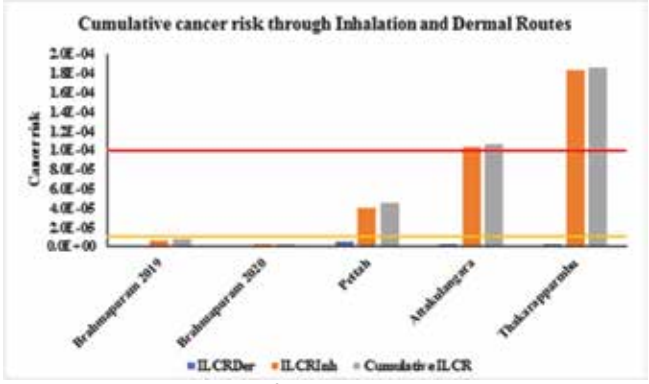


assessment of correlations between emission and MSW composition/combustion practices were conducted along with a comparative evaluation of $EF_{present}$ vis-à-vis EFs reported elsewhere and was published in the Journal of Environmental Management (https://doi.org/10.1016/j.jenvman.2021.114109)

Further, a comparative assessment of 17 PCDD/Fs and 12 dl-PCBs emitted to air and residue during the repetitive incidents of massive fire breakouts at a municipal solid waste dumpyard and localized street waste burning in cities of India were carried out. The study also evaluated the direct exposure routes viz. inhalation as well as dermal and predicts the carcinogenic and non-carcinogenic health risks to the receiving population. The observed PCDD/F levels in the ambient air and burned residue samples ranged from 2.7 - 41.4 pgTEQ/m^3 and 79.8-860 ngTEQ/kg, while that of dl-PCB varied from 0.2-2.3 pgTEQ/m^3 and 6.0-46.2 ngTEQ/kg respectively. The dermal, as well as the inhalation daily exposure doses were estimated and the non-carcinogenic hazard indices of the children were found to be in levels of concern at two of the street burning sites while for adults the levels were found to be within the threshold limit. The cumulative Incremental Lifetime Cancer Risk (ILCR) values ranged from 2×10^{-6} to 2×10^{-4} suggesting moderate to low risk to cancer or cancer-linked illnesses to exposed individuals. The major findings of the work got accepted for publication in Exposure & Health (https://doi.org/10.1007/s12403-021-00450-4)



a and b: Hazard quotient and hazard index chart for adults and children



Cumulative incremental life cancer risk associated with PCDD/Fs and dl-PCBs through dermal and inhalation routes

Proposed city-specific interim targets for India based on WHO air quality guidelines 2021

The World Health Organization has proposed the ambient air quality guidelines 2021. The uniqueness of the guidelines of the World Health Organization — air quality guidelines 2021 — is the inclusion of interim targets. Higher levels of air pollutants including PM2.5 for ambient air in India were recorded in recent times, and its association with respiratory and cardiovascular health risks was evidenced in the recent literature. To achieve the ambient air quality standards in India as per the World Health Organization — air quality guidelines, there is a need for interim targets in the future National Ambient Air quality standards to be proposed in India. These interim targets may be proposed for attainment/attainment cities based on the $PM_{2.5}$ concentration levels to achieve a realistic target of recommended levels in a graded manner and thereby minimize air pollution in the specific location.

Field demonstration of perchlorate remediation technology.

Perchlorate (ClO_4^-) is a persistent, endocrine-disrupting micropollutant. Salts of perchlorate are extensively used in space R&D and strategic sectors, and a number of industries including SMEs like cracker and match box making. In India, CSIR-NIIST is the pioneer in the environmental surveillance of perchlorate, as well as the development of its remedial measures. In 2012, CSIR-NIIST flagged heavy perchlorate contamination in drinking water sources around places where perchlorate salts are handled in bulk (Keezhmad panchayat in Ernakulam dist., Kerala). Severely contaminated community wells (perchlorate ~50,000 ug/L against WHO guidance level of 70 ug/L) are closed since 2012 in this region, and people are provided with alternate drinking water. Perchlorate was detected in well water samples up to 2 km distance from the point source.

Interactions with the local community at the project site, Keezhmad Panchayat, Ernakulam district, Kerala.

The continuing research over the last ten years in the environmental technology division resulted in a sustainable solution to perchlorate contamination. NIIST has developed a bio-physical, ex-situ remediation system (US 2021147269A1) where the perchlorate contaminated well water was pumped out, treated to potable quality and distributed to the public. A demonstration-scale treatment unit was installed at kulakkad in Keezhmad panchayat, one of the severely contaminated regions and the plant was operated for a period of five months. The project was funded by Jal Jeevan Mission, Ministry of Jal Shakti, and the project was implemented with support from the panchayat. The treatment unit consisted of a bioreactor (2000 L capacity) inoculated with a perchlorate reducing microbial system (NIIST proprietary culture) that converted perchlorate into non-toxic chloride and oxygen. The bioreactor-treated water was passed through a combination of custom-designed UF and

The pilot-scale perchlorate remediation system installed at Kulakkad colony in Keezhmad panchayat, Kerala.

Inauguration of the perchlorate remediation system for community well water.

RO modules to generate potable water. Around 2000 water was produced daily at a cost of 20 paise per litre (including operator charge).

MATERIALS SCIENCE AND TECHNOLOGY DIVISION

Brief report of the division's activities highlighting major achievements

In the MSTD, the scientists are engaged in developing the cutting-edge technologies in the fore-front areas of metals, alloys, composites, polymers, ceramics, electronics and energy materials as well as multifunctional coatings for the aerospace, defence, transport and many industrial requirements. The division has a work force consisting of 21 Scientists, 3 technical officers, and about 90 research students/project fellows. The division has around 33 Grant-in-aid government funded projects, 5 CSIR projects, 9 industrially supported projects, and six international collaborative projects that earned a total revenue of around Rs. 440 lakhs. Division also established a Centre of Excellence for Lightweight Materials Technology with financial support of WABCO India Ltd, Chennai. With the financial support (Rupees 6.8 Crores) of CSIR, New Delhi, a state of art facility for Aluminium Alloy Squeeze Casting as well as spray pyrolysis set-up for powder processing have been created to cater to the R&D needs of advanced processes and product developments for the identified sectors. Some of the research endeavors and achievements are highlighted below. The division also has strong activity on recovery of rare earths and utilization of mineral industrial wastes for building materials. In the year 2021-2022, the division transferred a technology on, 'Manufacturing of bricks from foundry silica sand' to the company Autokast Ltd, a public sector undertaking by Government of Kerala.

Major Activities of MSTD

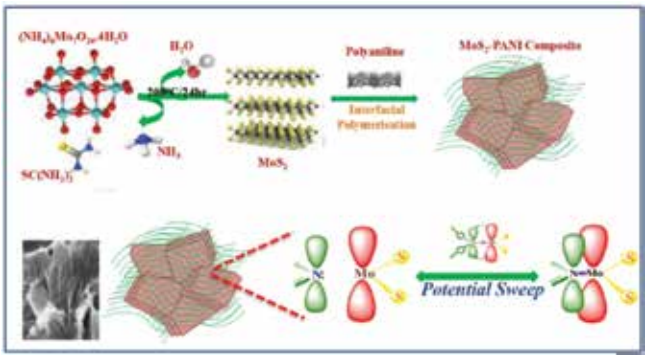
- **Advanced ceramics for energy, environment and functional coatings**
- **Electronics and Energy Materials**
- **Metallic Materials**
- **Minerals**
- **Polymers and Composites**

Highlights of some of the R&D activities

Electrochemical Capacitive Charge Storage in MoS_2-PANI Nanocomposites

Molybdenum disulfide (MoS_2), a graphene analogue, is the highly regarded 2D material for energy storage devices by virtue of its improved electrochemical properties such as high specific capacitance, larger energy and power density, excellent capacitive properties, and long charging-discharging rate. The semiconducting 2H MoS_2 phase, which is the thermodynamically stable state, has lower electrical conductivity and can be further enhanced by the inclusion of conducting polymers. Herein, we synthesize the MoS_2-PANI nanocomposite with improved crystallinity via a simple and facile interfacial polymerization route. The growth of polyaniline fibers doped with HCl through the MoS_2 sheets developed an intrinsic strong π back-donation between the Mo and the N of the polyaniline fibers. This characteristic π bond has enhanced the conductivity as well as the intrinsic pseudocapacitance by an additional redox electron exchange occurring at the Mo centers. Electrochemical studies were conducted on the single electrode as well as symmetric and asymmetric supercapacitor configurations in 1 M H_2SO_4 electrolyte. An electrode fabricated using the optimized composition (1 wt % MoS_2 in PANI) and a corresponding symmetric cell showed a specific capacitance (Csp) of 657.5 at 1.5 A/g and a gravimetric capacitance (Cg) of 424 F/g at 0.5 A/g,

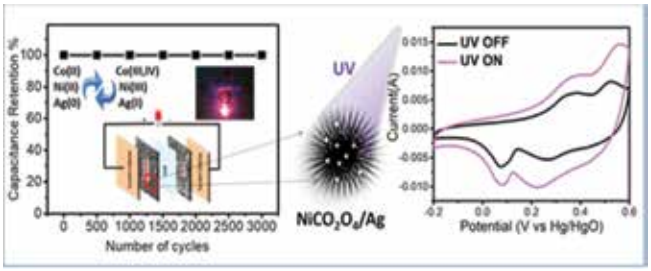
respectively. On the other hand, an asymmetric cell fabricated using the MoS_2-PANI composites as the positive electrode and activated carbon as the negative electrode showed a potential window up to 1.5 V, a specific energy of 104.9 Wh/kg and a specific power of 937.9 W/kg. This work thus demonstrates beneficial effects of interfacial polymerization of polyaniline on MoS_2 for electrochemical capacitive charge storage.



Morphologically Engineered Nickel Cobaltite based Electrodes for Supercapacitor Applications

The expeditious interest in portable electronic devices and electric vehicles has stimulated extensive research in high performance supercapacitors, batteries and fuel cells. Electrode materials constituting the cell architecture play a dominating role in defining the device performance. Among the desired material properties, the surface area and associated textural features, induced by subtle variations in morphology, are decisive in achieving high electrochemical performances. Materials with tuned morphological features impart effective electrolyte diffusion leading to improved charge transportation and storage. Nickel cobaltite ($NiCo_2O_4$), owing to its multiple oxidation states and morphologically diverse nanostructures, enables rich redox reactions leading to superior charge storage capacity than its monometallic oxides and several of its transition metal analogues like V and Mn. The potential for horizontal recycling of nickel and cobalt from used cells enable nickel cobaltite to be used sustainably as the working electrode for electrochemical capacitors. $NiCo_2O_4$ heterostructures with tuned morphological features have garnered significant attention due to their shape-dependent properties and are explored as potential electrode materials for supercapacitors, batteries, sensors and catalysts Despite being superior to carbon-based EDLC's in terms of capacity, the sluggish kinetics during the faradaic reactions impede its practical use. $NiCo_2O_4$ electrodes suffer suffer from limited participation in redox reactions owing to reduced electrode/electrolyte interface area. Also, the electrical conductivity and textural properties of $NiCo_2O_4$ needs further improvements to promote complete electrode utilization, specific capacity, and rate capability

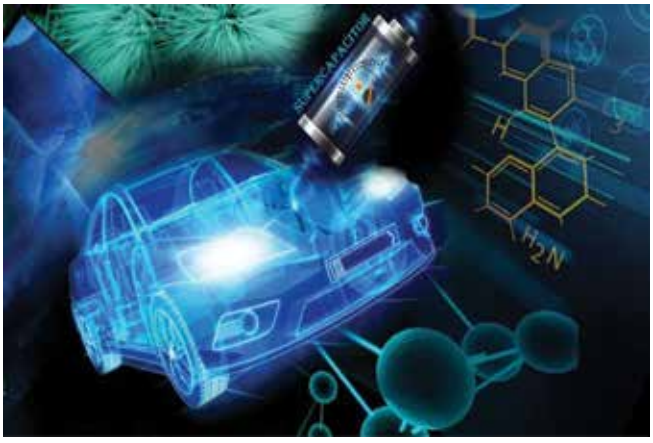
In this regard our efforts are directed towards the development of optimally porous morphologically engineered nickel cobaltite through wet chemical synthesis route with enhanced electrochemical performance. In one such attempt, we explore a viable strategy to promote the electrochemical performance of nickel cobaltite by incorporating conductive silver nanoparticles, which co-participate with $NiCo_2O_4$ in the redox reactions in alkaline electrolyte. The optimal composite with a favorable macro-mesoporous architecture exhibited a specific charge of 832 Cg^{-1} (1386 Fg^{-1}) and demonstrated good durability in an alkaline medium. A hybrid supercapacitor device composed of $NiCo_2O_4$/Ag/activated carbon provided energy density as high as 42.6 Wh kg^{-1} at a power density of 512 W kg^{-1}. Furthermore, the composite electrode with optimized Ag loading exhibited roughly 1.3 times higher plasmonic capacitance on UV illumination, facilitated by the photo-induced "Ag hot electron sink" mechanism active in the composite material.



Nanostructured electrode materials for Supercapacitors

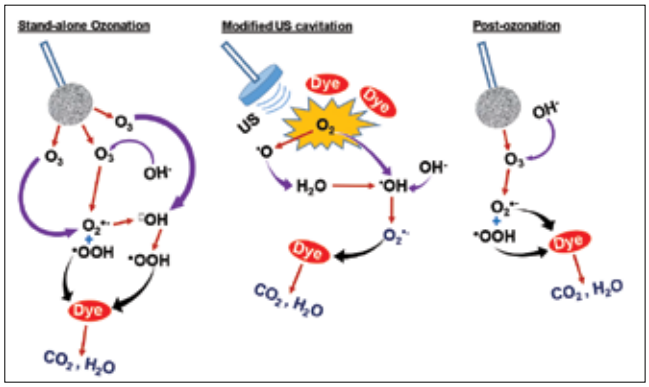
Recent developments in electronics focus on miniaturization, as necessitated by the lifestyle of the modern world. With the increasing demand for

portable electronic devices, flexible ultra-thin energy storage items have become an integral part of many electronic gadgets. Similarly, factors such as depletion of fossil fuels, high cost of petroleum products, and the environmental pollution from the burning of fossil fuels force the automobile manufacturers to shift towards electric vehicles. Automobile manufacturers are among the primary customers of portable energy storage devices. The future of automobiles is hybrid electric vehicles, which consist of battery-supercapacitor hybrids. Supercapacitors are electrochemical energy storage devices with higher power density than the batteries and higher energy density than the dielectric capacitors and find applications in both portable electronic devices as well as in high density energy storage devices for automobiles. Nanostructuring of electrode materials is crucial for improving the electrochemical performance of supercapacitors. Graphene is considered a promising electrode material for electrochemical energy storage devices due to its unique physical and electronic properties. Recently, two-dimensional materials similar to graphene have attracted significant research focus in storage devices because of their attractive energy storage performance properties. Transition metal dichalcogenides such as MoS_2, WS_2 and $MoSe_2$ and MXenes are the major graphene analogous materials used as the supercapacitor electrodes. In supercapacitor research at CSIR-NIIST, we aim to increase the energy storage density of supercapacitors both in symmetric and asymmetric configurations by innovative electrode design with nanostructured materials and by the wise choice of the suitable electrolytes.



Schematic of supercapacitor used in the electric vehicle

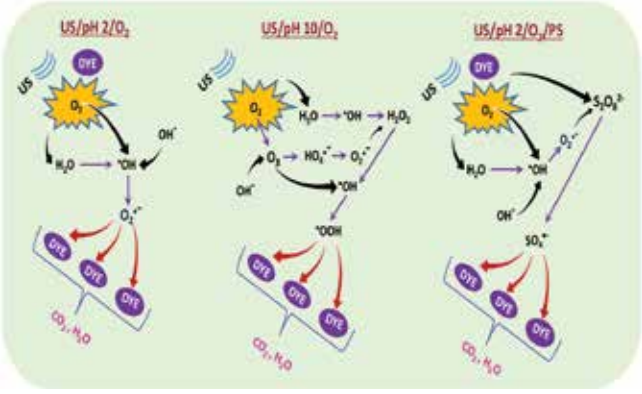
Treatment of real time textile effluent containing azo reactive dyes via ozonation, modified pulsed low frequency ultrasound cavitation, and integrated reactor



The common effluent treatment plant (CETP) of Kerala Industrial Infrastructure Development Corporation (KINFRA) at Kannur, Kerala, undertakes the treatment of textile effluents containing the azo reactive dyes and is in urgent need for the replacement of stage-1 facility, consisting of physical, chemical, and biological processes, which generates large quantity of solid sludge. Advanced oxidation processes (AOPs) are the potential candidates for the textile wastewater treatment without the sludge formation. We investigated the stand-alone ozonation (O_3) and modified pulsed low frequency ultrasound (US) cavitation as well as their integrated reactor for the possible replacement of stage-1 facility. The major criteria for the replacement are to achieve minimum 90% of chemical oxygen demand (COD) removal, without the sludge formation, with the final COD level of less than 150 mg L^{-1} as per the requirements of KINFRA. The stand- alone ozonation and modified pulsed low frequency US cavitation processes provide the COD removal of 90 and 65%; while, their integrated reactor provides 86% COD removal, without the sludge formation, with the final COD level less than 150 mg L^{-1}. Since all the conditions are satisfied only by the stand-alone O_3 process, the latter is highly suitable for the replacement of stage-1 facility. The COD removal is predominantly achieved via the generation and attack of $^{\cdot}OOH$ for the stand-alone O_3 process; while, the same is achieved via the generation and attack of $O_2^{\cdot-}$ for the modified pulsed low frequency US cavitation process and their integrated reactor.

Removal of methylene blue and azo reactive dyes from aqueous solution and textile effluent via modified pulsed low frequency ultrasound cavitation process

Organic dyes in the aqueous solutions and textile effluents cause severe environmental pollution due to their carcinogenic and mutagenic nature. Ultrasound (US) cavitation is one of the promising advanced oxidation process (AOP) to remove the organic dyes from the aqueous solutions and textile effluents. Nevertheless, the conventional low frequency US cavitation process exhibits very low efficiency in the dye removal process and demands effective modification to improve its performance. In this investigation, the conventional pulsed low frequency (22 kHz) US cavitation process has been modified by varying the US power (50-250 W), initial solution pH (2-10), and O_2 flow rate (1-4 L min^{-1})

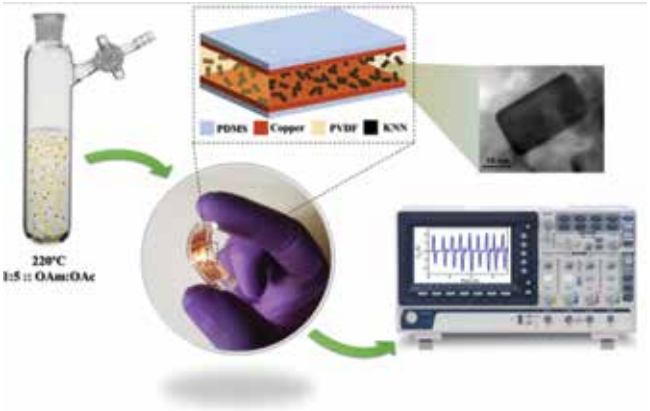


to enhance the decomposition of cationic methylene blue (MB) dye in an aqueous solution. The operation of classic Haber-Weiss reaction, both in the forward and backward directions, and the ozone effect have been observed under the modified US cavitation process as confirmed via the radical trapping experiments. Moreover, the hydrothermally synthesized hydrogen titanate ($H_2Ti_3O_7$) nanotubes (HTN) are utilized as sonocatalyst for 100% dye removal with their effective regeneration obtained via the in-situ thermal activation of persulfate (PS, $S_2O_8^{2-}$). The decomposition of industrial azo reactive dyes in an aqueous solution as well as in the textile effluent is also demonstrated by using the modified pulsed low frequency US Cavitaion process involving the thermal activation of PS which justifies its suitability for the commercial application.

Flexible Piezoelectric Nano generators based on KNN-PVDF Nano composites:

Energy autonomous nano generators offer limitless possibilities for scavenging ambient energy to power consumer electronic components and sensors, thereby giving new dimensions to portable electronic systems. The ambient energy sources include sunlight, wind, mechanical vibrations, fluid flow, electromagnetic and sound waves. In this regard, high-performance piezoelectric materials, which can generate an electric signal from mechanical vibrations, are the most promising candidates for developing flexible piezoelectric nano generators (PENGs). Though ubiquitously available in the environment, effective energy scavenging from mechanical vibrations poses umpteen challenges. Nonetheless, due to their simple device structure, small form factor and long-term stability, the application horizon of PENGs is expanding day by day, including electronic skin, self-powered portable electronics, touch screens, wearable medical devices, flexible printed circuit boards and so on.

Herein, we have developed a lead-free flexible piezoelectric nano generator based on KNN-PVDF nano composite, in which the KNN nano blocks were synthesized using a novel non-aqueous surfactant-assisted hot injection method. Also, the synthesis of KNN employed non-toxic surface stabilizer, oleic acid and reaction catalyst, oleyl amine respectively, making the preparation environmental benign. The KNN nano blocks homogeneously dispersed in the PVDF matrix up to 10 wt % filler loading, enhanced the piezoelectric



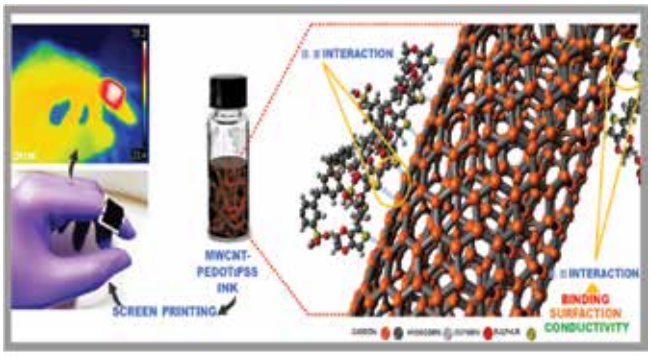
Schematic representation of the fabrication of flexible piezoelectric nanogenerator based on KNN-PVDF nanocomposite

and dielectric properties of the composite. Further, the fabricated flexible piezoelectric nano generator without any external poling process exhibits an output open circuit voltage of 2.1 V and a short circuit current of 42 nA on a gentle finger tapping force (~3N). The results demonstrate the potential of chemically engineered KNN nano blocks dispersed in PVDF for large-scale sustainable piezoelectric nano generator applications.

MWCNT - PEDOT: PSS Composite Ink for Energy Efficient Flexible Heating Applications:

Wearable electronics will be a bleeding-edge niche area of the future apparel industry, where the integration of body-worn smart devices with fabrics is realized in an unobstructed way. Future designer fabrics can simultaneously function as heating, communication, and health monitoring systems and can perform these functions according to the body's requirements intelligently. For example, a smart jacket is a popular wearable that provides temperature feedback of the body and surroundings which can maintain the inner temperature using flexible printed heaters. Such heaters are integrated directly onto the fabric's surface that requires local heating. Compared to buried coils, the printing of heating elements on to the fabric is ideal to ensure more efficient heat transfer to the substrate and reduces chances of failure.

In this work, the multifunctionality of the conducting polymer PEDOT: PSS as an effective binder, dispersant, and conductivity enhancer in the multi walled carbon nanotube (MWCNT) ink, is successfully demonstrated. A room temperature curable conductive ink for screen printing was developed using the MWCNT-PEDOT: PSS nano composite for the first time. The ink possesses ideal flow characteristics for screen printing at higher shear rates. Addition of PEDOT: PSS enhanced the dispensability of MWCNT against their inherent van der Walls interaction. Through FTIR and Raman spectroscopy, it is proved beyond doubt that steric stabilization is facilitated through a π-π interaction between PEDOT: PSS and CNT. This specific ability of PEDOT: PSS, in addition to its inherent film forming capability, is carefully manipulated as a poly functional binder to formulate a durable CNT ink, which otherwise



Schematic representation of π-π interaction between MWCNT and PEDOT: PSS used as the filler in the resistive ink for flexible heater applications

is not possible with intrinsically conductive polymers.

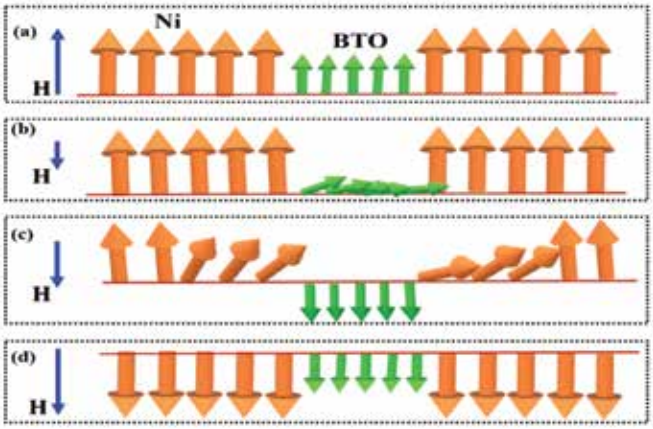
Furthermore, MWCNT affected the electronic energy levels of PEDOT: PSS, causing an enhancement in the conductivity of the material as a whole. Impressive sheet resistance of 51.31 ± 0.25 Ω/'sq' was obtained for a 5 stroke print on Mylar® substrate with only 2.5 wt.% of MWCNT loading, making the formulation a low cost alternative to noble metal inks. Further, to test MWCNT ink's suitability for printed electronic applications, an all printed flexible heater was fabricated. A highly uniform temperature distribution with a peak temperature of 136 ^{o}C at an electrical power density of 0.137 W/cm^2 could be attained using the flatbed screen printed flexible heater. Further, a detailed thermal analysis attests the thermal stability of the device for prolonged usage. The present research demonstrated that PEDOT: PSS stabilized MWCNT ink and the screen printed circuits thereof can survive all kinds of structural deformation like wrinkling, twisting, and bending. More importantly, the MWCNT based heater is an energy efficient and cheap flexible heating solution that can be integrated into any flexible electronics regime.

Exchange-spring mechanism in Ni-$BaTiO_3$ magneto electric composite

Multiferroics exhibit multiple properties like ferromagnetism, ferroelectricity, ferroelasticity etc. in the same system, enabling cross control of ferroic order parameters. Among various multiferroics, magnetoelectric (ME) materials whose magnetism can be controlled by electricity, have drawn great attention. Due to coupling between ferromagnetic (FM) and ferroelectric (FE) order,

they find immense applications in sensors and memories, where one ferroic property can be manipulated using the conjugate field of the other. Most single-phase ME materials have minimal ME coupling and majority of them possess Curie temperatures much below ambient. Hence single-phase ME materials are likely to be too weak for practical applications. Among them, $BiFeO_3$ shows high Curie and Neel temperatures far above the room temperature, and thus it is widely investigated. In comparison to single-phase ME materials, ME composites have high demand due to their much higher ME coefficient and operating temperature. Multifunctional composites are defined using the connectivity schemes such as 2-2 (2 dimensionally laminated), 0-3 (contain dispersed particles in the 3-dimensional matrix), and 1-3 composites (1-dimensional materials embedded in the 3-dimensional matrix). In a magneto electric composite, the ME coupling is generated due to the magnetostrictive and the piezoelectric effects, mainly happening at the interface.

For the present study, magneto electric (ME) composites are prepared by taking sea urchin-like Ni nanoparticles and hierarchical prickly Ni nanowires as the ferromagnetic constituents and $BaTiO_3$ (BTO) nanoparticles as the ferroelectric part, with different Ni:BTO ratio. As expected, the remanant polarization (Pa) value of both NP-BTO and NW-BTO series slightly increases as a function of BTO concentration. Due to the grinding of Ni and BTO samples, weak ferromagnetism is induced in BTO present in the ME composites, and the ferromagnetic order increases with the increase in the grinding time. Owing to the difference in coercive fields of Ni and BTO phases, the Ni-BTO ME structures act as a hard-soft magnetic composite and exhibit the exchange-spring mechanism. Due to the presence of short-range FM and AFM clusters in the PM matrix, Ni-BTO composites show peculiar Griffiths-like phase. The exchange bias shift observed in these Ni-BTO ME composites confirms the formation of the AFM layer of NiO at the Ni-BTO interfaces. An indirect implication of magnetoelectric coupling between Ni and BTO is given by the observation of structural transitions of BTO in the magnetic measurements of Ni-BTO composites. The ME composites of NP-BTO series show a maximum



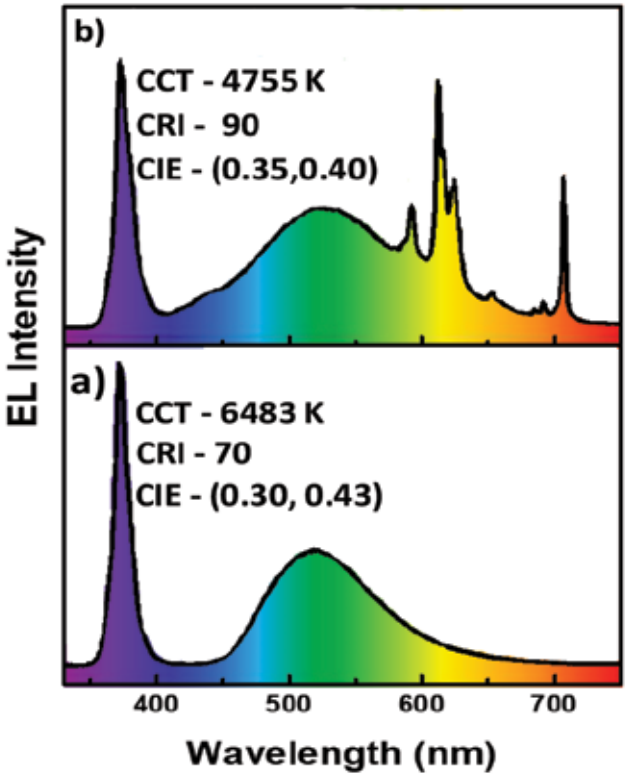
Schematic representation of exchange spring mechanism (ESM) in Ni-BaTiO3 composites.

value of coupling coefficient 18.53 mV cm^{-1} Oe^{-1} for composites with 1:1 ratio, and further, the ME coupling reduces as a function of BTO content. Due to the large aspect ratio of NW-BTO 1-3 composites, they possess high magnetostriction, which leads to the shift of maximum value of ME coupling coefficients towards the BTO rich sample NW-BTO 1:5. The obtained α values of investigated composites fulfil the required criteria for potential magnetoelectric applications and could be used for room temperature magnetoelectric sensing and energy harvesting applications.

Newly developed $(Sr, Ba, Eu)_2Al_3O_6F$ phosphors promising for white-LEDs

Phosphor white LEDs (pc-LEDs) are the cutting-edge lighting devices which are reflected as a superior technology compared to the existing lamps owing to their specific properties including robust nature, considerable life span and green-eco features. Phosphor-transformed white LEDs are the appropriate sources to shrink energy depletion. Yet, upgradation of broadband emitting phosphors is highly necessary to achieve better white light from the pc-LEDs. During executing a CSIR-funded project a series of novel broadband emitting $(Sr, Eu)_2Al_3O_6F$ phosphors have been developed by a newly designed microwave-assisted diffusion method with high reaction rate and homogeneity. The phosphors synthesized by this technique showed smoother and more regular particles than the same composition obtained via the normal solid-state route. Eventually, $(Sr, Eu)_2Al_3O_6F$ system elaborated potential broadband

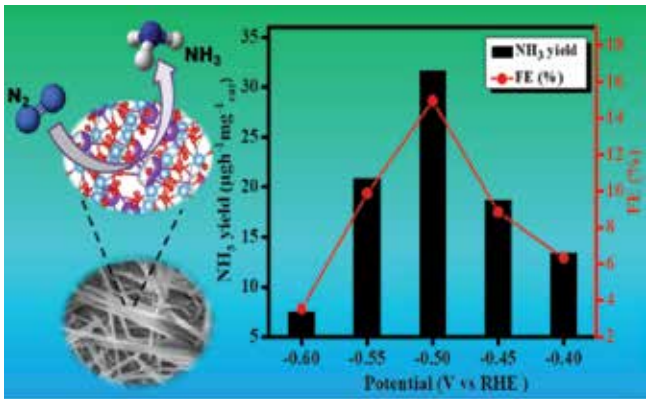
absorption that ranges from UV (200 nm) to deep blue (475 nm). Incorporating Eu^{2+} ions in $Sr_2Al_3O_6F$ host enabled strong bluish-green emission under the UV excitation. This emission is successfully altered to a greenish colour by adjusting the activators' amount. Interestingly, multiple absorption sites of Eu^{2+} ions in $(Sr, Eu)_2Al_3O_6F$ are responsible for its bluish-white emission under blue irradiation. The emission intensity is further enhanced by the Ba^{2+} to Sr^{2+} substitution in the optimum $(Sr, Eu)_2Al_3O_6F$ system. The as-fabricated white-LEDs by applying the improved $(Sr, Ba, Eu)_2Al_3O_6F$ phosphor showed a cool-white light under 365 nm NUV-LED (Fig. a(i)) and 420 nm blue-LED (Fig. b(i)) with a reasonable colour rendering of ~70 and colour temperature > 6000 K. With the addition of appropriate red-emitting source, this bluish-white light has been altered to natural white with the colour temperature ~ 5000 K, and the colour rendering > 80 (Fig. a(ii) and b(ii), respectively). The lighting performances of the developed as well as the optimized system could be adequate for commercialization.



Cool white emitting $(Sr, Ba, Eu)_2Al_3O_6F$ system under the irradiations of near-UV LED (Fig. a). With a preferred red phosphor, this system efficiently produced natural white light with elevated colour rendering (Fig. b).

Electro-catalytic Nitrogen Reduction Reaction under ambient conditions by $K_3Ti_8O_{17}$ nanorods:

Electrochemical Nitrogen Reduction Reaction (NRR) as one of the idyllic alternatives for the energy-intensive Haber process. Metal oxides are significantly recognized as efficient electro-catalysts for NRR, since they can facilitate the activation of N_2 triple bond. A new titanate based mixed metal oxide, $K_3Ti_8O_{17}$, having nanorod morphology was synthesized through a simple citrate-gel process at a lower calcination temperature as electrocatalyst for NRR. Under the ambient conditions, the obtained $K_3Ti_8O_{17}$ nanorods exhibited excellent activity towards NRR in acid medium with 31.6 $\mu g h^{-1} mg^{-1}_{cat}$ NH_3 yield and 15% FE at -0.5 V versus the reversible hydrogen electrode in 0.1 M HCl.



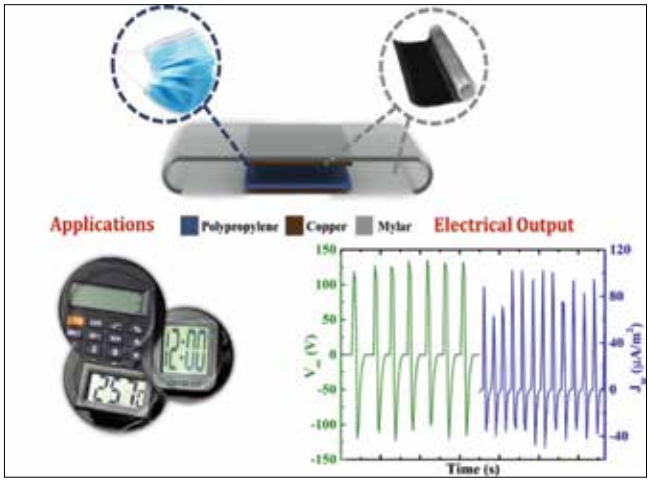
$K_3Ti_8O_{17}$ nanorods for electro-catalytic nitrogen reduction reaction

Triboelectric Nanogenerator from Used Surgical Face Mask and Waste Mylar Materials Aiding Circular Economy:

Apart from claiming the lives of more than 3.2 million people, COVID-19 pandemic is worsening the global plastic pollution every day, mainly with the over flux of single-use polypropylene (PP) facemasks. In this scenario, as an innovative solution to mitigate plastic pollution as well as meeting the rising electrical energy demand, we are introducing an all flexible and facile waste material-based triboelectric nanogenerator (WM-TENG), aiding towards circular economy. The WM-TENG operating in contact separation mode is fabricated

using the PP from used face mask in combination with recovered Mylar sheets from solid-wastes as triboelectric contact layers and flexible supporting structure. After detailed investigation and trials to study the effect of various disinfection mechanisms of PP material on the energy output of WM-TENG, UV-C radiation is selected for disinfecting the used mask owing to the retention of electrical energy output. Under a tapping force of 3 N, the WM-TENG having an active area of 6 cm^2, delivers an open-circuit voltage of 200 V and short circuit current density of 0.29 mA/m^2 respectively. The WM-TENG also delivered a maximum power density of 71.16 mW/m^2 under 10^8 Ω load. Additionally, the WM-TENG is demonstrated for powering electronic gadgets such as calculator, digital thermometer and LCD clock. This flexible and low-cost nanogenerator without any complex fabrication steps is a sustainable solution for the alarming plastic pollution as well as the rising energy demands. ***[ACS Applied Materials and Interfaces***, 2021, **13**, 51132-51140]

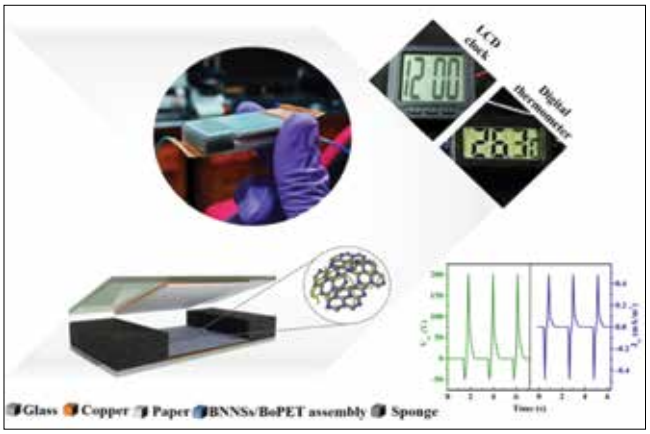
Massive Enhancement in Power Output of BoPET-Paper Triboelectric Nanogenerator Using



Schematic illustration of the TENG developed from used surgical mask and waste Mylar materials for powering electronic gadgets.

2D-Hexagonal Boron Nitride Nanosheets

In the present era of the Internet of Things (IoT) and sensor networks, clean and sustainable power sources are in huge demand, and triboelectric nanogenerators (TENGs) are a hot cake in green energy production. We have developed a contact-separation mode TENG

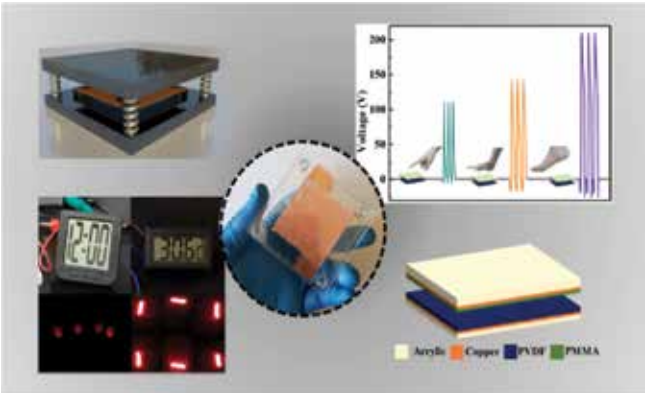


Schematic depiction and actual image of 2D-hBNNs based TENG device and its electrical output performance

using liquid-phase exfoliated 2D-hexagonal boron nitride nanosheets (BNNSs) coated on biaxially-oriented polyethylene terephthalate (BoPET) and paper as counter triboelectric materials, which showed an impressive 70 times higher power output than simple BoPET-paper TENG assembly. Even under a moderate finger tapping force (~3 N), the developed BNNSs/BoPET-paper TENG device could generate an open circuit output voltage of ~200 V and a short circuit current density of 0.48 mA/m2. While under load testing, the peak value of electric power density for the BNNSs/BoPET- paper TENG device reached ~0.14 W/m^2 at 200 MΩ resistive load. The incorporation of BNNSs has significantly enhanced the electron-accepting capabilities of the BoPET film which is evident from the enhanced dielectric permittivity of the BNNSs/BoPET assembly, and thus resulted in the enhanced electrical output of TENG. Additionally, the fabricated BNNSs-TENG was successfully demonstrated for powering electronic gadgets such as LCD clocks, digital thermometers, and LEDs through cyclic finger tapping force. ***[Nano Energy***, 2021, **90**, 106628]

Spring Assisted Triboelectric Nanogenerator (Sa-TENG)

A spring assisted TENG (Sa-TENG) based on polyvinylidene difluoride (PVDF) and polymethyl methacrylate (PMMA) films operating in contact separation mode has been designed, fabricated and demonstrated for harvesting mechanical energy associated with human activities such as finger tapping, palm tapping and heel tapping into usable electricity.



Schematic depiction and actual image of Sa-TENG device and its electrical output performance for various mechanical inputs.

With a moderate finger tapping force, the Sa-TENG has generated an open-circuit voltage of ~115 Vpp (peak to peak) and short circuit current of ~ 0.25 µApp (peak to peak). Also, it is shown that the electrical output of Sa-TENG can be enhanced with increase in input mechanical energy and area of contact. The fabricated Sa-TENG has been demonstrated for powering electronics gadgets such as LCD clock, digital thermometer, LEDs and seven segment display. ***[Sustainable Energy Fuels***, 2021,**5**, 5287-5294]

Self-Sterilizing Printed Fabric Heaters for Application in Reusable Personal Protective Equipments:

Description of Technology:

A low-power consuming, self-sterilizing fabric heater by printing of custom developed thick film conductive silver ink formulations on fabric substrates for annihilating pathogens by resistive heating at a sterilization temperature of 120°C. Further, the fabric heater device has been integrated with a stopgap face mask having a reusable cartridge, in which the cartridge comprises of a self-sterilizing fabric layer in addition to other filter layers for annihilating pathogens by resistive heating, enabling on-line protection at 70°C as well as offline protection at 120°C. In addition, the present invention relates to the development of conductive aqueous based printable silver ink formulation as the heating element of fabric heater device, which comprises of silver flakes and/or silver particles and its vehicle carrier, wherein the carrier consists of a eutectic mixture co-solvent, binders, dispersants, anti-foamer, wetting agent and thixotropic agent. The design of the self-sterilizing fabric heater has been optimized for energy efficient heating with full and partial coverage designs of heating element over fabric substrate. The sterilization temperature for fabric heater has been achieved through a DC voltage source with less than 0.25W/cm^2 power consumption by fine-tuning the resistance and thickness of heating element printed on fabric substrate

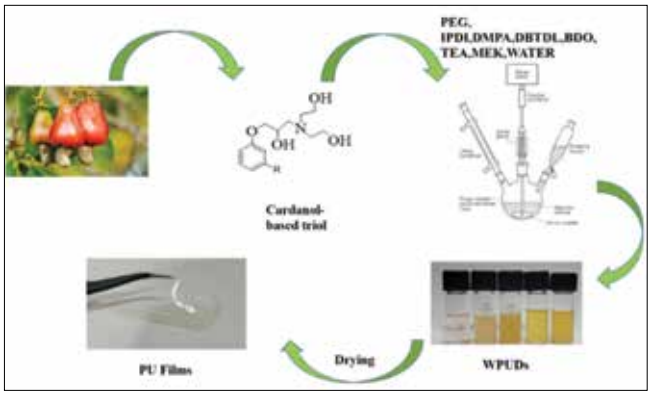
(Patent Application No.: 202111046365) Filed on: 11. 10. 2021

Photograph of self-sterilizing fabric heater integrated stopgap face mask and its thermal image during operation at 4V DC supply.

Functional Polymers and Composites

Sustainable Polymers and Polymer Nano-composites:

Bio-based aqueous polyurethane dispersions (PUD) and hybrid Nano-composite dispersions (NCDs) are important specialty chemicals to develop environment friendly and technically superior products for various applications in coatings, adhesives and other sectors. Under CSIR-Chemicals theme an FTT project is proposed to develop polyurethane dispersions based on cardanol, a byproduct of the cashew processing industry as outlined in scheme 1. The bio-based polyol improves not only the technical properties but also the film formation without the need for any coalescing aids or VOC's. The effect of polyol characteristics like hydroxyl value, dispersing mechanism, and hybrid nanocomposite formation on various properties are being evaluated. The addition of functionalized nanoparticles further achieves control of performance properties. The developed PU dispersions as well as the nanocomposite dispersions will be evaluated in leather finishing, metallic coatings and wood coatings. Sustainable specialty chemicals with

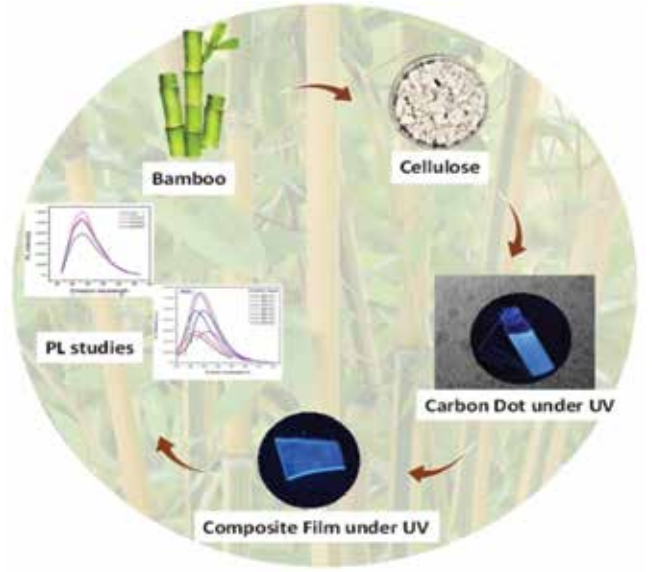


Schematic of the Synthesis of bio-based PUD and polyurethane films.

multifunctional properties are considered important for economic growth, import substitution and growth of the MSME sector.

Bio-based Carbon Dot Polymer Nanocomposites:

Carbon dot (C-dot)–Polymer nanocomposites have received much attention due to their diverse applications, including anti-counterfeit coatings, packaging, and in biomedical applications such as drug delivery, imaging, and tissue engineering scaffolds. Cellulose based N-doped C-dot synthesis was achieved from the bamboo stem, using the hydrothermal method. The cellulose particles are initially characterized by IR, XRD and thermal analysis. The obtained C-dots were characterized for various properties like crystallinity, particle size and fluorescence. The nanocomposites are prepared using PVA, a benign and water-soluble polymer with excellent film-forming properties. The optical properties of the nanocomposite films and solutions were recorded at different C-dot concentrations. The prepared C-dots and the nanocomposites showed a light brownish colour in daylight and blue colour when observed under UV light at 365 nm, and the un doped C-dots show green colour under UV light. The UV visible absorption spectrum showed two absorption peaks at 269 nm and 323 nm and an excitation wavelength dependent emission spectrum. The composite films prepared in this work are being evaluated for different applications.



Schematic of the synthesis of fluorescent, biobase C dot- and its nanocomposites.

Polymer/Coir Composites

Development of Coir/Polymer Composites for Electrical Insulation Applications

The use of coconut husk-derived coir fiber-reinforced composites is on the rise due to the constantly increasing demand for sustainable, renewable, biodegradable, and recyclable materials. Coir is a hard and stiff biodegradable lingo cellulosic fiber obtained from the fibrous mesocarp of coconut fruits and makes up about 25% of the nut. It is an abundantly and cheaply available lingo cellulosic fiber obtained from the outer shell (endocarp), or husk, of the coconut, the fruit of Cocos nucifera. The average chemical composition of coir fibers ranges from 32 to 50% cellulose, 0.15–15% hemicellulose, 30–46% Lignin and about 3–4% pectin. At CSIR-NIIST, various polymer/coir products have been fabricated as part of the ongoing projects from NCRMI. Polymer-coir composites for electrical insulation applications were developed with specific product fabrication. Both thermoplastic polymers like polyethylene and thermosetting polymers like phenol-formaldehyde resin and epoxy resin were used along with coir mat fibers. Coir fibers were used as the reinforcement to the polymer matrix to obtain polymer-coir composites with specific properties. Keeping the recycling option in mind, we have used thermoplastics as well. The impact of coir loading on the physical and mechanical properties of the composites was examined in more detail. Among the composites, epoxy-coir composites show excellent

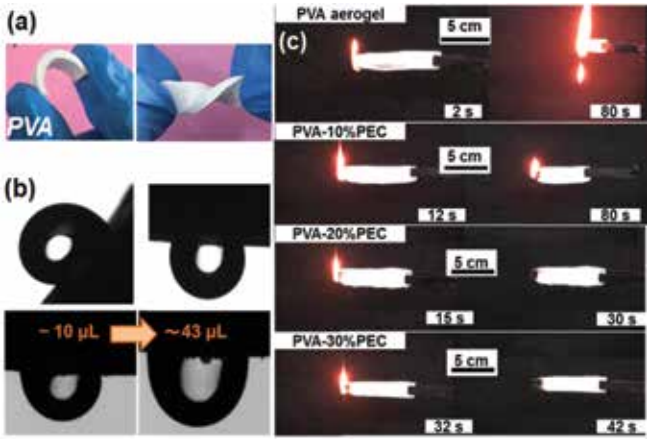
properties. Epoxy-coir composites have very good tensile and flexural strength with 50 wt.% of coir fiber loadings. Impact strength reduced proportionately with increment in fiber loading. Impact strength is maximum for PF-coir composites with a value of 1454 KJ/m^2. Epoxy-coir composites show excellent thermal and flame retardant properties. Dielectric breakdown strength (DBS) is one of the most important properties of electrically insulating material. The DBS of these polymer composites depends heavily on the fiber content. DBS of polymer-coir composites decreases with an increase in fiber loading because of the voids present in it. The Epoxy-coir composites show better DBS than PE and PF composites which are recommended for electrical insulation applications. Different types of strain insulators have been fabricated such as egg-type strain insulators, low voltage, and high-voltage strain insulators. These products show good mechanical strength, high resistivity, good dielectric strength and are lightweight. They are 70 % lighter than the equivalent ceramic units which are currently used.

Electrical insulators developed in collaboration with NCRMI, Government of Kerala

Polymer Aerogels

High Strength, Flexible, Hydrophobic, Sound Absorbing and Flame Retardant Polyvinyl Alcohol/ Polyelectrolyte Complex Aerogels:

Polymer aerogels are an important class of materials from both the viewpoints of science and industry. The combination of extremely high porosity and small pore sizes provides aerogels with properties such as high surface area, low sonic velocity, low dielectric constant and low thermal conductivity. Being a highly absorbable material, aerogels can be widely used for large-scale oil–water separation and water purification and their low thermal conductivity makes them efficient heat-insulating materials. The vibration and sound absorption ability of aerogels make them an excellent sound insulation material. Aerogels find applications as low-density EMI shielding materials as they can weaken the reflection and scattering of incident electromagnetic waves between pore walls. As a three-dimensional porous material with a high effective surface area, aerogels can facilitate better strain accumulation and charge generation inside the open cells of aerogel, which makes them potential candidates for various energy harvesting and sensing applications. Polyvinyl alcohol (PVA) is a formidable candidate for the preparation of aerogels owing to its low cost, high solubility in water and good mechanical properties. Its biodegradable, biocompatible and non-toxic nature makes it an even more versatile polymer. However, the limiting factors of pristine PVA are the high flammability (limiting oxygen index (LOI) ~19.8 %) and super-hydrophilicity induced by its organic skeleton composed of plenty of hydroxyl groups, which restrict its feasibility in many practical applications. In our study, we have used a completely organic and sustainable polyelectrolyte complex (PEC) as filler for fabricating mechanically strong, sound absorbing and flame retardant polyvinyl alcohol (PVA) aerogels with the aid of an environmentally-friendly freeze-drying method. The non-covalent interactions between the polymer and filler ensured excellent compatibility as well as interfacial adhesion of the filler, and we could achieve a perfect balance between the density and mechanical properties of the aerogels. The prepared aerogels exhibited flexibility, good sound absorption ability in the mid-frequency range and excellent flame-retardancy (LOI ~ 28 %) with self-extinguishing behavior. A simple silane modification endowed sticky hydrophobicity to the aerogels and further enhanced their anti-fire properties. These sustainable multifunctional aerogels could find a plethora of applications in real life, particularly in buildings and structures as fire-safety materials and sound insulators. (Gowd et al. *ACS Applied Polymer Materials*, 2022)

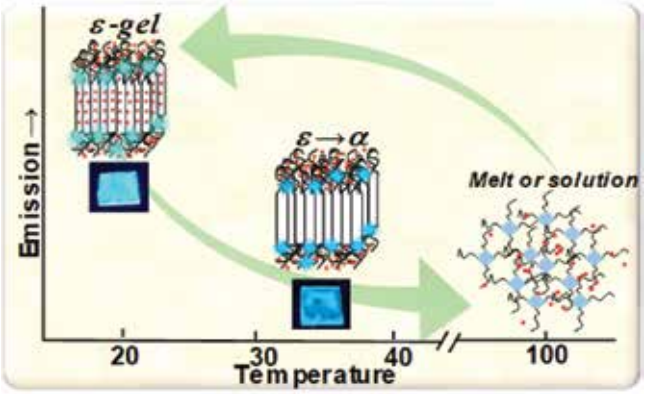


(a) Flexible PVA aerogels. (b) Photographic images demonstrate the excellent water adhesion property of PVA-PEC aerogels. The water droplet did not fall down even after the rotation of the aerogel surface. (c) Photographs showing the burning behavior of PVA and PVA-PEC aerogels during the horizontal burning tests conducted using a butane flame.

Biodegradable Fluorescent Polymers

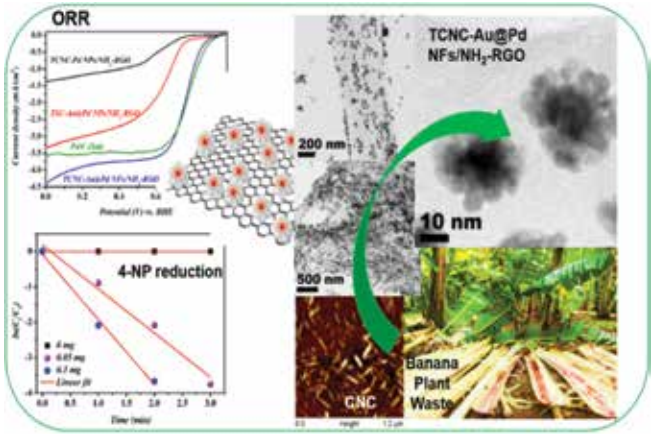
Poly (L-lactide)s with Tetraphenylethylene: Role of Polymer Chain Packing on Aggregation-Induced Emission Behavior of Tetraphenylethylene

Fluorescent materials have attracted immense interest in recent decades due to their enormous applications in biosensors, bio-imaging, mechanochromism, optoelectronic devices, optical waveguides and organic light-emitting diodes. Most of the fluorescent molecules exhibit reduced emission or are completely non-emissive in the aggregated or solid states due to self-quenching associated with the strong noncovalent interactions. In contrast, some fluorescent molecules are non-emissive in dilute solution and fluorescence increases upon crystallization/self-assembly or aggregation. The restricted rotation of chromophores in the aggregate or crystalline states is mainly responsible for aggregation-induced emission (AIE) due to the radiative decay of excitations. The role of polymer chain packing on the emission behavior of TPE molecules in one-armed, two-armed and four-armed PLLAs was investigated. Hydroxyl modified tetraphenylethylenes (TPE) were used as a macroinitiator to carry out the ring-opening polymerization of -lactide. Compared to one-armed and two-armed PLLAs, four-armed PLLA (SSPLLA) shows strong emission in aggregate and gel states. For that reason, SSPLLA was selected for a detailed study to understand the role of polymer chain packing on the emission behavior of the core molecule TPE. SSPLLA shows non-emissive behavior in good solvents (e.g., chloroform) and typical AIE behavior in aggregate and gel states. The fluorescence behavior of SSPLLA could be regulated by multiple factors, including solvents, polymer chain conformation, crystal-to-crystal transition of the host polymer and temperature. The change in the emission behavior of SSPLLA is attributed to the restriction of intramolecular rotation of the peripheral phenyl rings of core molecules induced by the chain conformation of arm PLLAs. We believe that the marriage of AIE molecules with biocompatible/biodegradable polymer will impart remarkable fluorescent properties and guide a new way with fascinating functions and applications in medical and pharmaceutical fields and bio-imaging. (Gowd et al. *Polymer Chemistry*, 2022, 13, 838-849)



Role of TEMPO-Oxidized Cellulose Nanocrystals as Structure Directing Agent for Ultra-Stable Au@Pd Nanoflowers with Enhanced Catalytic Properties

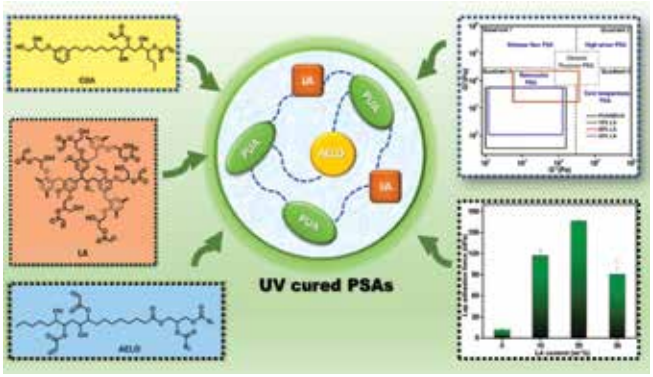
Tailored synthesis of palladium (Pd)-based bimetallic systems having improved catalytic activity as an alternative to platinum-based catalyst enables hydrogen economy and industrial catalysis applications. We developed a green strategy for the synthesis of core-shell Au@Pd nanoflowers (NFs) employing banana pseudo-stem-derived TEMPO-oxidized cellulose nanocrystals (TCNC) as both capping and shape-directing agent via seed-mediated strategy is presented. Flower-like nanostructures of Au@Pd bound to TEMPO-



oxidized cellulose nanocrystals (TCNC-Au@Pd) were decorated on amino-functionalized graphene (NH_2-RGO) without losing their unique structure, allowing them to be deployed as an efficient, reusable and a green alternative heterogeneous catalyst. The decisive role of TCNC in the structural metamorphosis of nanoparticle morphology were inferred from the structural and morphology analyses. According to our study, the presence of -OH rich TCNC appears to play a pivotal role in the structured evolution of intricate nanostructure morphology. The feasibility of the bio-supported catalyst has been investigated in two concurrently prevalent model catalytic reactions, namely the oxygen reduction reaction (ORR) and the reduction of 4-nitrophenol, the best model reactions in fuel cell and industrial catalytic applications, respectively. ***(Ref: Saju Pillai and coworkers, Carbohydrate Polymers*, 292, 119723, 2022*)***

Lignin incorporated bio-based pressure sensitive adhesives

Renewable Pressure Sensitive Adhesive (PSA) is an emerging field in adhesive industries as it is an excellent green alternative to depleting petroleum sourced adhesives. Novel bio-sourced UV curable PSAs are developed with ~ 50 % biomass content originated from alkali lignin, cardanol and linseed oil. Alkali lignin based acrylates (LA) in liquid phase was incorporated into PUA/AELO PSA system The viscoelastic window also confirmed the incorporation of 10-20% LA could improve the viscoelastic properties effectively to be used as removable PSAs. The addition of 20% LA into PUA based PSA system showed reasonable tackiness, lap shear adhesion (25 kPa) and 180° peel strength (~2.1 N/25 mm) for possible non-structural/semi-structural applications. Lignin improved the thermal stability at higher temperatures. Therefore, the lignin based PSAs with high bio-based content paved a way of replacing petro sourced PSA by proper tuning the lignin content and modifications. ***(Biomacromolecules, 2022, 23, 3, 816–828)***



Metallic Materials

Pilot-scale Squeeze Casting facility for High-Strength Aluminium Alloys

Squeeze casting is a novel high yield, energy-efficient process developed from conventional die casting for producing near net shape casting. Squeeze Casting (SQC) is a generic term to specify a fabrication technique where solidification is promoted under high pressure within a re-usable die. It is a metal-forming process, which combines permanent mold casting with die forging into a single operation where molten metal is solidified under applied hydrostatic pressure. SQC is known as liquid metal forging. In squeeze casting, the applied pressure improves the wettability and the bonding force between the Al alloy by the undercooling effect which, together with the loss of heat through the dies, favors rapid solidification. SQC is mainly used to fabricate high integrity engineering components with or without reinforcement.

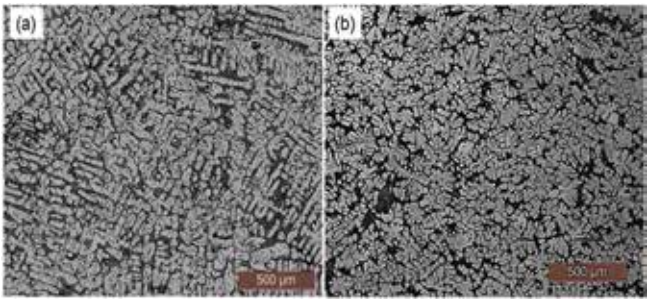
Bühler Evolution 340 comes with a proven locking unit for the highest level of reliability that allows rapid movements of the die platen and a maximum locking force of 340 tonnes. The injection unit allows an efficient die filling and power reserves to compensate for process fluctuations and for a stable production.

The entire production cycle can be programmed using intuitive Data View machine control which allows real-time control of the die-casting machine. The trial run of the machine was initiated with loading the die unit on to the corresponding fixed and moving platen of the squeeze casting machine. The 200kg melting furnace was loaded with ADC12 alloy ingots with temperature of the furnace set at 780°C. The melt was purged with Nitrogen gas for degassing the dissolved Hydrogen from the melt, for about 3 hours. The both half of die cavity is preheated to 200-250°C using flame torch. Once the melt and die is ready to take the shot, the auto-ladler is programmed to automatically collect the melt from the furnace and pour into the shot-sleeve cavity. The plunger rod sweeps and pushes the melt from shot sleeve to the die cavity through the gating channel provided in the die. The metal fills and solidifies within the die cavity to form the required product. The casting parameters like plunger velocity, the plunger pressure, shot duration etc. can be controlled to achieve the desired quality of the product. The application of plunger pressure reduces the casting porosity. The squeeze casting process confirms finer microstructure and a negligible amount of shrinkage.

The SQC facility at CSIR-NIIST, Scroll compressor component and engine component produced using squeeze casting technique. The revenue model is Product development, Process know-how and Technology transfer. The products aimed are compressor heads, heat Sinks components, Scroll Compressor plates, Flange, Connecting Rod, Suspension Arm, Knuckle. The user agencies of the pilot-scale Squeeze Casting are Atlas Copco, Belgium, ZF-WABCO India Limited, ADE & GTRE (DRDO), VSSC (ISRO), Sri Kaliswari Metal Powders (P) Ltd, Sivakasi and Roots Cast, Coimbatore.

Pilot-scale squeeze casting facility (Bühler Evolution 340) at CSIR-NIIST. Scroll compressor component and engine component produced using near net shape Squeeze Casting process.

The difference in microstructure of A356 alloy produced using Gravity Die Casting (GDC) and Squeeze Casting (SQC) is shown in Figs. 2(a,b). Squeeze pressure enabled finer microstructure can be evidenced.



(a) Microstructure of A356 alloy with Sr modification (0.02 wt%) produced using Gravity Die Casting (GDC) and (b) Microstructure of A356 alloy with Sr modification (0.02 wt%) produced using Squeeze Casting (SQC)

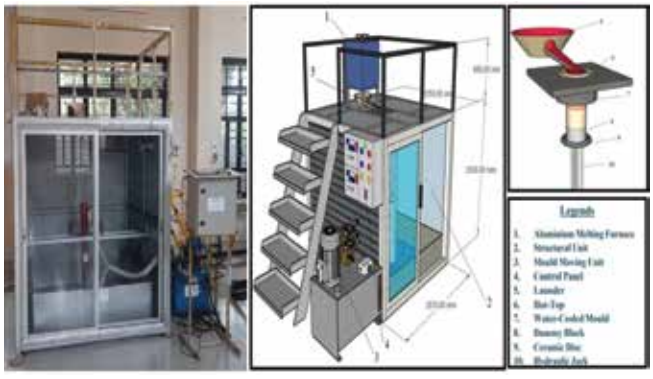
Direct Chill Casting Facility at CSIR-NIIST for Producing Specialty Aluminium Alloys

Direct chill casting is a semi-continuous process in which molten aluminum enters the top of a water-cooled mold, is cooled, and forms a solid ingot. The molten aluminum begins to solidify due to the cooling effect of the mold wall. As the ingot is withdrawn from the bottom of the mold, water jets impinge on the surface, directly cooling the billet and forming a solid layer around a liquid melt. Rapid development and industrial use of Direct Chill Casting (DCC) is facilitated by requirements of the aircraft industry for large billets (both round and flat). This demand is driven by increasing passenger airline transport and, strategic needs. Typical DC cast products include large rectangular sections known as ingots (approx. 500 mm x 1500–2000 mm which are further rolled into plate, sheet and foil) and cylindrical sections known as billets (up to 1100 mm in diameter which are further forged or extruded to form rods, bars, tubes, and wires). The force cooling due to water jet ensure high cooling rate. Moreover, the high cooling rate ensure extension of solid solubility, fine grain size, and improved mechanical properties of the products. During DC casting, liquid metal is poured

into a water-cooled mold, which is initially closed by a starting block beneath. Once the liquid metal freezes on the starting block and a solid shell is formed close to the mold walls, the starter block is lowered into a pit with a constant casting speed Vcast while keeping the metal level in the mold at a certain height. The solid shell forms due to the heat flow through the water-cooled mold (primary cooling). The outer part of the ingot is solid, the inner core is still semi-solid/ liquid. Interaction between the (semi-) solid shell and the mold may cause a rough surface with a different types of defects, such as cold shuts, bleed-outs, and drag marks). To counter the above undesirable effects, several mold technologies such as low-head casting, hot top casting, lubrication through the mold, air pressurized molds, electromagnetic casting (EMC), etc. have been devised with the aim to control the mold (primary) cooling. The hot top, most widely used nowadays in DC casting molds is a refractory reservoir with a ceramic insert in the mold.

India's defense applications require about eight to ten thousand tons of specialty aluminium alloys per annum and this requirement will increase as more DRDO programs attain production status and as the Indian armed forces modernize with time.

The DCC unit at CSIR-NIIST and schematic of the different parts of DCC unit. The products aimed are specialty aluminium alloys ingots, billets, rods, bars, tubes, and wires. The user agencies are LPSC-ISRO, GTRE-DRDO, CMTI, Bengaluru and Hindalco.



Direct Chill Casting unit at CSIR-NIIST for producing high strength wrought aluminium alloys

Centre of Excellence for Lightweight Material Technologies

Online inauguration of the "Centre of Excellence for Lightweight Material Technologies" on April 26, 2022

A Centre of Excellence for Lightweight Material Technologies is established for the development of advanced lightweight material technologies and components for automotive applications supported by WABCO India Limited Chennai. The centre of excellence was virtually launched on April 26, 2021. The proposed CoE will be an interdisciplinary technology incubation centre with focus on development of structural and functional components in vehicle brake control systems for WABCO applications using light alloys based on aluminium, advanced composites and coatings using state of art facilities for material processing, characterisation and component development. The centre will also implement product specific projects in collaboration with WABCO based on requirements and separate MoUs. The centre will be supported by WABCO India Limited at least for 5 years. The identified areas of research are Light Aluminum alloys and composites, Thermal management and frictional materials and Multi-material structures.

The studies have been initiated in the development of aluminium alloys and composite materials development for the thermal management application for the fabrication of aluminium compressor head components for the automotive air compressor application. A new alloy composition of modified ADC3M alloy was developed and the thermal conductivity of 173 W/mK is obtained in the annealed conditions. The copper – graphene composite coating of 30 µm thickness

is also made by electro co-deposition technique on the surface to further enhance the thermal conductivity and dissipate the heat from the surface of the component.

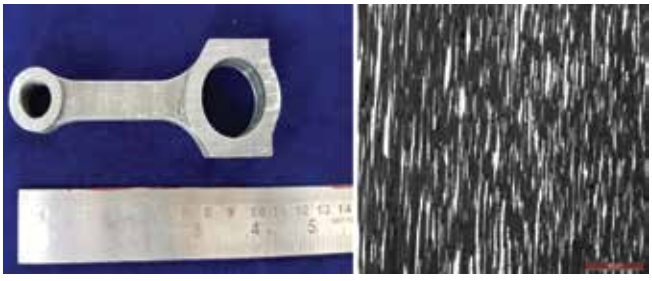
Design and development of near-net-shape manufacturing process for light weight high strength aluminium composite and engineering components by squeeze infiltration technique for automotive and aerospace applications (IGSTC)

Process development and demonstration of Aluminium Carbon (Al-C) fibre composite manufacturing using squeeze infiltration technique is one of the major objectives of the project and the work package to be contributed by CSIR-NIIST. The processing of Al-C fibre composite by squeeze infiltration technique involves the following steps and related work packages (a) surface treatment process for continuous carbon fibre and its preform (b) Design and fabrication of die for liquid metal squeeze infiltration processing of Al MMC and the near-net shape component (c) Development of Al squeeze infiltration process for near-net-shape C-Fibre (CF) preforms and (d) characterization of carbon fibre performs and Al-MMC and heat treatment studies.

Surface treatment of continuous carbon fibre and its preform improves the properties of the interface between the CFs and the metal matrix such as improved wettability, lower the residual stress and minimize or to prevent interfacial reactions at the interface. Desizing by pyrolysis in a protective atmosphere was successfully transferred to 3D textiles of ITA. The copper coating on the CF facilitated their wetting with the molten aluminium during infiltration process. Copper based metallic coating was successfully formed over the PAN based carbon fibres by electroless and electrolytic coating process. The coating parameters were optimised to attain fine grained and uniform coating with varying thickness on unidirectional and bidirectional carbon fibre mat. The coating was successfully formed on the carbon fibre 3D fabric supplied by ITA. A successful method for desizing and subsequent coating with Cu or Ni was developed on a laboratory scale and experimentally confirmed (TRL 4 to 5). All processes are easily scalable and suitable for series applications.

The process layout of the squeeze infiltration has been established and tested with different carbon fibre fabrics. The relevant process parameters have been investigated with unsized carbon fibre fabrics and A356 aluminium. The matrix alloys compositions were optimised by Fenfe Metallurgical and were provided to CSIR-NIIST for composite infiltration. A process optimisation has been carried out (Preform and die preheat temperature, infiltration pressure, melt pouring temperature and infiltration time). Complete infiltration of multiple layers (up to 20 layers) of reinforcement fabric could be achieved with very good and reliable quality. Microstructure analysis have shown that the liquid metal had infiltrated in between each and every carbon fibre with the elimination of shrinkage, porosity and damage of fibre. This was achieved by selecting suitable process parameters. The squeeze infiltration process was successfully implemented and tested under laboratory conditions. (TRL 4- 5).

The demonstrator prototype component identified for the fabrication of Al-C composites are connecting rod for automotive, exit guide vane for aeroengines and thermal management heat sink plates. The prototype connecting rod was fabricated using the liquid metal squeeze infiltration of Al-Cf composite.

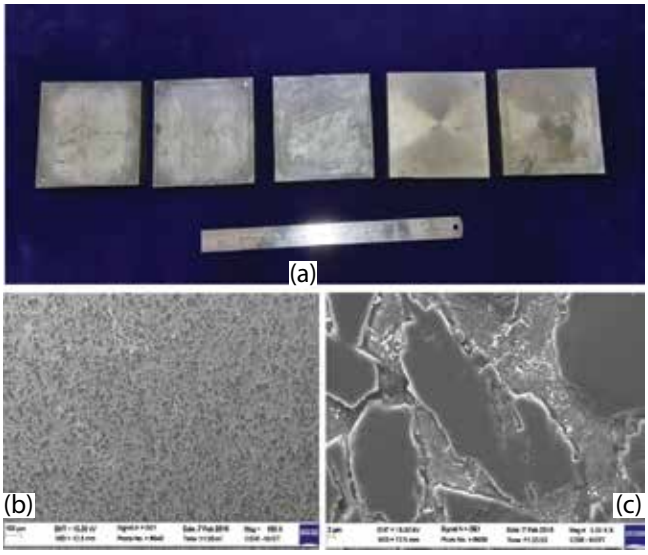


(a) (b)

(a) Al Composite connecting rod made from T700Cf-A356 squeeze infiltrated composite and (b) microstructure of the Al-carbon composite

Development of light weight functionally graded metal-ceramic composite armour materials for defence applications

Aluminum-Silicon carbide functionally graded aluminum composite plates were fabricated by squeeze infiltration technique using 42 µm average particle size and the plate is supplied to CVRDE for evaluation. The dimensions of the plates are 120 x 120 x20 mm.

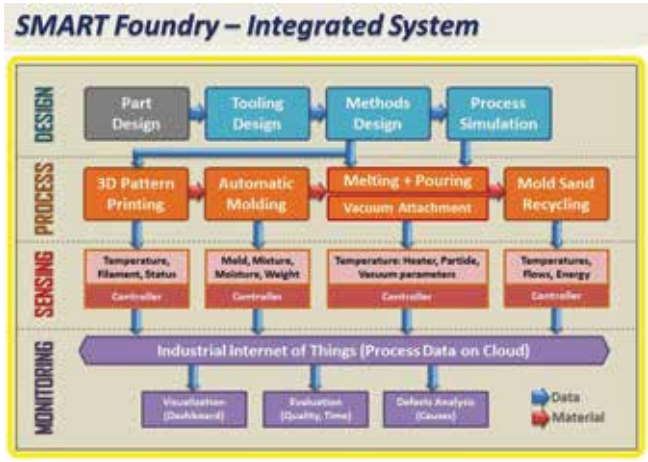


(a) Al-SiC FGMMC prototype armour plates fabricated and supplied to CVRDE, Chennai, (b) and (c) 2024 Aluminium-SiC infiltrated composite fabricated using 50%SiC preform

Figure shows five numbers of the Al-SiC FGMMC prototype armour plates fabricated and supplied to CVRDE, Chennai. (a) shows 2024 Aluminium-SiC infiltrated composite plate fabricated using 50% SiC preform. The microstructure show the uniform infiltration of liquid aluminum into the propus SiC preform (b and c). The composite with 50% SiC volume fraction shows the maximum hardness of 205 BHN in the heat treated condition.

SMART FOUNDRY (Sustainable Metal Casting by Advanced Research & Technology)

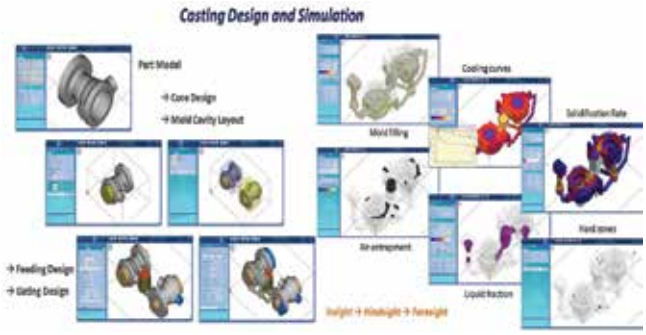
The primary objective was to develop Industrial IoT enabled compact metal casting system called **'SMART Foundry'** for rapid manufacture of small parts in light metal alloys (up to 1 Kg), which could be set up with an investment of Rs. 25 lakhs within a floor area of 25 m^2. The acronym SMART stands for sustainable metalcasting by advanced research and technology. This project is a multi-institutional project coordinated by CSIR-NIIST including 3 National Laboratories (CSIR-NIIST, CSIR-CMERI, CMTI, Bangalore) , 5 public Institutions (IIT-B, VNIT, Nagpur, COEP, Pune, Jadavpur University, Kolkatta) and 3 private educational Institutions (CHARUSAT, Anand, DKTE, Ichalkaranji, MEFGI, Rajkot) and 1 private industry (3D Foundry Tech Pvt. Ltd., Mumbai). There are five key technology drivers – virtual engineering, Cloud computing, smart sensors, Internet of Things, and big data analytics in this work. This is achieved by developing the complete product-process value chain as shown in Figure 2. It includes 3D modelling of the required part, tool design, optimal positioning of feeders and gates using in-house casting design & simulation software (AutoCAST X1), plastic 3D printing of pattern, no-bake sand moulding, direct melting and metal pouring using IIOT enabled machines.



Key modules are briefly described here.

(a) Intelligent Design

An integrated software AutoCAST X1 for casting methods design, solid modelling and basic and advanced simulation which was initially developed by IITB and CSIR-NIIST enables semi-automated decisions regarding part orientation in the mould, parting line, core prints, mould cavity layout, gating and feeding. The Tooling module of the software gives the cope and drag portions of the pattern. The software also simulates mould filling and casting solidification, followed by visualization of velocities, temperatures and cooling rates. It enables prediction of defects, and their prevention by appropriate changes to casting design.

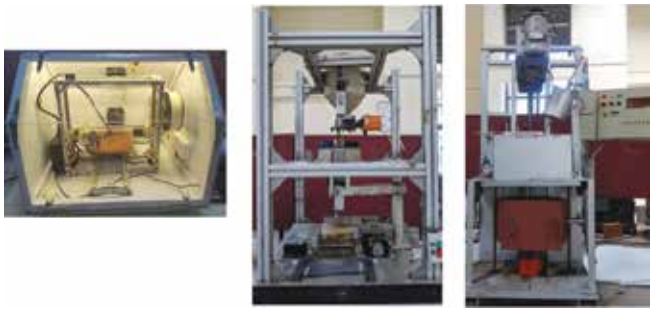


(b) Smart Manufacturing

SMART Foundry is comprised of three hardware units: 3D pattern printer, moulding, unit and direct casting unit.

3D Pattern Printer automatically fabricates cope and drag patterns (from their CAD models) layer-by-layer using fused deposition method. This improved printer is integrated with several sensors, which send real-time data to a controller, to monitor and control the process.

Smart Moulding Unit creates resin mould of consistent quality for casting of small components. It has four operations namely sand discharge, sand mixing, ramming and mould disengagement for preparing the cope & drag portions of sand mould with match plates. The process parameters are controlled by a central controller, which can be used in manual and automatic mode. Various sensors are integrated with the system for monitoring the process parameters.



Direct Casting Unit combines metal melting and pouring in a single system. The mould box is assembled and inserted below the crucible of the casting unit. It comprises a resistance heater type furnace with 70% thermal efficiency in the first melt itself. Sensors are embedded for collecting data for on-line and off-line data analytics. The first casting (1 kg aluminium) can be produced in 55 minutes and subsequent casting in 25 minutes. The unit has add-on modules for vacuum-induced casting and metal-matrix casting (with particle adding and stirring). The system is computer controlled and integrated with data acquisition for monitoring and logging through smart interfaces and devices.

(c) Data Sensing & Analytics

An IOT platform was developed in-house by the project team for data sensing and collecting from the hardware units of SMART Foundry. It has cloud-based dashboards for data monitoring through display of live data streamed from sensors in various hardware units. Control buttons on the dashboard enable critical operations like emergency on/off for sub-systems and overall power shutdown on emergency. The data is analysed using Bayesian inference, for identifying critical parameters along with their specific range of values to achieve the desired quality of metal casting.

The integrated system shown in Figure 6 which is under trials is now ready for demonstration at CMTI and for commercialization.

Mg-Rare Earth based alloys for Bio Implant Applications

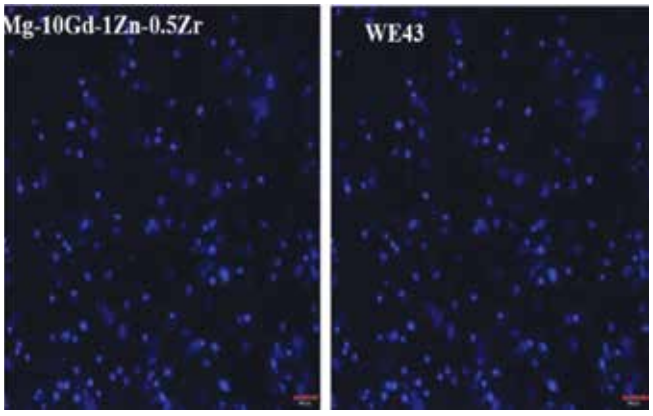
Magnesium alloys and composites have shown excellent potential in bone repair applications. The degradable magnesium based materials eliminates the need of a second surgery to remove the implants. In

addition, most of the studies report that the degradation products of magnesium based materials are usually not toxic, provided the degradation occurs in a controlled manner. Some of the Mg alloy based products are under clinical trials in Europe and China. However, significant advances are to be made to limit the degradation rate to avoid the premature failure of the implants. Researchers have thus focused on further alloy modifications and surface treatments to address the issues.

Mg-RE based alloys are known for high strength and corrosion resistance in Mg alloy systems. Mg-Y-Nd (WE43) alloy is a familiar bench mark alloy system in Mg-RE alloy systems mainly used for high temperature application in aerospace industries. Number of studies suggested that WE43 alloy is highly suitable for biomedical implant applications. More recently, Mg alloy contain high soluble Gd added alloys are also developed with high strength and corrosion resistance for orthopedic scaffolding applications. Among various RE elements Gd is highly biocompatible and Gd based material is already in use for bio application. In a recently concluded SERB project we have developed few Mg-Gd-Zn based alloys with different ratio of Zn/Gd to toiler the microstructure with different intermetallics. Their complete in-vitro behavior, biodegradation and cell viability (in MG63 human osteosarcoma cell line) were carried out. Based on the results few alloys were screened for further in-vivo studies. Following are some of the observations from the study.

- Degradation rate of Mg-10Gd-1Zn and Mg-4Y-3Nd immersed in cell culture medium (MEM+10%FBS+1%Pencillin) for 14 days by maintaining solution volume to surface area of 1.25 cm2/ml were 0.79 and 0.68 mm/y respectively.
- Mg-10Gd-1Zn-0.5Zr showed superior mechanical properties with a Yield strength of 270 MPa, ultimate tensile strength of 328 MPa and % elongation of 12.76.
- Mechanical integrity of the alloys were studied by immersing the tensile specimens for 14 days in cell culture medium and still Mg-10Gd-1Zn-0.5Zr showed superior mechanical strength.

Photograph of the alloys before and after extrusion.



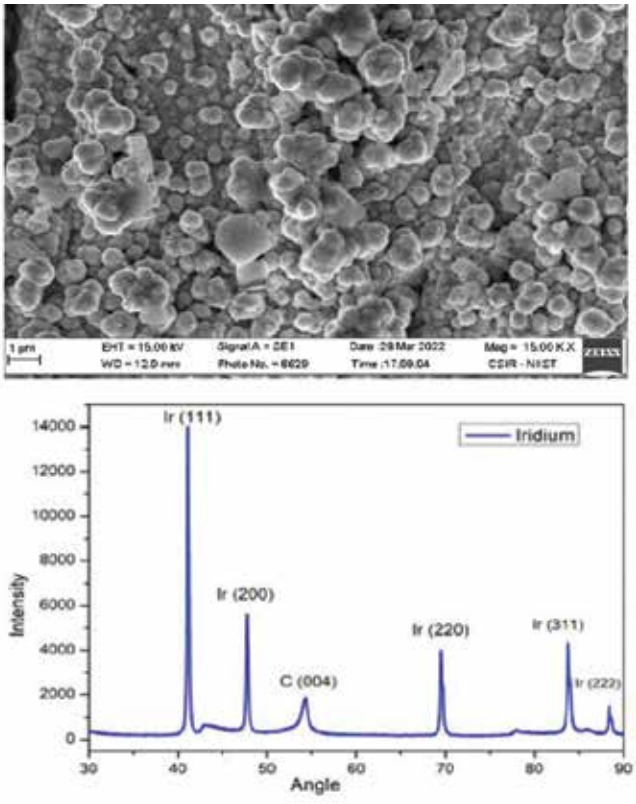
DAPI stained image of the cell nucleus after 3 days culture.

- In vitro cell culture analysis (MTT assay, DAPI staining) showed that Mg-4Y-3Nd was more viable in comparison with Mg-10Gd-1Zn. However, both the alloys were having a viability greater than 75% at all test conditions.

Development of Iridium Coating over Carbon-Carbon Composites for Space Applications

Carbon-Carbon Composites exhibit light weight and excellent mechanical properties at high temperature, high thermal stabilities, and better erosion properties for its consideration as a synergistic material for thermal protection system (TPS) and hot structures for re-entry applications, divergent cones and throats for rocket nozzles. However, carbon structural materials are prone to oxidation when the application temperature is higher than 400^{0}C, which severely restricts its high-temperature applications. Iridium (Ir) is considered as promising candidate for oxidation resistant materials at elevated temperature due to its high melting point (2430^{o}C), good chemical stability, low oxygen permeability etc. Considering the various merits offered by molten salt electrodeposition (ED) method for coating, it is proposed to develop the coating of Iridium (Ir) on Carbon-Carbon

Indigenously developed high temperature molten salt electrodeposition set up for Iridium coatings



SEM photograph and XRD pattern of iridium coated over C-C substrate

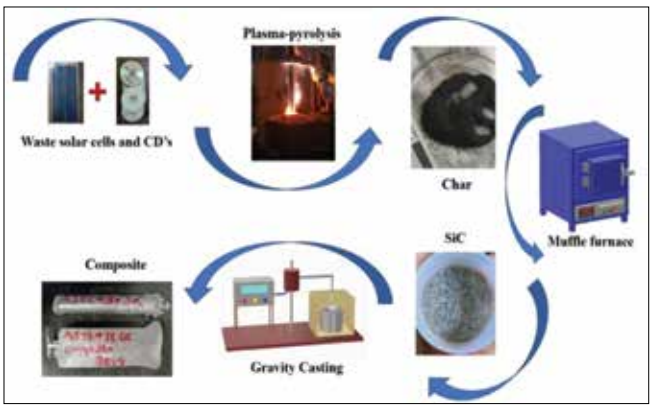
(C-C) Composite through molten salt electrodeposition. Iridium coated C/C composite combustion chambers will enable induction of C-C Composites based thrusters for Space crafts.

A high temperature molten salt electrodeposition set up under ISRO project has been indigenously designed and installed at NIIST. This is in line with the Make in INDIA programme of Government of India. Iridium has been coated over C-C substrate supplied by VSSC using a ternary salt system (NaCl-KCl-CsCl) as the electrolyte at 580° for 30 minutes. Formation of Iridium has been confirmed by XRD of the coated substrate and SEM photograph shows the morphology of coated Iridium. The optimization of the coating parameters and uniform coating with required thickness are in in progress.

Minerals

Novel recycling approach for transforming the solar panel wastes into SiC bearing resource

Solar panel waste has recently been included in the category of waste electrical and electronic equipment to restrict the negative influence of continual development. In India currently 200,000 tonnes of solar photovoltaic waste are expected to be produced by 2030 and 1.8 million tonnes by 2050. Globally it will increase up to 60 million tonnes. Solar cell is primarily composed of glass, plastic and aluminium and these are recycled in mass quantities except other rare, finite recoverable elements include copper, silver, tin. Current recycling methods are just recovering a portion of materials so there a plenty of research for this progress.



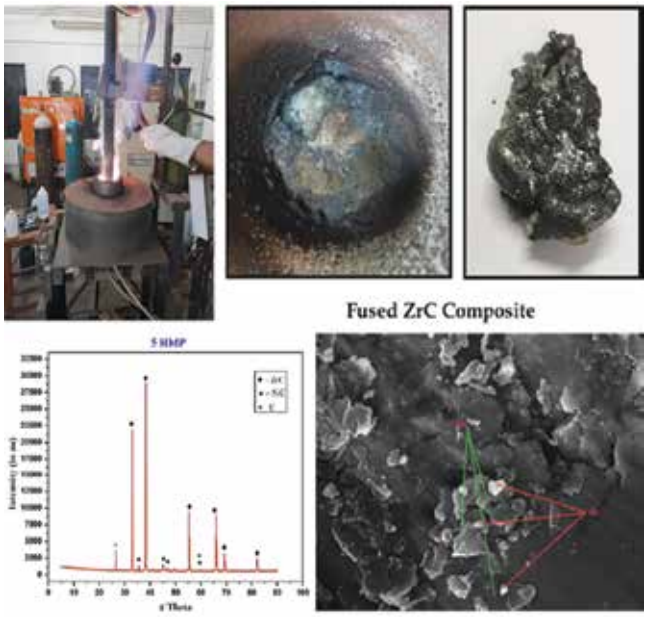
In this study aims to establish a novel pathway for transforming complex electronic waste into an advanced hybrid material. The transformation process consisted of two steps. In the first step is the synthesis of silicon carbide from end-of-life solar panels and discarded compact disc (CD). In the second step these SiC were combined with Al alloy to produce a composite by gravity casting.

The waste solar panels and compact disc which was collected from two different sources. The non-metallic fraction of end-of-life solar panel waste and compact disc was subjected to combined plasma pyrolysis at 2000°C in an argon atmosphere for 25min. The resultant char again subjected to heat treatment for 3hrs at 900°C in muffle furnace.

Stir casting/Gravity casting is a liquid technique in which a molten slurry of metals with solid phase additives of different compositions are prepared, transferred, and allowed to solidify in a preformed cavity. A uniform distribution of SiC in the A356/SiC composite slurry is prepared by melting A356 aluminium alloy in the melting chamber and introducing micron sized preheated SiC powder in the vortex created by mechanical stirrer rotating at constant speed in the molten A356 aluminium alloy. The molten metal slurry of A356 alloy with SiC particles is transferred to a preformed die set with pouring temperature at range of 650-700°C and allowed to solidify. The obtained composite is subjected to mechanical studies such as hardness, density, tensile strength. SiC is an extremely important ceramics material in application area due to its important properties such as abrasion resistance, high melting point and thermal stability.

Direct thermal plasma dissociation of zircon for making ZrC composites for high temperature applications

The synthesis of ceramic powders through thermal plasma technology is an active field of research as thermal plasma process facilitates both equilibrium and non-equilibrium phase transformations. The advantage of thermal plasma processing is that we can achieve very high temperature (2,000 – 20,000 K) within a short span



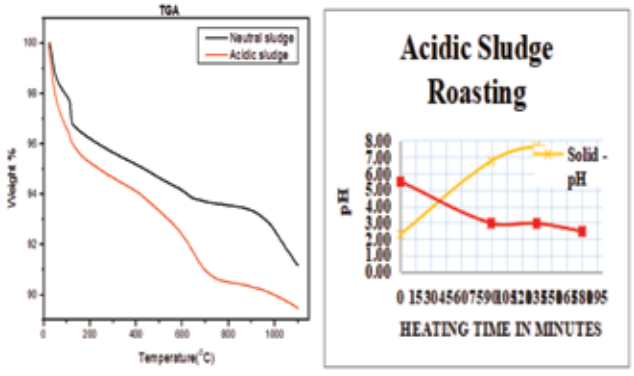
XRD and SEM of ZrC –SiC composites

of time and can attain very high energy density (104 – 107 W/cm2) as compared to conventional chemical reactions. In recent years the fabrication of ZrB2-SiC-HfC and ZrC-SiC-HfC Super-strong materials have been possible through thermal plasma processing of zircon sand and activated charcoal. Due to excellent properties such as high fracture strength, high temperature resistances, high erosion and chemical resistance, Zircon and Silicon Carbide are categorized under structural ceramics. The only limitation of these ceramics is low mechanical strength at high temperatures which can be overcome by using biphasic powder mixtures of very hard and tough compounds such as zirconia and silicon carbide and hafnium. Thermal plasma dissociation of zircon sand has been studied in 40 kW thermal plasma reactor. The reactor essentially consists of two graphite electrodes, arranged vertically inside a double walled water-cooled reactor vessel. Top electrode (cathode) has an axial hole and has a provision to introduce particle feed and plasmagen gas. It is attached to a rack and pinion mechanism to enable a vertical movement for arc stabilization. The bottom electrode (anode) is fixed. Product is collected in a split pan fixed to the bottom electrode. The reactor is simple and inexpensive and the performance of the reactor found to be excellent with respect to arc stability, particle flow ability and

penetration of particles into hottest zone of plasma. It was noted that sample milled for more than 3 hours were able to be form the composite upon heating to a temperature above 1600^{O}C in plasma furnace.

Neutralization of Titanium oxide acidic sludge by Recovering Sulphur from in the form of Sulphuric acid

Titanium industries use the sulfate process to treat the ilmenite mineral and are based on the digestion of the ilmenite with sulfuric acid, followed by thermal hydrolysis of the titanium (IV) ions in highly acidic solutions, and then by the calcination of the obtained titanium(IV) hydrous oxides. 7 Metric tonnes/day of TiO_2 acidic sludge and it contains > 60% of TiO_2 as a waste which is not being utilized as of now. For temporary solution, these acidic sludges are neutralized with the addition of CaO. In view of the stringent environmental guidelines and other socio-economic issues related to effluent disposal, a scientific intervention is needed to utilize the industrial waste to extract the value-added mineral. The typical composition of both acidic and neutral sludge is given below along with the treated/ roasted acidic sludge after recovering the S in the form of Sulphuric acid. Further this, neutralized solid sample will be used for producing Ti-Fe-Al alloy.



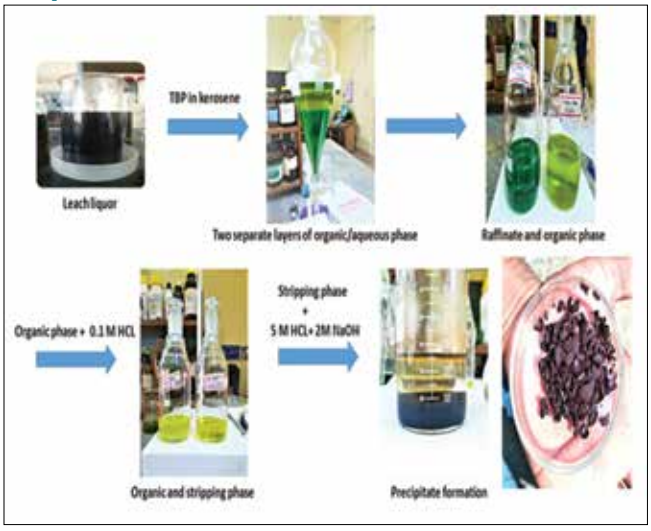
TG Results of both acidic and neutral sludge Change in Solid sample pH and DM water pH w.r.t. time

SiO_2	TiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	LOI	
Acidic Sludge	15.2	48.4	2	11.1	0.19	0.44	4.52	16
Neutral Sludge	19.4	39.6	4.69	8.15	4.43	0.67	4.02	16
Acidic Sludge_ Roasted	18.4	60.1	2.5	14	0.22	0.48	0.57	1

Recovery of Scandium metal from acid leach liquor from Titanium mineral industries

In this laboratory scale study, we investigate the Recovery of Scandium metal from acid leach liquor from Titanium mineral industries by solvent extraction route. A series of solvent extraction experiments were carried out on the leach liquor sample using different organic solvents (Tributyl phosphate/TBP). Multiple stage separation process carried out for separation of other scandium from Other REE's. Each stage studied for elemental concentrations. Solvent extraction products and each stage aqueous/organic phase samples analyzed by ICPMS. The mass balance for the recovery of Scandium from the leach liquor was calculated and it was found out that in order to get 1 g of dry scandium oxide powder, around 50 liter of leach liquor has to be processed. Advance characterization such as XRD, XPS and SEM were used for determination of Scandium in both raw material and final product. Metalothermic reduction studies to obtain pure scandium metal were studied with tailor maid reduction assembly furnace.

Graphical abstract:



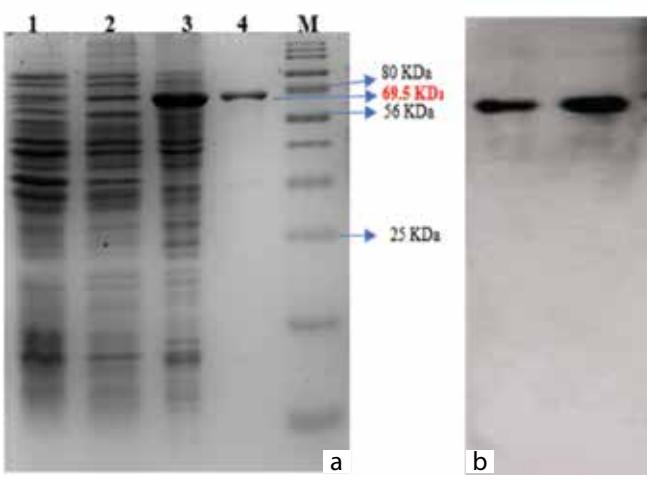
MICROBIAL PROCESSES AND TECHNOLOGY DIVISION

I. Bioprocesses and Products

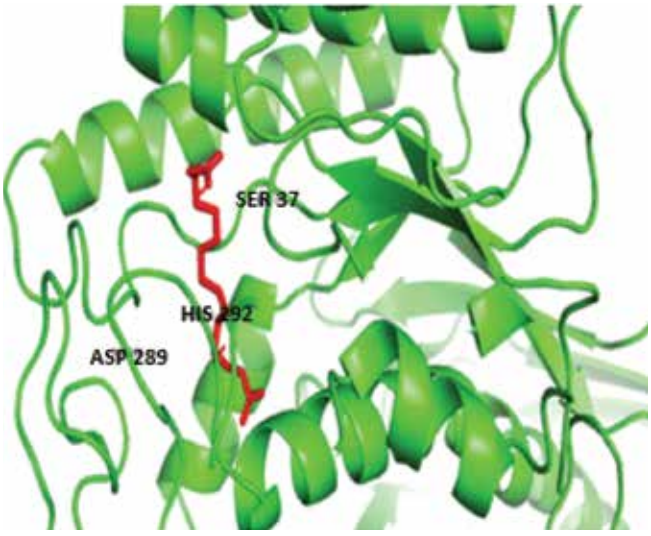
1. Industrial Enzymes

1.1 Heterologous expression, purification and characterization of a novel Outer membrane lipase/ esterase gene of *Pseudomonas guariconensis*

Esterases and lipases from microorganisms have attracted attention for their potential applications in the pharmaceutical, food, biochemical, and biological interests. Outer membrane lipase/esterase is an autotransporter (AT) protein belongs to the GDSL family (equivalent to the classical GXSXG motif of lipases/esterases) produced and secreted by gram negative bacteria with catalytically active serine as nucleophile. A novel outer membrane lipase/esterase (OML) gene of *Pseudomonas guariconensis* was cloned and expressed in *E. coli* BL21 (DE3) cells. Outer membrane lipase /esterase has an open reading frame of 1863 bp and encodes the 621-amino acids, which contains an autotransporter (AT) domain (350–621 amino acids). The purified proteins showed a band around 69.5 KDa and the his- tag specific antibodies were used to confirm the purified protein using Western blot analysis. The biochemical characterization and the bioinformatics analysis was also used to predict the active site and other *invitro* findings like substrate specificity which confirmed the higher substrate specificity of OML towards the fatty acid ricinoleic acid as compared with other long chain fatty acids (Fig 2). Molecular dynamics (MD) was performed using GROMACS v2020.6 which, an open-source tool in order to predict the stability of the protein and protein ligand (OML-ricinoleic acid complex).The intact protein was simulated at 268.15K (–5°C), 278.15K (5°C), 293.15K (20°C), 310.15K (37°C), 313.15K (40°C), and 333.15K (60°C) temperature. RMSD graph showed that protein has minimum fluctuation at 313.15K 40°C).



a). The result of SDS-PAGE gel showing the purified recombinant protein OML b)Western blot analysis of the His tagged purified OML.
Lane 1: Induced control, Lane 2: Soluble fraction, Lane 3: Insoluble fraction, Lane 4: Purified OML , Lane M: Marker (11-245 KDa)



Docking study of OML using AutoDoc Vina showed the binding energy with ricinoleic acid as -7.4 Kcal/mol.

2. Biopolymers, Bio-surfactants and Microbial Metabolites

2.1. Environmental impact assessment of the process for sorghum biomass to 2,5-furandicarboxylic acid through Life Cycle Analysis

The main goal of the study was to quantify the environmental impacts of sorghum biomass to 2,5 - furandicarboxylic acid (FDCA) production. The functional unit of life cycle analysis was the production of "1 Kg of FDCA" at the factory gate. The "cradle to gate" approach was chosen for the processes where the processes from sorghum cultivation up to the production of purified FDCA. The complete process of sorghum to FDCA synthesis was segmented into four sub systems (SS).

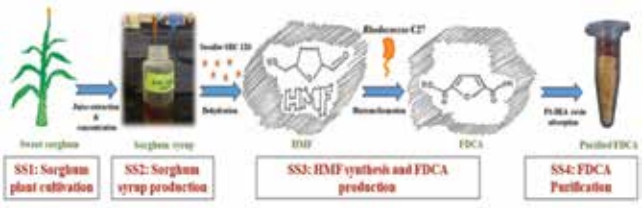
SS1-Sorghum plant cultivation: The data of land preparation, water irrigation, fertilizers and chemicals were collected. The cultivated sorghum stalks were crushed for juice preparation.

SS2-Sorghum syrup production: The juice was extracted from the sorghum stalks and sorghum syrup was produced by concentrating the extracted juice.

SS3-HMF synthesis and FDCA production: HMF was produced from sorghum syrup through Seralite SRC 120 cationic resin mediated dehydration. All the input data was calculated and validated. Sorghum syrup derived HMF biotransformation to FDCA was carried out using *Rhodococcus qingshengii* C27. HMF synthesis and FDCA production processes were made as one subsystem because of the unutilized sugars (glucose and fructose) of HMF synthesis were directly used for the *R. qingshengii* C27 enrichment/boosting. Therefore, the inventory data of HMF synthesis and FDCA production were given in subsystem 3.

SS4-FDCA purification: The produced FDCA was then purified and recovered using PS-DEA mediated adsorption. The system boundary with other processes, i.e. sorghum to purified FDCA is given in Figure 3.

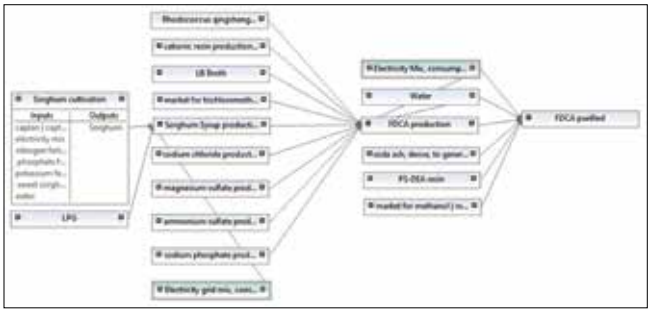
The method for the environmental impact assessment of the current study was TRACI 2.1 (Tool for the Reduction and Assessment of Chemical and other environmental Impacts) developed by Environmental Protection Agency (EPA). TRACI 2.1 has 10 impact



System boundaries of sorghum biomass to FDCA production

categories (environmental and human health related). The open LCA v 1.10.3 software was used for the LCA study. SuperPro12.01.1002 software was used to calculate the standard power consumption for different process (fermenter, centrifuge etc.).

The model graph of product system was made through OpenLCA software. This product system involves all the inputs and outputs from sorghum plant cultivation, sorghum syrup production, FDCA production and FDCA purification. All the unit processes were linked with supply chains in the product system.



FDCA product system- model graph

The environmental impact analysis was done with 10 impact categories. The complete results are given in Table 1. In all categories we considered 5% above contributors. The LCIA category includes seven environmental impacts and three health related impacts.

Table 1. Life cycle impact analysis results

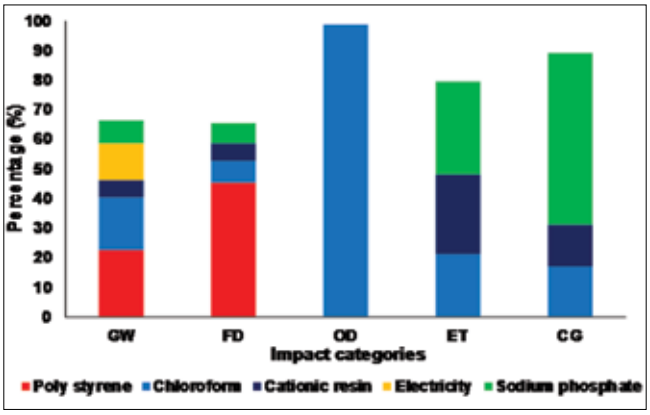
LCIA category	Unit/Kg	LCIA result
Eutrophication	kg N-eq	0.22817
Acidification	kg SO2-eq	0.349
Fossil fuel depletion	MJ surplus	108.01
Global warming	kg CO2-eq	72.404
Carcinogenesis	CTUh	7.23031E-6
Ozone depletion	kg CFC-11-eq	0.00548

Non carcinogenics	CTUh	2.27344E-5
Smog	Kg O3 eq	3.365
Ecotoxicity	CTUe	703.181
Respiratory effects	kg PM2.5-eq.	0.006320

The major contributors in all environmental impact categories were studied and compared based on their contribution percentage (Table 2). Most important five impacts were selected such as global warming (GW), fossil depletion (FD), ozone depletion (OD), eco toxicity (EC) and carcinogenesis (CG). The major contributors were polystyrene, chloroform, cationic resin, electricity and sodium phosphate. Most of the contributors were from HMF and FDCA purification (chloroform and polystyrene). The major electricity usage was for fermenter, electrical heating (HMF synthesis) and centrifugation. Among all contributors, chloroform was the most contributing factor for all environmental impacts. Especially, the 99% contribution in ozone depletion. The sodium phosphate was the next contributor; it was mainly used in the FDCA production (QMSM). The sodium phosphate contributes 57.89% in the carcinogenesis, still it is not directly involved in the sorghum to FDCA process (sodium phosphate production process). The polystyrene was contributed in the global warming and fossil depletion. We used polystyrene in the PS-DEA (polystyrene Diethanolamine) resin synthesis for FDCA purification. The cationic resin was used for HMF synthesis (sorghum syrup derived sugar dehydration). It is contributing to the ecotoxicity and carcinogenesis (26.91% and 14.15% respectively). The comparative study clearly indicates that environmental impacts can be reduced by changing raw materials used in the HMF and FDCA purification.

Table 2. Environmental impact contribution (percentage)

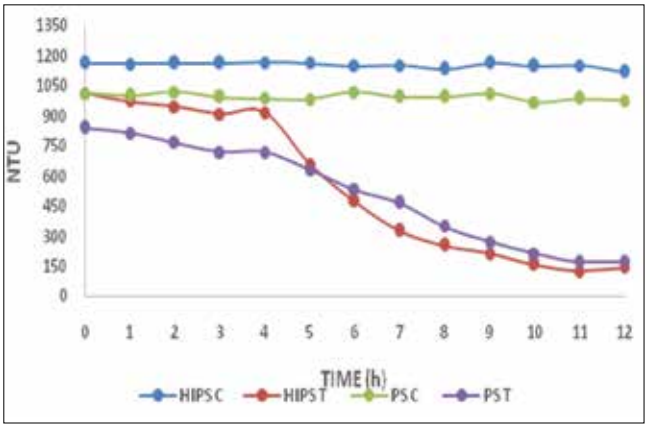
Contributors	GW (%)	FD (%)	OD (%)	ET (%)	CG (%)
Poly styrene	22.5	45.5	0	0	0
Chloroform	17.7	7.0	99	21.3	17.27
Cationic resin	6	6.0	0	26.91	14.15
Electricity	12.4	0	0	0	0
Sodium phosphate	8.0	6.92	0	31.32	57.89



Environmental impacts and major contributors

2.2. Molecular Investigation on microbial degradation of polystyrene

Plastics are becoming an inevitable part of our daily life due to their versatility, low cost and lack of competing alternatives. At the same time, it has already gained notoriety as an environmental killer. Polystyrene is a widely used plastic among all plastics, and widely reaching on all over the environment because of its use as a onetime use packaging material. Polystyrene has a stable chemical structure, and it makes this plastic extremely difficult to degrade in the environment after disposal. In this study, we are focusing on some possible ways such as biodegrdation or flocculation methods of micro and nano plastic mitigation by microorganisms. One of the isolates, *Alcaligenes sp* was found to be capable of flocculating the high impact polystyrene (HIPS) and polystyrene(PS) emulsion which comes in nanoplastic range. Both *Alcaligenes sp.* culture supernatant and extracted bioflocculant can settle the prepared HIPS

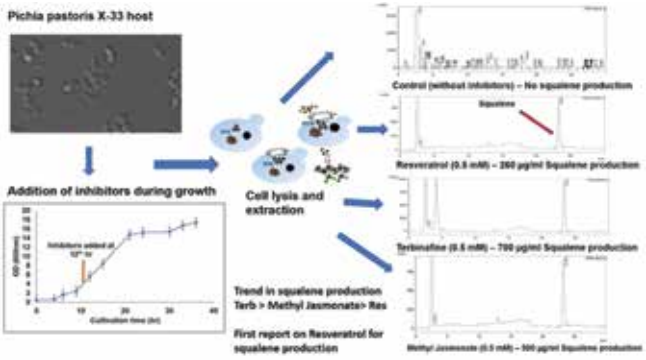


Change in turbidity of polymer emulsions with time by Alcaligenes supernatant.

and PS emulsion and showed a turbidity clearance of 85.7% (HIPS) and 79.1% (PS) with 12 h of settling time.

2.3. Engineering methylotrophic yeast *Pichia pastoris* for enhanced production of the triterpene Squalene

Triterpenes like squalene finds immense applications ranging from anti-cancer to anti-oxidant, vital lipid in cosmetic industries, detoxifier and as an adjuvant for vaccines to boost the immune response. Annually, 2.7 million sharks are killed for application of squalene in cosmetic industries and 500,000 sharks may have to be sacrificed to meet the global COVID vaccine supply. Alternative to shark liver squalene (1ton squalene from 3000 sharks), plants, fungi and yeasts were found to be attractive host. However, considering factors like ease of genetic manipulation, accumulation volume per gram Dry Cell weight (DCW) yeasts were identified as suitable host. In general yeast accumulates 0.04-70.32 mg/g DCW of squalene as compared to fungi that accumulate up to 0.3 mg/g DCW of squalene. In this study, industrial host *Pichia pastoris* which is well established for recombinant protein production will be exploited for the metabolite squalene production. Squalene accumulation in yeast cells is mediated by selective rate limiting enzymes and not by the entire enzymes of a pathway reported in previous studies. In mevalonate pathway, HMG CoA reductase (HMGR), ERG20 (FPP synthase), ERG9 (squalene synthase) and ERG1 (squalene epoxidase) are known to be the bottleneck enzymes that control the squalene accumulation inside the cells. Hence in this study, overexpression of key genes namely HMGR, ERG 20, ERG 9 would be individually studied on the ERG 1 downregulated clones. Individual strain harbouring each of the gene would be compared to the strain with the all the three incorporated genes. Terbinafine has been the major inhibitor used in previous study to downregulate ERG1 (squalene epoxidase). In our study, alternative inhibitors like methyl jasmonate and resveratrol would be tested for its efficacy. Preliminary studies show improved production of squalene upon addition of inhibitors like Terbinafine, Methyl jasmonate and Resveratrol.



Effect of different inhibitors on the production of squalene

3. Probiotics and Nutraceuticals

3.1. Development of Probiotic and Functional Yoghurt

The consumption of fermented food products has outgrown the market demands since last decades to improve and maintain a healthy lifestyle. To enhance the food quality and nutrient enrichment, food fortification plays a major role and among all the known fermented dairy products, yoghurt is high on demand. We currently work on studies that deal with (1) the fortification of skim-milk yoghurt with incorporation of LAB (Lactic acid bacteria) exopolysaccharides for improvement in texture and (2) production of vegan-milk yoghurt with enrichment of antioxidants and total phenolic contents. Both these yoghurts with high nutritional benefits and health-promoting additives serves as functional foods as the fermentation is carried out by a NIIST consortium of food grade lactic acid bacteria especially *Streptococcus* (NCBI accession no: MT176494), and *Lactobacilli* (NCBI accession no: MN176402) species. With the emerging trend in functional foods and acceptance of pre-biotics, pro-biotics and post-biotics in the food industries, the use of potent starter cultures is becoming a mandatory factor. In the yoghurt preparation, we use *Streptococcus* strain as the potent starter culture as it can curdle the milk in 6-8 hours both in vegan-milk as well as skim -milk. Other different criteria that this starter culture possesses includeproduction of desirable flavour, aroma, consistencyand texture in the fermented products. The culture is acid tolerant, shows bile salt resistance, produce antibacterial compounds, have a good acid production ability to name a few. They are characterized to have good curdling abilities, acid, and bile salt tolerance,

Skim Milk Yogurt fermented with *Streptococcus* starter culture enriched with EPS for texture improvement.

provides firmness with rich textural properties. Secondly, the *Lactobacillus* strain, *Lactobacillus plantarum* is reported to produce an exopolysaccharide, a potential postbiotic, with good antioxidant properties. These exopolysaccharides are characterized as glucomannan type of heteropolysaccharides. Further investigations of the products under progress

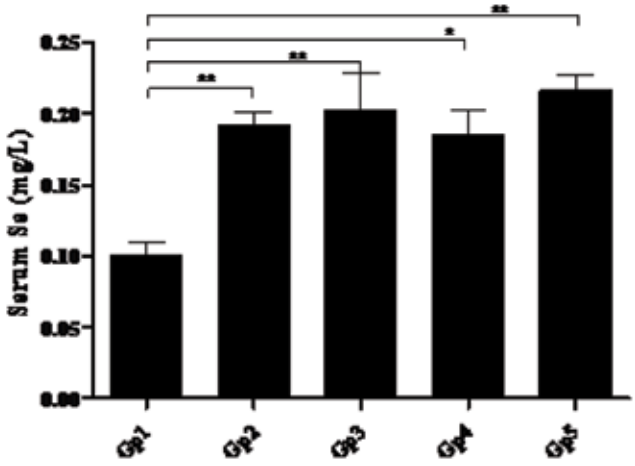
3.2. The organic selenium-enriched microalgae: Scale up in 50 L Photobioreactor

The scaling-up process of Selenium-enriched microalgae involves selenium enrichment and enhancement of selenoproteins as a form of organic selenium in microalgae. The edible marine microalga enriched with over 99% organic selenium was scale up for large scale commercial cultivation. Initially, the microalgae are cultured in 250 ml, 1 L Erlenmeyer flasks, then to 5 L and scaled up into 50 L Photobioreactor.

Photograph showing cultures are growing on a large scale on photo bioreactor (50 L x 4 (Cultures in each reactor are in the different stage)

3.3. *Validation of organic Se enriched biomass as food/feed suppliment*

Serum selenium: Serum selenium was found to be increased in all experimental groups when compared to control. In all Se fed groups including both organic and inorganic, serum Se level increased very significantly as compared to control. In control alga fed group (group 4) also, there was a significant increase in serum Se level as compared to control. Difference in serum Se level among group 2- 5 was insignificant.



Effect of organic Se enriched *N.oceanica CASA CC201* on serum selenium. In all experimental groups serum selenium level has increased when compared to control. Among the experimental groups, the Se levels were higher in groups 3 and 5 ($P<0.001$) as compared to control.

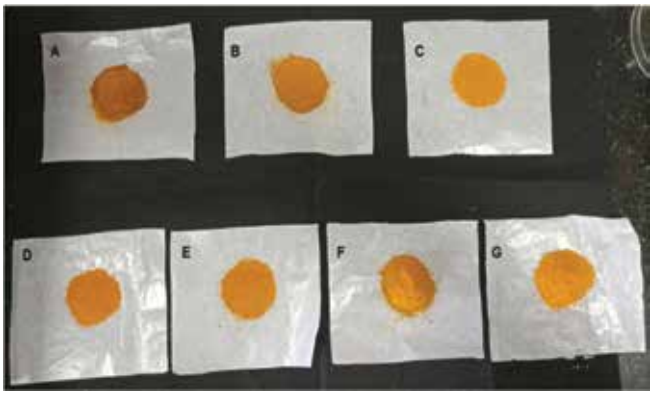
3.4. Biochemical profiling of Edible marine microalga:

Green extraction technology was adopted for the suitability of usage of end products in the food industry and soxhlet-based extraction using hexane and ethanol was performed. Ethanol was not effective for complete deoiling since fats are sparingly soluble in alcohols whereas 80 cycles of hexane-based extraction resulted in complete fat-free biomass. Phosphovanillin assay shows that this oleaginous microalga as the name implies possesses higher lipid content (44.85 %) and constitutes almost half the proportion of entire biomass. The native release of protein was found to be 28 % in Microalgal Biomass (MB) and there was a significant loss in the case of deoiled biomass (DMB) (14.2 %), this can be probably due to the loss of lipid anchored proteins which might have leached out of biomass

into the solvent during the process of extraction. In contrast, carbohydrate content was increased after the lipid extraction (39 %) in DMB compared to MB (25.76). Ash content was almost similar in both. Moisture content was 7.88 % in MB and it was slightly increased to 8.31% in DMB upon solvent extraction. Chlorophyll a and Carotenoid content was observed more in MB in comparison with DMB whereas chlorophyll b content was very negligible in both. Besides this, it was also investigated that ethanol-based extraction is suitable for pigment-free biomass production and the maximum amount of pigments can be extracted together with lipids from solvent. From the comparative biochemical analysis, it was found that most of the biomolecules were partially lost in the process of solvent extraction and the procedure adopted is not enough to break the cell wall and release those active molecules outside the cell. In this aspect for valorising de-oiled biomass as a major coproduct from the biofuel industry, more studies have to be performed and the best strategy has to be finalized for future bio economy.

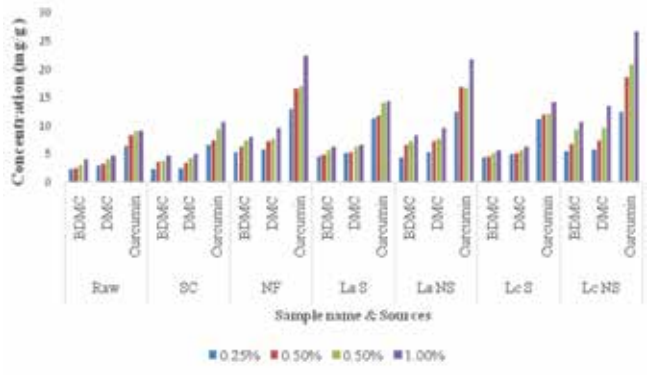
3.5. Fermentation of Fresh Turmeric and Fermented Turmeric Product (s)

Turmeric (*Curcuma longa* L.) is the only edible dietary source of curcuminoids. The three major curcuminoid components in turmeric are curcumin, de-methoxy-curcumin (DMC) and bis-de-methoxy-curcumin (BDMC). The interest of the scientific community on curcumin increased in the last decade owing to its bioactivity in humans and as curcumin is implicated as anticancer, anti-inflammatory, immunomodulatory and having liver protective and multiple other beneficial effects. However, curcumin shows low body absorption through oral route, poor bioavailability and the taste of curcumin /turmeric is unpleasant/bitter for direct consumption. Recently, fermentation by probiotic bacteria has drawn the attention of both scientific research and agricultural industries as a way to improve the nutritional value, flavour, and aroma of food. Probiotics are well known for their beneficial effects on the host; hence, fermentation of plant resources with probiotics might synergistically amplify their beneficial properties. To date, several fermented turmeric products have been developed that not only enhance liver function but also improve palatability while having antioxidant, anti-obesity, and antimicrobial activities, Probiotic fermentation of turmeric was undertaken as a sponsored project funded by M/s Abrin Aldrich, Ernakulam, Kerala to develop fermented turmeric products with improved palatability and enhanced release of curcuminoids. Probiotic *Lactobacillus* cultures were employed for the turmeric fermentation.



Powder preparations from rhizome samples A) Raw turmeric B) Sterilized turmeric C) Fermented with natural microflora [NMF] D) Fermented with *Lactobacillus acidophillus* E) Fermented with *L. acidophillus* & NMF *F)* Fermented with *L. casei G)* Fermented with *L. casei* & NMF.

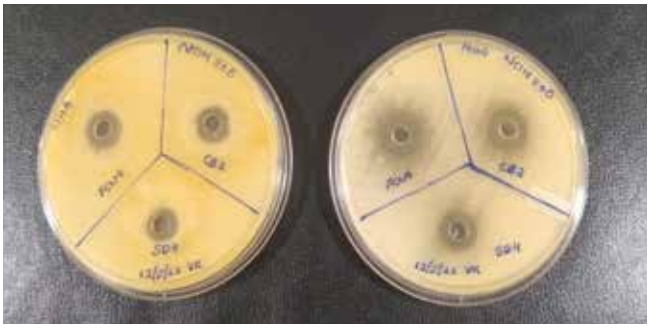
Fermented turmeric were prepared using different latic acid bacteria and the solid part were removed and dried showed improved palatability (no bitterness and improved flavour compared to unfermented turmeric. Also the liquid from fermentation process has enhanced content of curcuminoids showing that fermentation could release curcuminoids from the cell wall of turmeric rhizome. The HPLC analysis report revealed that fermentation with two *Lactobacillus* strains as well the natural microbial flora improved the curcuminoid content. Upon fermentation, the curcuminoid content was significantly increased (~ 2 fold) in fermentations with *L. casei* and Natural Microbial flora. Similarly, in both Natural Microbial flora (NMF) alone and in *L. acidophilus* with Natural NMF there was approximately1 fold increase in curcuminoids content. Meanwhile, the curcuminoid content of turmeric when fermented alone with *L. acidophilus* or *L. casei* were similar and slightly improved when compared to unfermented turmeric. Overall, the curcuminoid content in turmeric fermentation liquor was markedly enhanced through natural fermentation along with *Lactobacillus* strain.



HPLC analysis of curcuminoids content in fermented turmeric liquid of different inoculum percentages. Abbreviations: Raw - Raw turmeric rhizome samples, SC - Sterilized Control, NF - Natural Microflora, La S - Fermented with *L. acidophilus* sterile, La NF - Fermented with *L. acidophilus &* Natural Microflora, Lc S - Fermented with *L. casei,* Lc NSFermented with *L. casei &* Natural Microflora

3.6. Biotechnological approaches promising grains and food free of *Fusarium* mycotoxins

Mycotoxins are secondary metabolites with low molecular weight formed by filamentous fungi that are generally resistant to different environmental factors and therefore undergo slow degradation. The major mycotoxins produced by *Fusarium* species are Deoxynivalenol, Fumonisin, Zearalenone and T2/HT2 toxins, which are known to cause harmful effects on humans and animals. Recent research suggests that LAB is the best choice for extenuating fusarium mycotoxins. Sour dough, pickle, curd, cheese, goat dung, cabbage, carrot, new-born faeces etc were the sources used to isolate *Lactobacillus* bacteria. Isolates were selected and characterized by using Gram staining, Catalase test, $CaC0_2$+MRS Agar clear zone assay. Modified MRS was the media used for antagonism studies. Antagonism studies reveal that FCW4,CB2,SD4 are the potent cultures which can effectively inhibit both the *Fusarium monoliforme* strains (NCIM 1099 and NCIM 1100). Well diffusion assay was conducted to confirm the anti-fungal activity of the isolates against *Fusarium*.

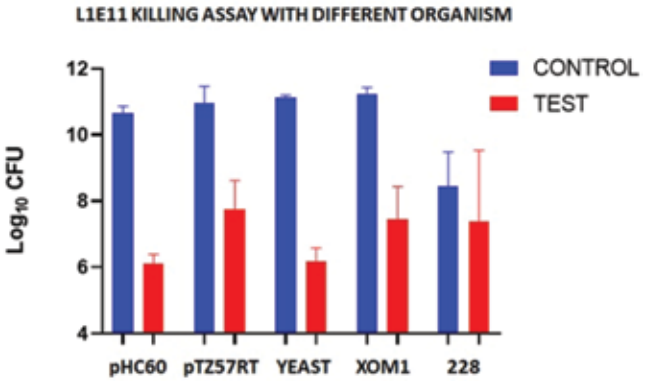


Well diffusion assay of *Fusarium monoliforme* NCIM 1100 against Lactic acid bacteria isolates, FCW 4CB2 and SD4

4. Plant Microbe Interaction

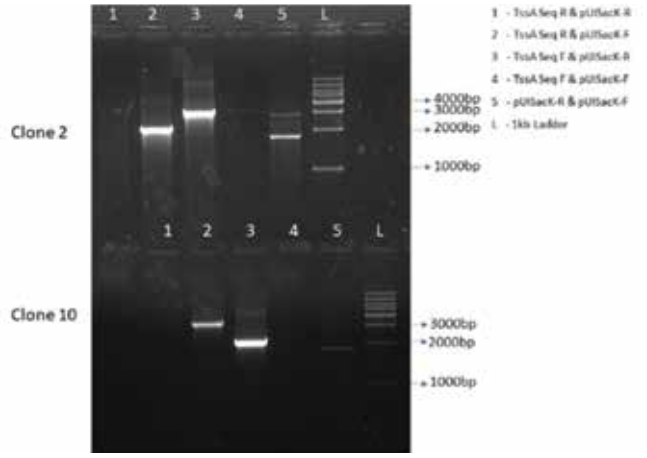
4.1. Genetic Dissection of Type Six Secretion System (T6SS) in *Pokkaliibacterplantistimulans* and its functional role in pokkali rice symbiosis under brackish conditions

The synergistic interactions between plant-microbe have been studied extensively for the past few decades. Plants and microbes have co-evolved to exhibit a complex network of interactions, mutually benefiting each other with deeply orchestrated by the external environmental conditions. Understanding the triangle of plant microbe interactions to know how environmental factors modulate this crosstalk is an emerging area of research. Our research on *Pokkallibacterplantistimulans* ($L1E11^T$), a novel mutualistic plant growth promoting bacteria has revealed a tight interaction with its host; salt tolerant pokkali rice under a highly competitive and complex brackish environment. Our in-vitro competition assays proved to be supporting our observation where we observed a contact dependent killing of $L1E11^T$ with different prey species (Fig. 14). Exploring the competitive ability of $L1E11^T$ in root association we identified key genes crucial for root competition as Type six secretion system (T6SS). To decipher functional role of T6SS in $L1E11^T$, we adopted genetic manipulation in $L1E11^T$ importantly, to disarm the T6SS machinery by targeted knockout of crucial T6SS genes (*clpV* and *tssA*). We employed pUISacK knockout vector, a sacB based



Recovery of different prey organism after killing assay.

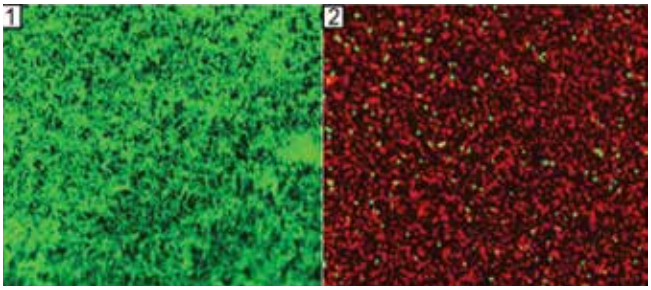
marker less suicide vector for our genetic studies. The structural gene *tssA* was selected for targeted gene knockout. Briefly 750bp upstream and downstream of *tssA* gene was amplified and cloned to pUISacK by Gibson assembly method. The construct was conjugated to L1E11^T by bi-parental mating using E. coli S17-1 strain. The first homologous recombinant clones were confirmed with specific flanking primers (Fig. 15) and was subjected to sucrose counter selection in LB medium with 5%, 10%, 15%, 20% and 30% sucrose,



Confirmation First Homologous recombination by pUISacK-TssA by specific sequencing primers

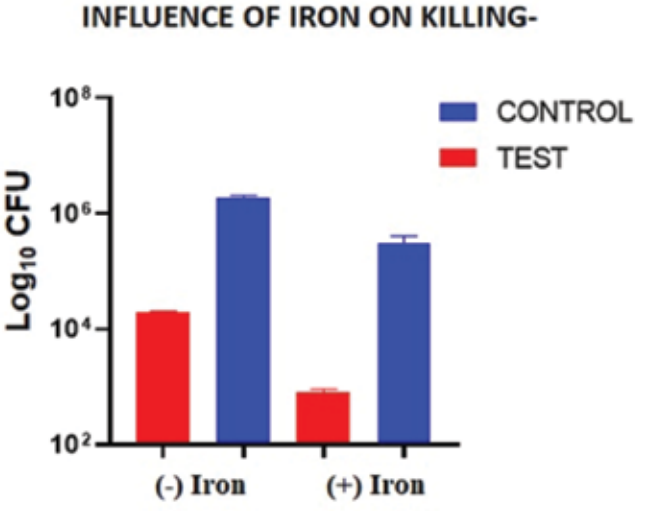
but failed to attain second homologous recombination and gene knockout in L1E11^T. Nearly 1000 clones were screened for knock out mutants but all the clones were sucrose and antibiotic resistance. Collectively, from our experiment the present strategies that we have devised for sucrose counter selection proved to be in-efficient to induce gene knockout in L1E11^T even though we tried different suicide vectors (pKmobSacB, pDM4) which intensifies our manipulation approach even more hard. Additionally, finding a compatabile vector for genetic manipulation was challenging due to the replicative ability of the suicide vectors inside L1E11^T which interferes with the integration process. The lack of a suitable antibiotic resistant gene for the selection of transconjugants negatively affected our screening strategies.

Alternatively, random mutagenesis approach was employed in L1E11^T to identify novel genes involved in interbacterial competition as well as and rhizosphere fitness. *E. coli* pRL27, a tn5 based random mutagenesis



Visual screening of L1E11^T mutants for killing efficiency based on fluorescence intensity after 6hr incubation on agarose pad. (1). *E. coli* alone visualised in 40x resolution. (2). *E. co*li (green) and L1E11^T (red) mixed in the ratio 1:5 showing clear inhibition of *E. coli* grow

strain was conjugated with L1E11^T for generating random mutants. We employed different screening strategy for screening large population of random clones. Contact dependent killing assay was used to identify mutants which is defective for type six secretion system, growth in siderophore media was checked to identify mutants limited to iron starvation as in our previous experiments we could notice an increase in killing efficacy under iron starved condition. However, we could not identify any candidate mutants from our extensive screening. The randomness of the insertion was amply higher with pRL27 but the desirable insertions site subjected to screening was spanning less area in the genome. Hence, a vigorous screening approach by increasing the mutant library can maximize the probability of generating random mutants. Our future goal mainly focuses on standardizing the genetic manipulation in



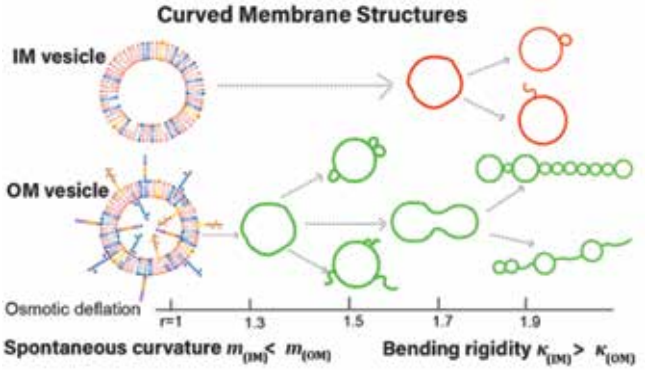
Recovery of *E.coli* from killing assay performed in an iron amended media

L1E11^T and also to increase the pool of random mutants in L1E11^T thereby identifying genes involved in root competition and colonization of L1E11^T.

5. Understanding Biological Processes and Molecular Biology of Industrial Microorganisms

5.1. Membrane structures induced by lipopolysaccharide in giant vesicles

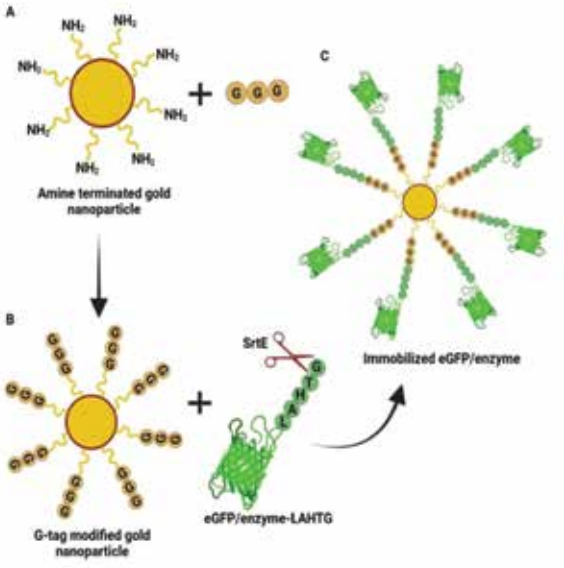
Native lipids in cell-membrane support crucial functions like intercell communication via their ability to deform into curved membrane structures. Cell membrane mimicking Giant unilamellar vesicles (GUV) is imperative in understanding native lipid's role in membrane transformation however remains challenging to assemble. We construct two giant vesicle models mimicking bacterial inner-membrane (IM) and outer-membrane (OM) under physiological conditions using single-step gel-assisted lipid swelling. IM vesicles composed of native bacterial lipids undergo small-scale membrane remodeling into bud and short-nanotube structures. In contrast, OM vesicles asymmetrically assembled from Lipopolysaccharide (LPS) and bacterial lipids underwent global membrane deformation under controlled osmotic stress. Remarkably, highly-curved structures mimicking cell-membrane architectures, including daughter vesicle networks interconnected by necks and nano-tubes ranging from micro to nanoscale, are generated in OM vesicles at osmotic stress comparable to that applied in IM vesicles. Further, we provide a quantitative description of the membrane structures by experimentally determining membrane elastic parameters, i.e., neck curvature and bending rigidity. We can conclude that a larger spontaneous curvature estimated from the neck curvature and softer membranes in OM vesicles is responsible for large-scale deformation compared to IM vesicles. Our findings will help comprehend the shape dynamics of complex native bacterial lipid membranes. (**K S Nair, et. al. , H Bajaj * Journal of Colloid and Interface Science, 2022,397-407 (IF- 9.96)**



Curved membrane Structures IM vesicle undergo small-scale transformation compared to OM vesicle which undergoes global shape changes.

5.2. Sortase E-mediated site-specific immobilization of green fluorescent protein and xylose dehydrogenase on gold nanoparticles

The Sortase E transpeptidase of *Corynebacterium glutamicum* ATCC 13032 is a versatile tool for site-specific ligation of proteins and for peptide engineering. Here, we present the immobilization of two proteins, enhanced green fluorescent protein (eGFP) and xylose dehydrogenase (XylB), over triglycine functionalized PEGylated gold nanoparticles (AuNPs) using a calcium-independent sortase E. The site-specific conjugation of proteins with LAHTG-tagged sequences on AuNPs *via* covalent cross-linking was successfully detected by surface enhanced Raman scattering (SERS) and UV-vis



Site-specific SrtE-mediated immobilization of enzymes. (A) Amine terminated PEGylated gold nanoparticle was synthesized. (B) The amine terminal of NH2-PEG@AuNP was coupled with triglycine produced by solid-phase peptide synthesis. (C) The purified recombinant proteins with LAHTG tag were immobilized via sortase E-mediated ligation on functionalized AuNP.

spectral analysis. The sortagging was initially validated by an eGFP model protein and thereafter with xylose dehydrogenase enzyme. The catalytic activity, stability, and reusability of the immobilized XylB were studied by converting xylose to xylonic acid. When compared to free enzyme, the immobilized XylB was able to retain 80% of its initial activity after four sequential cycles and exhibited no significant variations in stability after each cycle for about 72 h. These findings point to a promising application for the *C. glutamicum*s ortase for immobilizing site-specific protein/enzyme for biotransformation applications for value-added chemical production.

5.3. Understanding fungal biomass degradation mechanisms and regulation of lignocellulolytic enzymes, for potential applications in biorefineries

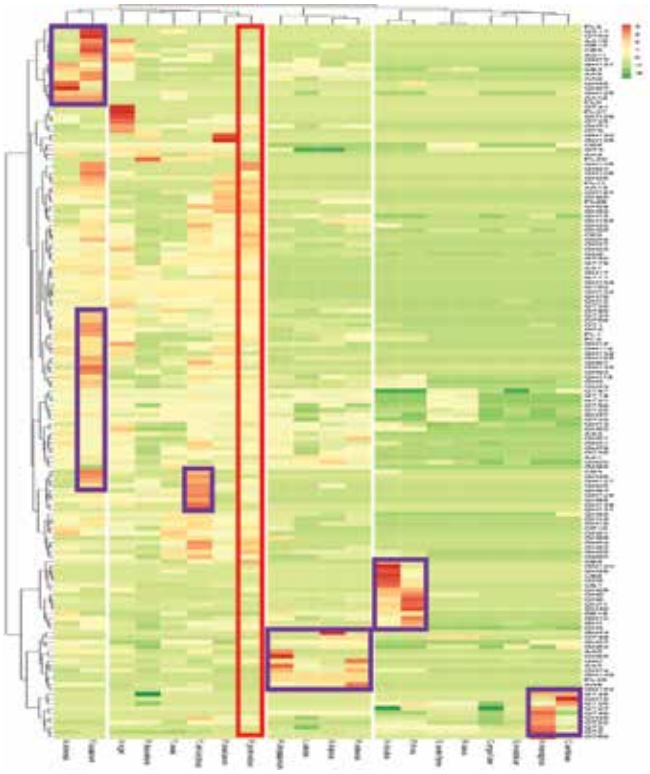
5.3.1. Patterns in the distribution of CAZymes in different cellulolytic fungi

The continuous cycling of carbon compounds is one of the fundamental activities in nature. Together with bacteria, fungi are responsible for recycling the bulk of recalcitrant polymers such as lignocellulose. Cellulolytic fungi are widespread in nature and belong to diverse subdivisions like *Ascomycetes*, *Basidiomycetes*, and *Deuteromycetes*. Among them, the most studied genera are *Chaetomium*, *Phanerochaete*, *Schizophyllum*, *Trichoderma, Aspergillus*, *Fusarium*, and *Penicillium*

Compared to other microorganisms, fungi, which have evolved progressively to decay organic debris via penetration using their hyphae and spores, exhibit better plant biomass degrading abilities due to the expression of functionally diverse isoforms of carbohydrate-active enzymes (CAZymes) as a result of genetic redundancy, differential mRNA processing and post-translational modifications. Since the portfolio of secreted CAZymes is important for growth and reproduction of the fungi, there exists a fitness-driven connection between fungal taxonomy and molecular function of the CAZymes produced by the fungus for carbon assimilation

Attempts towards the sustainable production of fuels and chemicals from lignocellulosic biomass (LCB) have led to intense efforts on improving the robustness, hydrolytic efficiency and cost of fungal CAZymes. In addition to sourcing organisms with an efficient battery of cellulases, genetic modifications and co-culturing techniques have also been used to develop complete cellulase cocktails. In spite of these advancements, the high cost of cellulase production is still one of the bottle necks for the industrialization of lignocellulosic bioconversions. In this context, the patterns in the distribution of CAZyme families in selected fungal divisions were investigated, in order to understand the cellulolytic potential of each group and hence to design specific cellulase cocktails with improved hydrolytic efficiency.

Of the 20 fungi studied, CAZyme representation in the total proteome varied from 0.26% (*Rhizophagusclarus*) to 3.67% (*Talaromycescellulolyticus*). The highest number of CAZymes (>300) were encoded by the genera *Talaromyces*, *Penicillium*, *Aspergillus* and *Fusarium*, all of which are ascomycetes. It was also noted that *Penicillium janthinellum* NCIM 1366 (red lane) encoded a more diverse set of CAZymes (116 classes) compared to the other fungi with similar CAZyme profiles. By



Clustering of CAZymes belonging to different fungi

Agglomerative hierarchical clustering of both rows and columns using Euclidean distance and Ward linkage. 151 rows, 20 columns. Distance Threshold = 10

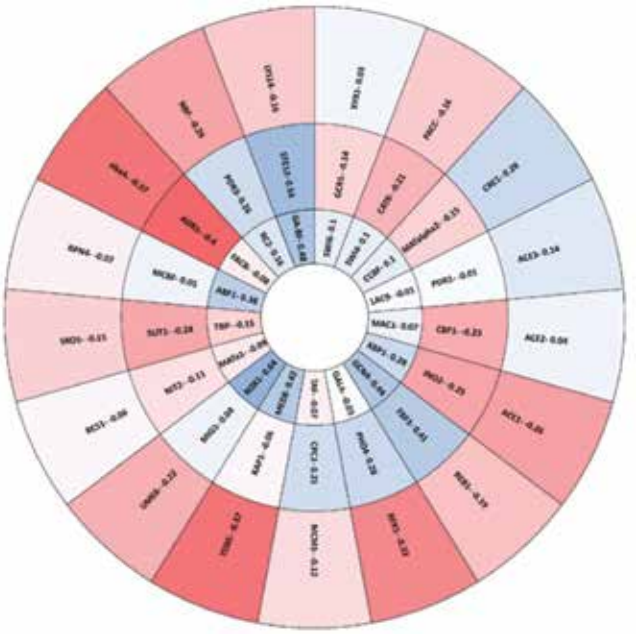
Hierarchical Cluster Analyses, co-distribution patterns of the CAZymes were also studied which showed that six clusters of CAZymes (blue) are under-represented/ lacking in *P. janthinellum*. The CAZymes are present in *Fusarium oxysporum* and *Alternaria alternata* (cluster 1); *F. oxysporum* (cluster 2); *Talaromyces cellulolyticus* (cluster 3); Basidiomycetes (cluster 4); Neocallimastigomycetes (cluster 5) and Blastocladiomycetes (cluster 6). Therefore, supplementation of theses CAZymes, either externally or via heterologous expression, may be used to improve the substrate range and hydrolysis efficiency of *P. janthinellum* cellulases.

5.3.2. Regulators of cellulase expression in *Penicillium janthinellum* NCIM 1366

For the complete mineralization of lignocellulose, fungi employ 3 classes of enzymes- hydrolases, which include cellulases and hemicellulases; lyases and oxidoreductases, which include the lignin degrading enzymes. Cellulose degradation is effected by exoglucanases (EC 3.2.1.91 and EC 3.2.1.74), endoglucanases (EC 3.2.1.4) and betaglucosidases (BGLs) (EC 3.2.1.21). Degradation of the heteropolymeric hemicellulose requires xylan-degrading and side-chain cleaving enzymes. As such, the fungi that can grow on lignocellulose possess a diverse arsenal of enzymes to convert this complex substrate into simpler sugars.

Since the production of extracellular enzymes is an energy-intensive process, the expression of cellulases is triggered only when the organism needs to utilize complex polymers as its energy and carbon source. In the presence of easily metabolizable sources like glucose, cellulase expression is repressed via Carbon Catabolite Repression (CCR). On encountering a cellulosic substrate, gene expression and protein secretion is triggered by a complex and coordinately regulated network of receptors, transporters, transcription factors (both activators and repressors), and other regulatory proteins.

Based on UniProt descriptions of extracellular CAZymes, 13 proteins of the cellulase hyper-producer *Penicillium janthinellum* NCIM 1366 (PJ-1366) were annotated as cellulases- 4 cellobiohydrolases (CBH), 7 endoglucanases (EG) and 2 beta glucosidases (BGL). In

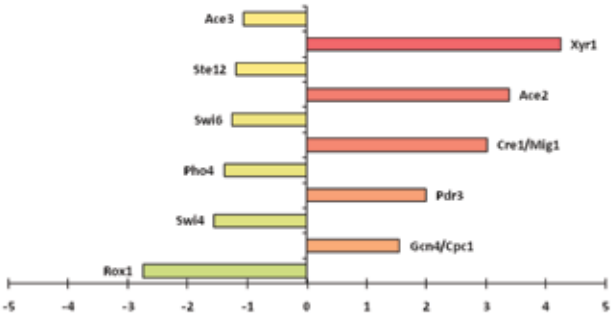


Correlations in protein abundance vs distribution of TF-binding sites.

Blue indicates perfect correlation while red shows negative correlation

order to uncover potential regulators of the cellulases, the upstream regions of the cellulase ORFs (up to 1500 bp) were analysed for the presence of binding sites of known fungal TFs. A total of 51 TFs were identified which can potentially bind on the promoter regions.

Using BLASTP, it was seen that PJ-1366 contained homologs for 15 factors. Further, the amino acid metabolism regulators GCN4 and CPC1 aligned with the same protein, as did MIG1 and Cre1 making the total number of homologs 13. Mapping of these 13 proteins to the transcriptome showed that Xyr1 had the highest differential expression on cellulose induction



Fold change in expression of PJ-1366 homologs of cellulase regulators

(Fig 22), although the highest number of transcripts were detected for Gcn4. Rox1, which is a repressor protein, was the most downregulated, as were the Swi4-Swi6 complex, and Ste12. No transcript was detected for Med8, a protein that is known to exercise both positive and negative control on transcription, and no change in expression was seen for Xbp1, another transcriptional repressor.

On the whole, it was seen that in addition to known cellulase regulators like Cre1, Xyr1 and the Ace proteins, expression of cellulases in *P. janthinellum* also seems to be regulated by factors participating in transcriptional control (Rox1, Xbp1, Med8, Pdr3), growth and cell cycle regulation (Rox1, Swi4-Swi-6), control of phosphate metabolism (Pho4), and global regulators like Gcn4 and Ste12.

5.3.3. Identification of potentially antiviral proteases

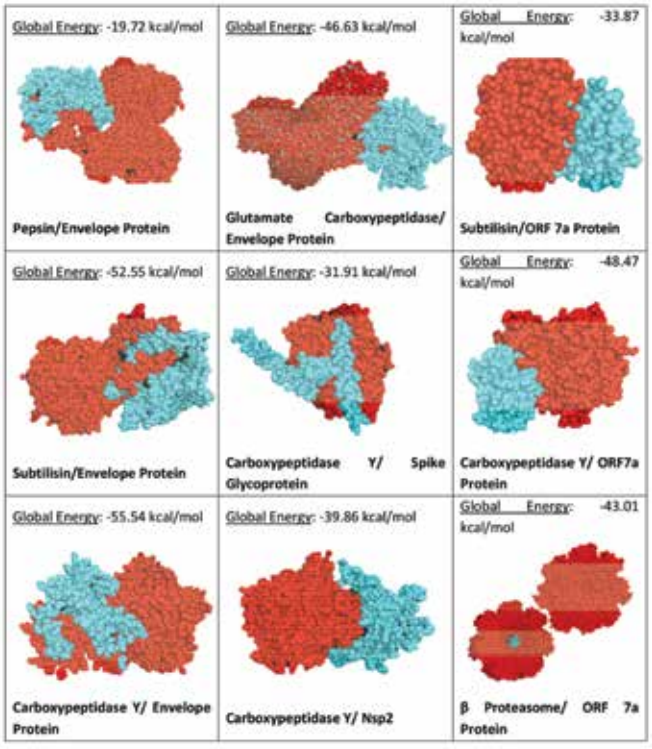
In the last 20 years, there has been seven significant viral threats – Nipah virus, SARS, MERS, Ebola, avian influenza, swine flu and now the SARS-CoV-2 mediated COVID-19. Estimates place about 60% of infectious diseases and 70% of emerging human infections as zoonotic in origin, with two-thirds originating in wildlife. Due to human encroachment on the natural world, experts worldwide agree that this pandemic will not be the last; there exists the ideal conditions for diseases from wildlife to spill over into humans and spread quickly around the world.

To date, the global COVID-19 pandemic has caused approximately 6 million deaths worldwide, including more than 500,000 deaths in India. The number of Indians who have/had infections stand at nearly 42 million. In addition to its devastating effects on healthcare systems worldwide, reports from the World Bank estimated that an outbreak of this scale could push about 49 million people into extreme poverty- almost half of whom will be in Sub-Saharan Africa, with an additional 16 million in South Asia. In India, due to factors like where they live, where they work, high dependence on public services and limited savings and unavailability of insurance, it is estimated that 260 million people will be back in poverty due to the pandemic, from which approximately 40 million people will be in "extreme poverty"

As such, it is vital that adequate and affordable prevention/treatment options are in place to mitigate the adverse effects of such pandemics on livelihoods, healthcare and other public systems. Due to these concerns, the development of new antiviral agents is warranted, that can be used either as an alternative treatment strategy or as part of a combinational therapeutic approach. Since recent technological advances have facilitated greater understanding of the essential viral enzymes, these proteins represent potential therapeutic targets. Because of the ease with each microbial proteases can be obtained, the recognition that proteases are an established class of safe and efficient drugs, and the fact that industrial scale processes already exist for the commercial production of many of them, it is worthwhile to explore their potential in degrading the viral enzymes, and thereby unearth additional therapeutic applications for these enzymes.

Using the proteins of the fungus *Penicillium janthinellum* NCIM 1366 as a model group, and the proteins encoded by SARS-CoV-2 as a representative of enveloped viral proteins, docking studies were performed to identify proteases that could bind, and potentially degrade, SARS-CoV-2 proteins. Binding energy evaluation identified 7 proteases belonging to 5 different families (aspartic protease- A1A, metalloprotease- M20A, serine protease- S8A and S10, threonine protease- T1A) that are suitable candidates for further evaluation. It was observed that while most of the non-structural viral proteins did not have favorable binding energies with the proteases, structural proteins like the spike glycoprotein and envelope protein, which are crucial for viral entry to host cells, were capable of being bound by the fungal proteases.

Any assessment of a protease-based strategy should take into consideration the availability, effectiveness, safety and cost of alternative measures, including checking the spread of infection, immunization or treatment with existing drugs. In addition to *in-vivo* effects, the possibility of using these proteases as external antiviral agents, either to hydrolyze or competitively bind viral proteins needs to be explored. New technologies for rationally engineering proteases, as well as improved



Docking of commercial proteases (red) with viral proteins (cyan)

Gene ID	Spike Glycoprotein	ORF-7a Protein	Envelope Protein	Nucleoprotein	Nsp1	Nsp2	Nsp14	ORF-6 Protein
ctg7180000009921.g250	-21.52	-8.29	-37.44	1.59	-1.59	-19.78	-1.82	-7.80
ctg7180000009929.g55	-1.41	-38.51	-51.88	4.62	-26.10	-10.87	-2.29	-37.64
ctg7180000009963.g312	-21.99	-4.14	-29.61	-17.95	-32.32	-18.23	-1.16	-31.94
ctg7180000014270.g175	-13.81	-49.18	-62.88	-12.64	-33.64	-55.01	-31.88	-32.73
ctg7180000014384.g300	-31.08	-50.48	-4.62	-24.32	7.42	-14.38	5.73	-33.05
ctg7180000014413.g297	-63.64	-44.00	-66.63	1.37	-30.95	-33.37	-42.17	2.14
ctg7180000014422.g216	-28.28	-30.87	-37.99	-2.79	-14.95	7.81	-24.27	-3.50
ctg7180000014558.g236	-40.42	-24.26	-6.38	11.38	-14.21	-16.86	-1.54	-7.88
ctg7180000014559.g244	-17.45	-23.49	-39.97	-8.51	-30.39	-5.12	-27.08	-49.31
ctg7180000015102.g232	2.89	-28.77	-47.90	-0.77	-25.04	-20.83	-32.78	-26.44
ctg7180000015122.g39	-0.02	-37.39	-25.32	0.60	-28.52	6.36	-32.21	-1.86
ctg7180000015128.g184	-18.47	-30.87	-43.98	-5.30	-23.48	-31.55	-19.62	-15.26
ctg7180000015233.g14	-15.74	-34.67	-25.22	-3.52	-31.06	2.61	-9.19	-27.63
ctg7180000015271.g77	-16.69	-72.50	-24.33	-0.87	-46.78	-7.13	-47.24	-30.83
ctg7180000015281.g270	-25.60	-37.26	-56.05	-0.78	-19.45	-12.46	-2.85	-23.27
ctg7180000015289.g86	-40.79	-42.48	-32.63	8.30	-48.85	-35.57	-18.54	-44.53
ctg7180000015373.g99	-3.77	-59.69	-53.50	-7.50	-13.94	-33.56	-8.19	-32.67
ctg7180000015242.g140	1.45	-34.63	-19.87	5.58	-21.20	-1.85	-23.59	-13.42

Binding energies of *Penicillium* proteases with SARS-CoV-2 proteins

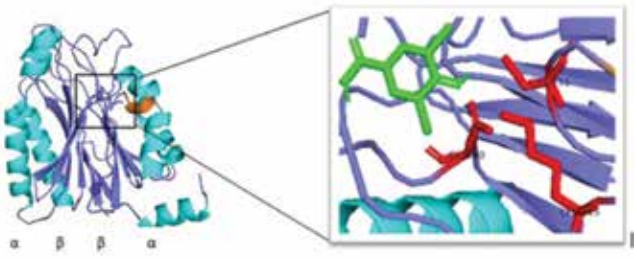
The energies are ranked from red (most favorable) to green (least favorable). Gene IDs of proteins with highly favorable binding energies (<-50 kcal/mol) are highlighted in yellow

delivery options, will significantly expand the efficacy of these enzymes. Based on our current understanding on the roles and physiological effects of proteases, it is proposed that a two-pronged clinical approach, aimed at either destroying or inhibiting viral proteins, could be applied for a more robust response against SARS-CoV-2, with due consideration given to the dosage and site of protease activity

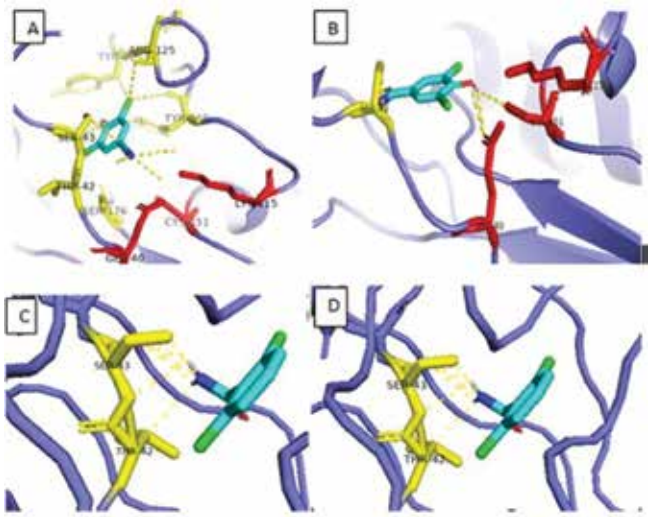
5.3.4. Insilco analysis of the regio- and enantioselective nitrilases of *Corynebacterium glutamicum* for bioremediation of nitrile herbicides

The nitrile compounds are produced either naturally or by synthetically, are highly used in many manufacturing industries such as pharmaceuticals, pesticides, chemical and polymer *etc*. However, the extensive use and accumulation of these nitrile compounds has causes severe environmental pollutions. The nitrilated herbicides are one such toxic substance which will persist in the soil for a long time.. In order to understand the effectiveness of using *C. glutamicum* for the degradation of such nitrile herbicides, an *in-silico* approach has been done and it mainly focused on the structural analysis and molecular docking studies *of C. glutamicum* with nitrilated herbicides such as dichlobenil, bromoxynil and chloroxynil. We also attempted molecular cloning and purification of the gene (Cg 3093) which is responsible for the nitrile degradation pathway.

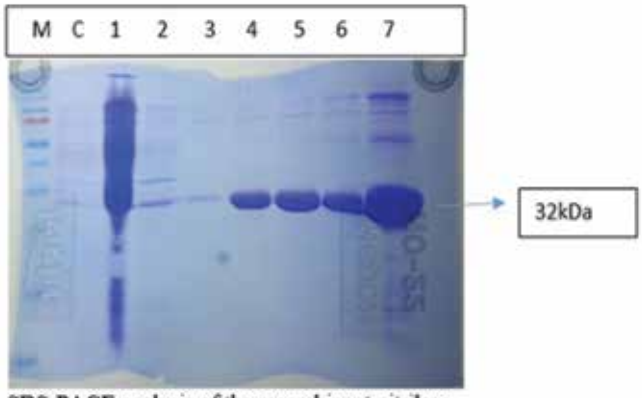
The bioinformatics analysis using different tools and softwares helped to confirm that the genome of *C. glutamicum* ATCC 13032 species's have genes (cg 3093) codes for carbon- nitrogen hydrolase enzyme, which specifically act on non- peptide bond present in the nitrile compounds. The homology modelled protein showed better affinity towards nitrile herbicides such



Homology modelled protein highlighted with their active site (Red)



Molecular docking analysis of nitrilase-3 protein with its ligands. A) Bromoxynil, B) Chloroxynil, C) BAM, D) CIAM



SDS-PAGE analysis of the recombinant nitrilase.

The result of SDS-PAGE gel showing the purified recombinant protein nitrilase

Lane M: Protein marker;Lane C: uninduced control; Lane 1: Supernatant of the induced cell-free extract; Lane 2: Flow-through; Lane 3- 6: imidazole gradient 50; 80; 100 ; 200; Lane 7: Purified nitrilase.

as BAM and CIAM with the affinity value of -5.8 and -5.7 kcal/mol respectively. Based on the above analysis we amplified the gene from *C.glutamicum* ATCC 13032 and cloned into an expression vector *E. coli* BL21 (DE3) cells. The protein was purified using different imidazole gradient from 80-200 mM and the active protein show good band at 32 kDa. The purified nitrilase converted various aromatic and aliphatic nitriles into corresponding acids. All these studies manifested that *C.glutamicum* ATCC 13032 is one of the promising strains for the bioremediation of nitrilated herbicides contaminated soil.

II. Biofuels and Biorefineries

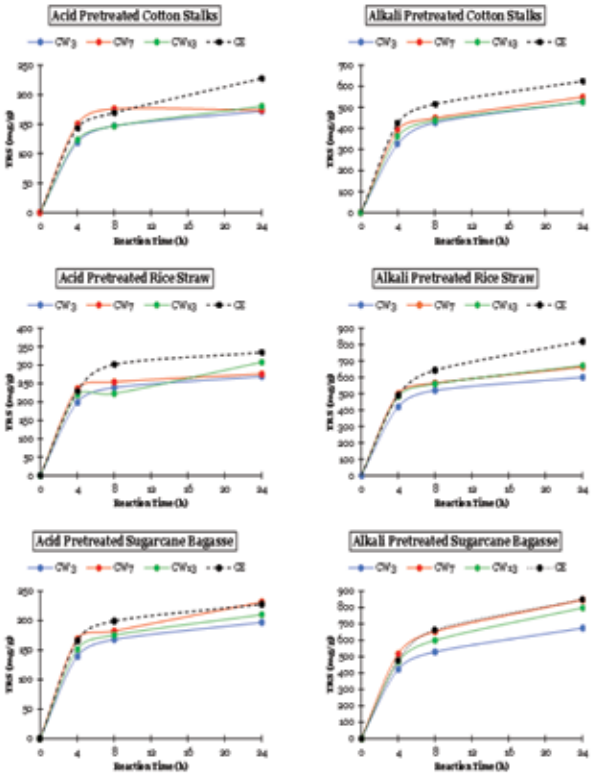
1. Facilitating Biorefineries: technologies and products

1.1. Factors affecting the performance of *Penicillium janthinellum* cellulases

The physical structure of lignocellulose consists of a network of cellulose fibril bundles, which are parallelly aligned in the secondary cell wall layers and less regular in the primary cell walls. The cellulose fibril network is embedded in an amorphous matrix of hemicellulose and lignin. Hemicellulose binds to cellulose surfaces by hydrogen bonds, crosslinking the cellulose fibrils, and is also covalently linked to lignin. Lignin fills the remaining spaces, reduces water permeability and works as a physical barrier towards enzymes. Overall, the lignocellulose architecture is very recalcitrant towards enzymatic hydrolysis. A major hindrance is considered to be the non-productive binding of enzymes on lignin. Cellulose accessibility, which depends on the available cellulose surface area, as well as the porosity of the material, has also been argued to play an even larger role in determining hydrolysis efficiency.

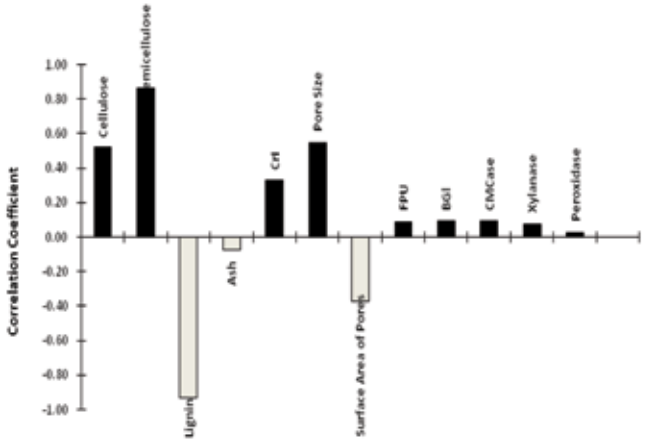
On hydrolyzing differentially pretreated substrates using 1mL/g of *P. janthinellum* enzymes harvested at different time points (CW3, CW7 and CW13) from Mandels and Weber medium containing 1% (w/v) cellulose-wheat bran as the substrate, it was observed that the rate of hydrolysis was highest in the initial 4 hours of reaction, and > 75% of the reaction was completed within this time period. For benchmarking, 10 FPU/g of a the best performing cellulase mixture currently available in the market was used (CE), and it was seen that in the case of alkali pretreated substrates, the performance of *P. janthinellum* cellulases was on par with that of the commercial enzyme.

To understand the substrate characteristics and protein factors that contribute to the hydrolysis performance of *P. janthinellum* enzymes, correlation analyses were performed between physical features of the substrate, enzyme loadings, and efficiency attained on hydrolyzing differentially pretreated biomass. It was observed that the greatest effect was imparted by



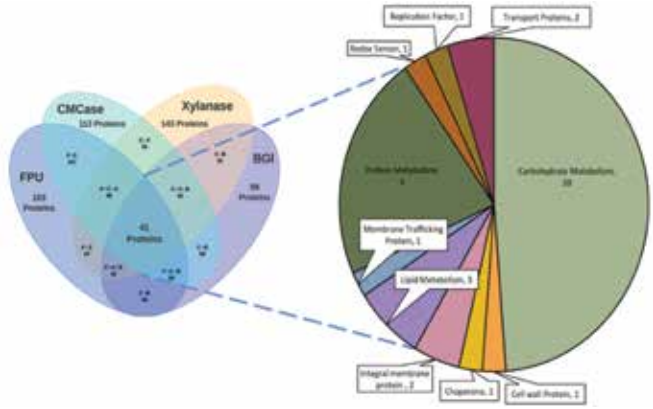
Sugar release on hydrolysis using PJ-1366 cellulases

the presence of lignin, pointing to the need for better pretreatment strategies for lignin removal and improved content of ligninases in the hydrolyzing enzymes to relieve the inhibitory effects of lignin. Consequences of alkali pretreatment, such as increase in crystallinity index (CrI) and larger pore size, also favorably affect hydrolysis efficiency probably via increasing enzyme accessibility and improving enzyme binding on the substrate.



Correlation of biomass features and cellulase levels with the efficiency of hydrolysis

Using the secretome profiles of *P. janthinellum* grown on different substrates (cellulose, cellulose-wheat bran, lactose and wheat bran), the abundance of the different proteins were correlated with the cellulase activities of the cultures. Forty-one proteins were identified whose abundance positively correlated with the calculated FPase, CMCase, Xylanase and Betaglucosidase activities. This set included 20 proteins involved in carbohydrate metabolism- three oxidoreductases, an esterase, an isomerase and 15 hydrolases. This set of proteins may be regarded as the drivers of cellulase activity and *P. janthinellum*, and so are suitable targets for overexpression in order to improve the saccharification efficiency of the fungus

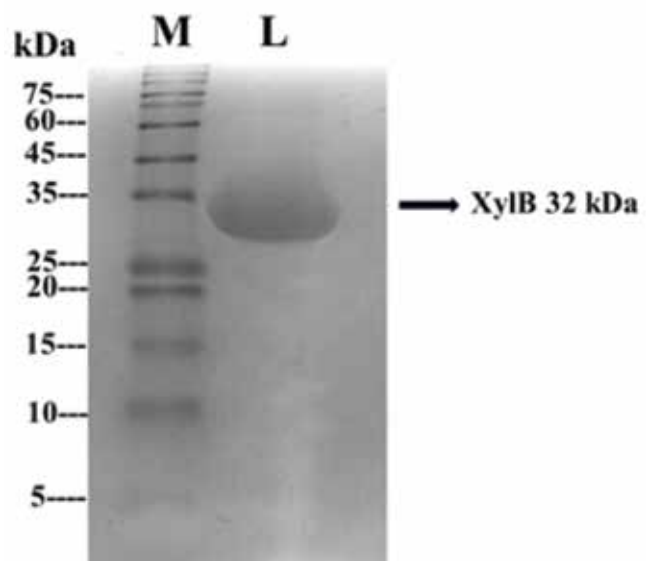


Predicted functions of the extracellular proteins that positively correlate with the cellulase profile of *P. janthinellum*

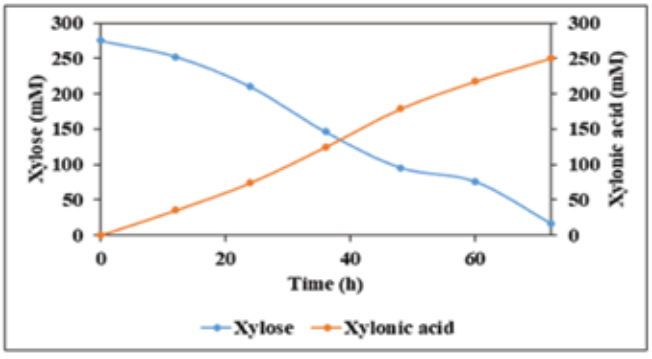
2. Non-biofuel products and by-product valorization for biorefineries

2.1. Xylose dehydrogenase immobilized on Ferro-magnetic nanoparticles for bio-conversion of Xylose to Xylonic acid

D-xylonic acid (XA), derived from pentose sugar xylose, is a multifunctional high-value chemical with a wide range of applications in the fields of medicines, food, agriculture and is a valuable chemical reagent for the synthesis of other useful commodity chemicals. In the bacterial system xylose dehydrogenase (XDH) catalyzes the oxidation of D-xylose into D-xylonolactone consuming NAD+ or NADP+ as a cofactor. The D-xylonolactone then undergoes auto-oxidation into D-xylonic acid. Herein, the XDH enzyme overexpressed in *E. coli* is purified and immobilized on ferro-magnetic



Over expression of recombinant xylose dehydrogenase of *C. crescentus*ATCC 19089.
Lane M, prestained protein ladder; Lane 1, purified xyl B.



Bioconversion of xylose into xylonic acid by immobilized xylose dehydrogenase

nanoparticle effectively converting xylose into xylonic acid. Parameters deciding the bioconversion were statistically optimized and obtained a maximum of 91 % conversion rate. Kinetic parameters of immobilized xylose dehydrogenase showed a two-fold increase in the maximum velocity of the reaction and catalytic efficiency compared to free enzyme. The operational stability test for the enzyme-nanoparticle conjugate retained 93% relative activity after ten successive experiments, exhibiting good recyclability of the biocatalyst for XA production.

3. Characterization studies of foulants extracted from membranes used in drinking Water plants

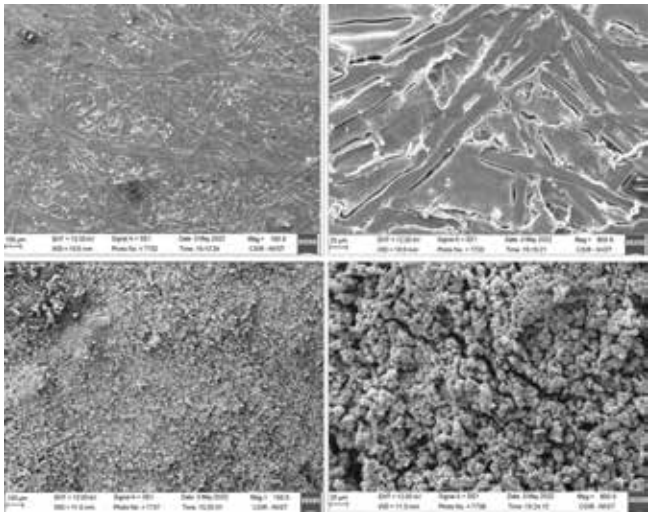
Reverse Osmosis (RO) membrane filtration is been commonly used in drinking water plants for purified water suitable for a wide range of potable and non-potable applications. However, blocking of membrane pores due to deposition of biological and non-biological materials present in source water is a challenging scenario in all water purification systems. Although extensive research is been carried out in understanding fouling related issues, very few studies only have focused on analyzing the components of foulants on fouled membranes as operated in actual drinking water plants. The present study aims to identify the nature of foulants deposited over RO membranes used for filtering water from various sources such as river water, well water, treated water etc. in actual plant conditions (household water purifiers) to suggest effective methods to improve membrane shelf life and performance.

Membranes collected from drinking water purifiers were dissected and the foulant was taken from membrane surface for spectral analysis which identified the presence of both organic and inorganic substances. Characteristic peaks corresponding to mainly polysaccharides (900-1200cm^{-1}) and proteins (1300–1700cm^{-1}) were observed. Cation Exchange Resin (CER, Dowex sodium form) was further used to extract organic foulants from scrapped off materials and total carbohydrate and protein concentrations were analyzed. Inorganic elements were quantified by ICP-MS analysis which indicated the presence of calcium, magnesium, strontium, titanium and manganese in the decreasing order of occurrence along with other heavy metals in trace amounts.

Scanning Electron Microscopic (SEM) imaging of fouled v/s virgin membrane revealed a thick layer of foulant deposition containing of microbial colonies

Fouled RO Membrane Filters

over fouled membrane surface which acts as a barrier to filtration process and reduces membrane performance. A very high concentration of viable bacterial cells (above 5 x 10^{-6} CFU/g) were isolated from foulants scrapped off from the membranes which indicated that household water purifiers can pose severe risks to human health if not maintained properly. Represents the SEM analysis of the virgin membrane and fouled RO membrane. The



a) & b) SEM Analysis Raw RO membrane at 150x and 800x magnification respectively c) & d) SEM Analysis Fouled RO membrane at 150x and 800x magnification respectively

results of the present study suggest that membranes used in household water purifiers should be replaced frequently and quality of filtrate should be analyzed as a parameter to validate membrane efficiency.

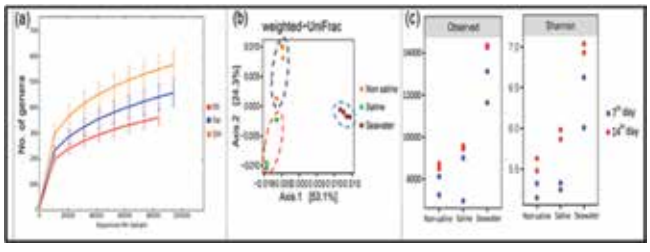
2. Area and Theme wise Significant S&T Contributions:

Theme: Agri Nutri Biotechnology (Mission and FBR Projects)

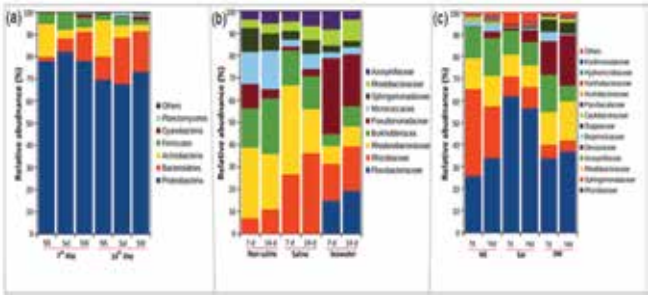
1. Biostimulants for stress amelioration, enhanced plant productivity and soil health (MLP 049)

1.1. Impact of seawater on Pokkali rice microbiome

Salinity is a major factor that limits crop productivity in coastal agricultural farming. Exploring the microbial communities that are specifically enriched in the root can excel our knowledge for the development of sustainable approaches for overcoming salinity stress. However, the information on the microbiome inhabiting the rhizosphere or roots of crops cultivated in a brackish ecosystem remains largely elusive. Therefore, we analyzed the bacterial metagenome of rice roots under different levels of salinity through 16S rRNA amplicon sequencing. The 16S rRNA amplicon sequencing generated a total of 18,89,535 raw reads from 12 samples (NS-Nonsaline (0% NaCl), Sal-Saline (100 mM NaCl) and SW-Seawater (30% seawater). Finally, 15,16,933 contigs were clustered with 97% sequence identity which resulted in 1,200 bacterial OTUs. The alpha rarefaction analysis showed a saturated and gave an exponential phase up to 250-350 in SW and 150-250 for both NS and Sal conditions (a). This suggests that the samples attained sufficient sequencing depth to capture the bacterial diversity and SW has more bacterial diversity compared to Sal and NS conditions. From the diversity analysis, it can be observed that both richness and evenness were higher in SW followed by Sal and NS conditions (b). A principal coordinate analysis (PCoA) between the samples displayed a close clustering for the replicates of the samples and showed differences according to the sample type (c). This suggests that there is no variation between the replicates, but has a significant variation between different conditions. Further, we have analyzed the bacterial metagenome compositions of rice roots under NS, Sal and SW conditions (a). From the microbial composition analysis, *Proteobacteria* was the most dominant phylum in all the samples. When compared between the samples, *Bacteroidetes* was higher in SW compared to NS and Sal conditions, whereas, phylum *Actinobacteria* was found to be higher in the NS compared to Sal and SW conditions. Then we analyzed the family level distribution of the most dominant phylum *Proteobacteria* (b). *Rhizobiaceae* was the most dominant family and it is higher in Sal compared to NS



(a) alpha rarefaction curve. (b) Principal coordinate analysis (PCOA plot), and (c) alpha diversities (Observed and Shannon)

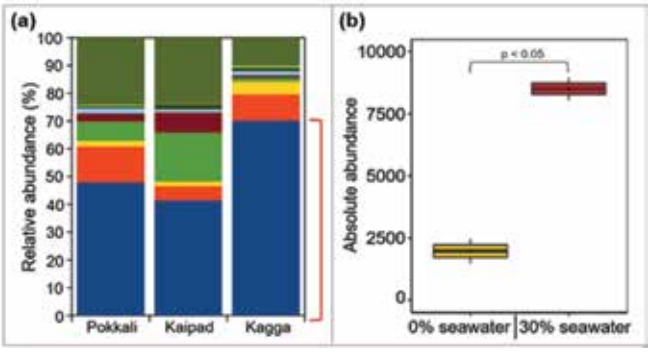


(a) Relative abundance at the phylum level (b) & (c) relative abundance at the family level.

and SW conditions. *Rhodobacteraceae* and *Devosiaceae* were the two major families that are enriched in SW compared to NS and Sal. In the *Bacteroidetes* phylum, *Flavobacteriaceae* was the most dominant family and was quantified at nearly zero in the NS and Sal conditions (c). All these results suggest that different forms of salinity can influence the diversity and abundance of different bacterial communities recruited by the plant root under specific conditions.

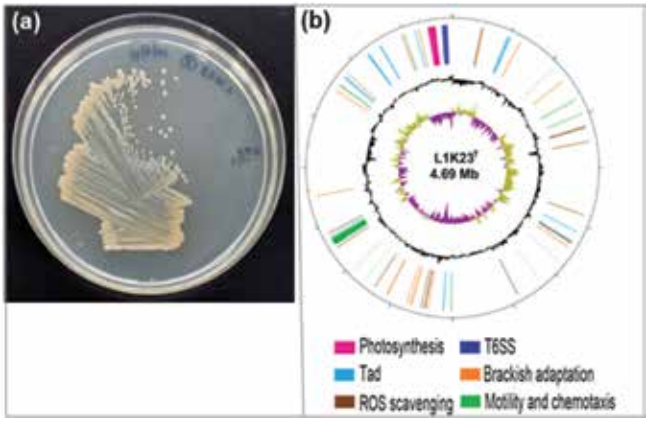
1.2. Insights into a novel Rhizobium with an unusual brackish adapted lifestyle:

Rhizobium genus comprises bacterial groups with 2 physiological lifestyles: a free-living lifestyle in soil and a symbiotic lifestyle in the legumes. Even though *Rhizobium* members are widely studied, knowledge of their distribution in brackish ecosystems and associated ecological relevance is very limited. To complement this grey area, we explored the abundance of *Rhizobium* genus in the South Indian brackish rice varieties – Pokkali, Kaipad and Kagga through metagenomic approaches. Interestingly, the number of operational taxonomic units (OTUs) corresponding to *Rhizobium* genus was very high compared to other genera which confirmed their dominance in the brackish rice varieties (a). To confirm if the brackish condition i.e., the seawater was the ecological factor that drives *Rhizobium* enrichment in brackish rice roots, we performed a hydroponic based pokkali root microbiome experiment under gnotobiotic setups. Intriguingly, the *Rhizobium* abundance in pokkali seedling roots increased by ~3-fold in the brackish condition (30% seawater) compared to the non-brackish condition (b) which validates the role of the environment in driving this bacterial group towards

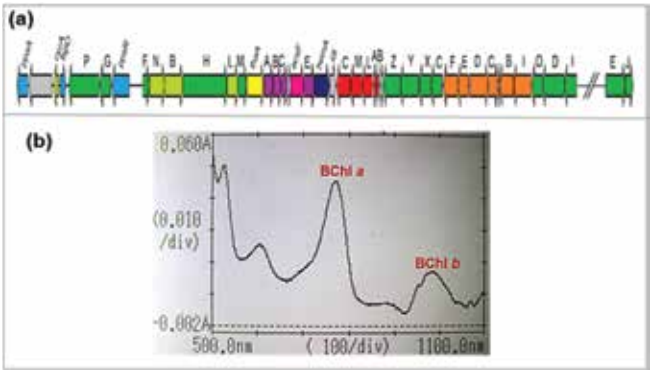


(a) stacked bar graph indicating the abundance of *Rhizobium* genus (dark blue stack at the chart base highlighted in red) in south Indian brackish associated rice varieties; pokkali, Kaipad and kagga. (b) brackish conditions (30% seawater) enriches *Rhizobium* abundance in pokkali rice roots (statistical significance represented by $p<0.05$).

its host. The microbiome-based findings lead us to isolate potential *Rhizobium* strains from brackish rice where we identified a probable novel genus strain designated L1K23 (a) with unique plant-associated traits. L1K23^T genome encoded motility, chemotaxis and tad genes for host-interaction, type six secretion system (T6SS) gene cluster for inter-bacterial competition, ROS scavenging genes for host defence evasion and certain brackish adaptation genes for environmental adaptation (b). Most interestingly, we could identify a photosynthetic gene cluster (PGC) in L1K23^T genome (a) and supportive of this we could extract and identify the bacterial photosynthetic pigments (bacteriochlorophylls) - BChl*a* and BChl*b* in L1K23^T cell extracts (b) confirming it to be a novel phototrophic *Rhizobium*. Further, to understand the host colonization ability of L1K23^T, we performed

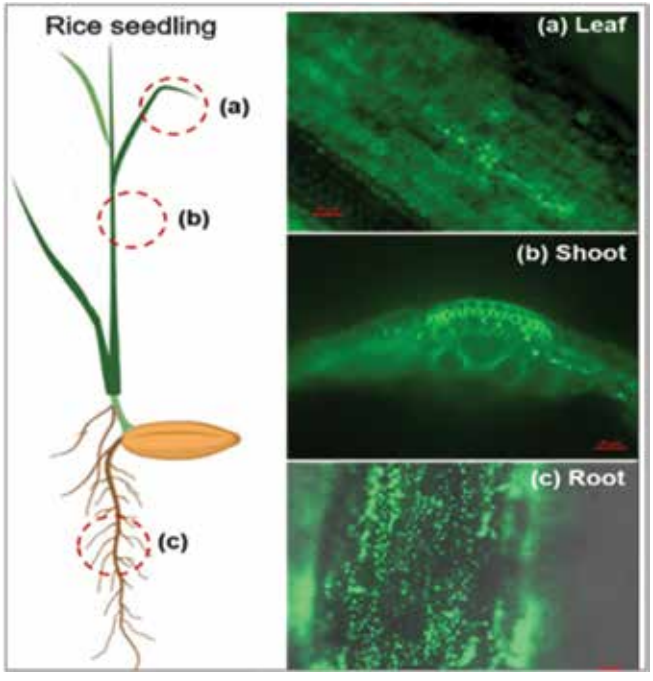


(a) Novel *Rhizobium* strain L1K23T growth in ZoBell Marine Agar medium. (b) circular map of L1K23T draft genome highlighting the plant-associated traits.



(a) Gene organization of photosynthetic gene cluster in L1K23^T genome (b) Absorption spectrum showing the presence of photosynthetic pigments in L1K23 cell extracts. The two peaks represent the major bacteriochlorophyll pigments - BChl *a* & BChl *b*.

fluorescence-based imaging of the pokkali seedling roots colonized by Gfp-tagged L1K23^T cells which confirmed the novel *Rhizobium* strain to be a robust colonizer of its host seedling. The most significant observation was that we could capture the fluorescence signals of colonized L1K23-gfp cells from the shoot cross-sections and leaf tissue of host seedlings which support their active interaction with the host probably through endophytic colonization (a, b, c). The unique presence of a functional PGC in L1K23^T could be correlated to the leaf colonization ability of this novel *Rhizobium* strain. Further studies are underway in validating if the PGC cluster in L1K23 is activated *in-planta* only upon leaf colonization in the presence of light or is it constitutively expressed. Current leads suggest that the novel *Rhizobium* strain, L1K23^T exhibit a unique brackish adapted host-associated lifestyle which can open new avenues in plant-microbe interaction.

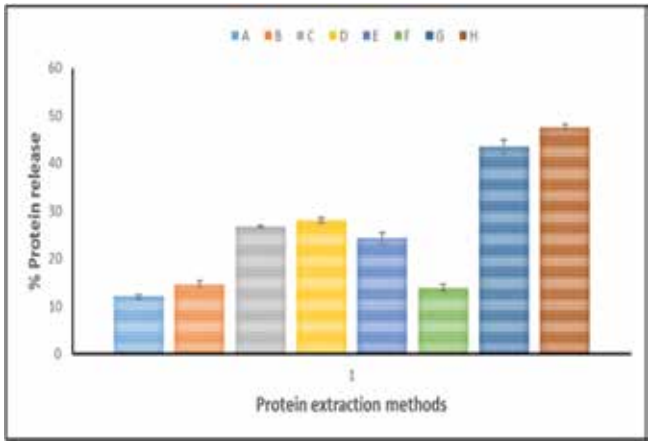


Schematic diagram of a 7-day old pokkali seedling with epi-fluorescent images showing the colonization of L1K23-Gfp cells alongs different portions of seedlings: (a) first leaf, (b) cross-section of leaf sheath above stem base and (c) roots.

2. Investigation on the separation, composition and utilization of deoiled microalgal biomass as value added nutraceuticals (MLP0051)

2.1. Process development for optimum protein recovery from edible marine microalga:

The accessibility of *marine microalga* protein and its recovery from deoiled microalgal biomass was analysed through various processes where mechanical stress, pH shift process, and chemical treatment play a major role. Since there was no observable protein release in course of aqueous extraction without any pretreatment, various cell disruption methods and chemical treatments were employed for finding out efficient method of protein extraction in terms of quantity. Among the different methods, Ultrasound-assisted three-phase partitioning was the most efficient method for the optimum protein recovery.

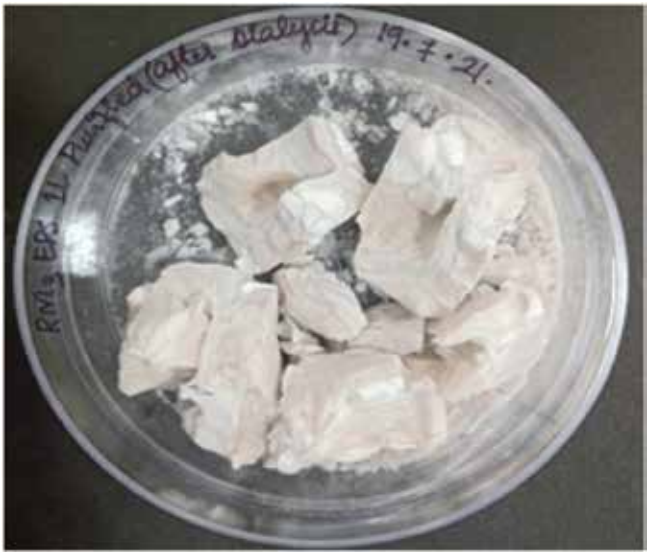


Protein recovery via different methods: Ultrasonication, 15 min (A), Ultrasonication,30 min(B), pH shifting with ultrasonication, 10 min (C), pH shifting with ultrasonication, 30 min(D), TCA precipitation with ultrasonication (E), High-speed homogenization(F), Ball milling(G), Ultrasonication assisted TPP (H). (Values are represented as mean ± SD, where n =2)

3. Food additive based on exopolysaccharides (EPS) of lactic acid bacteria – Process development, structural modifications, and functional characterization (MLP0052)

3.1. One step conversion of starch to Exopolysachharide by combined activity of amylase and glycosyltransferase enzymes

A newly isolated *Streptococcus sp.* culture from raw milk found to have significant amylolytic property and is further exploited for the utilization of raw starch materials and found that it is capable of producing exopolysaccharides in higher amounts.After screening various starchy raw materials and further media optimization, a max EPS titre of 19.92 ± 0.5 g/L was obtained using cassava starch as raw material (Fig.8). The crude EPS, after further purification and characterization (monosaccharide analysis, FT-IR, TGA, GPC, NMR revealed the dextran nature (glucose as the only monosaccharide) with a Mw of 1275.36 kDa. The particle size (447.8 dnm) and the zeta potential (-33.4). The culture also showed potential glycosyl transferase activity which is required for EPS production. Thus, the dual enzyme system, amylase and glycosyl transferase activities enabled the one step conversion of sustainable starch substrates as raw materials, without supplementing any external enzymes for starch hydrolysis, improved the economic viability of EPS production.



EPS produced from Cassava starch by an amylolytic *Streptococcus* Sp

4. Process development for enzymatic production of Ascorbic Acid 2 glucoside (MLP0053)

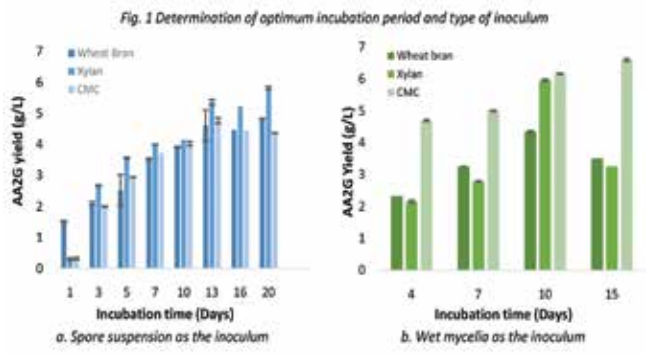
4.1. Enzymatic trans-glycosylation for organic synthesis

L-Ascorbic acid or Vitamin C is a water soluble essential vitamin with various physiological activities. It is a known antiscorbutic factor and an antioxidant. It also plays a major role in collagen synthesis, iron metabolism and tyrosine metabolism. The ability of ascorbic acid to inhibit melanin synthesis makes it an important compound in cosmetic industries. But the major drawback lies with the unstable nature of ascorbic acid under oxidative conditions, resulting in the formation of dehydroascorbic acid. The stability of ascorbic acid can be increased by the glycosylation at C2 carbon to form 2-O-D-glucopyranosyl ascorbic acid. Studies showed the ability of this analogue to retain all the physiological activities as ascorbic acid.

Chemical synthesis of AA2G is an intensive multistep process which involves benzylation, debenzylation and hydrolysis. This can be made less tedious by enzymatic conversions, providing a much greener approach in the synthesis of AA2G.Transglycosylation property can be exhibited by certain glycoside hydrolases apart from their hydrolytic activity. This property can be exploited for the synthesis of different glycated organic molecules of industrial importance, like AA2G. Previous studies identified *Aspergillus niger* NII 08121 to be a potent organism for the secretion of transglycosylating enzyme using different carbon sources like CMC, xylan and wheat bran,

Process optimization studies have performed to evaluate the effect of different types of inoculum like spore inoculum and mycelial inoculum, incubation time and media components on the production of transglycosylating enzyme.

When spore inoculum was used, the transglycosylation yield (Ty) with respect to AA2G synthesis was increasing till 20th day for wheat bran and xylan as carbon sources, whereas the activity was decreasing from 13th day for CMC as the carbon source. In all the three cases the increase in activity beyond 13th day was not so significant when taking into account

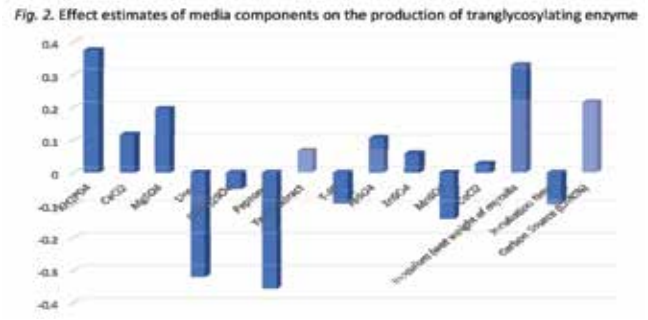


Determination of optimum incubation period and type of inoculum

of the technical feasibility of production process, in an industrial scale. The production shifted in favour of transglycosylation on the 10th day itself when mycelia was used as the inoculum. The Ty for wheat bran, xylan and CMC as carbon sources were 4.35 ± 0.03 g/L, 5.96 ± 0.03 g/L and 6.16 ± 0.02 g/L respectively. As the Ty was higher for enzyme produced using CMC as carbon source, it was selected for further optimisation studies to improve the Ty of enzyme. The increase in activity may be due to the use of an acclimatised culture for enzyme production.

2k factorial design for media optimisation for the production of tranglycosylating enzyme

A 2k factorial design matrix was used to identify the significance of each media component in the Mandel and Weber medium. The design matrix with the corresponding Ty (AA2G-g/L) for each run is given in Table 2. The Ty ranges from 1.43 - 4.54 g/L of AA2G. The effect estimate of different media components on the production of tranglycosylating enzyme was calculated and denoted.



Effect estimates of media components on the production of tranglycosylating enzyme

The media components with significant higher effects were KH_2PO_4, urea, peptone, inoculum wet weight (%) and CMC (%). Urea and peptone showed a negative effect, whereas the other three showed a significant positive effect. This result could attribute to the requirement of high carbon concentration and C:N ratio for the growth of certain fungi, which is a strain dependent characteristic and also for the production of secondary metabolites.

Multi-parametric analysis for designing the optimal media for tranglycosylating enzyme production

The factors or media components that showed a significant positive effect towards the enzyme production from the 2k factorial model were selected as the parameters in this design. The parameters were KH_2PO_4, inoculum wet weight (%) and CMC (%). The pH of the media was also taken into account. All other media components with positive effect were maintained in their higher levels and those with a negative effect were kept in the minimum level as mentioned in the previous two factorial model.

Transglycosylation yield measured are given in Table 1. A maximum AA2G production of 6.57 ± 0.02 g/L was obtained after media optimisation and was verified. Two suggested solutions were selected randomly and verified with the predicted yield (Table 2).

ANOVA of the design indicated that the quadratic model was significant with a p value of 0.0442. Only two parameters of the study, inoculum size (%) and pH of the media was found to be significant with a p value of 0.0028 and 0.0335 respectively. No significant interaction between these parameters was observed.

Thus, a modified Mandel and Weber medium, with CMC as the carbon source was designed for the optimal production of enzyme from *Aspergillus niger*, with a significant transglycosylation yield.

The crude enzyme was showing an initial production of 1.64 g/L AA2G. Assay optimisation and media engineering further increased the AA2G production to 6.91 g/L, which is a higher reported concentration of AA2G, by a crude enzyme till date. The single step enzymatic reaction adds on to the

advantage of this enzyme to be used for the large scale production of AA2G. Process development with whole cell immobilisation. Enzyme immobilisation and downstream processing can be attempted in the future.

Table 1: Response surface model (Box-Behnken design) of final media optimisation for the production of enzyme with significant transglycosylation activity

Run	KH_2PO_4 (g/L)	Inoculum (%)	CMC (%)	pH	AA2G (g/L)
1	4	15	1.5	5.5	6.13
2	4	12.5	1.5	4.5	6.14
3	6	10	1.5	5.5	5.59
4	5	15	1	5.5	6.2
5	5	15	2	5.5	6.2
6	5	10	1.5	4.5	5.9
7	5	12.5	1.5	5.5	5.73
8	6	15	1.5	5.5	6.26
9	5	12.5	1	4.5	5.93
10	5	12.5	2	6	5.83
11	5	12.5	1.5	5.5	5.88
12	4	12.5	1.5	6	5.93
13	5	12.5	1.5	5.5	5.91
14	5	15	1.5	4.5	6.33
15	6	12.5	1.5	4.5	6.03
16	5	10	1.5	6	5.38
17	5	12.5	1	6	5.67
18	5	10	2	5.5	6.16
19	6	12.5	1.5	6	5.92
20	5	12.5	2	4.5	6.56
21	4	12.5	1	5.5	6.57
22	5	15	1.5	6	5.76
23	6	12.5	1	5.5	6.04
24	6	12.5	2	5.5	6.06
25	4	12.5	2	5.5	6.30
26	5	12.5	1.5	5.5	6.21
27	4	10	1.5	5.5	4.81
28	5	12.5	1.5	5.5	5.63
29	5	10	1	5.5	5.04

Table 2: Experimental validation of optimal media composition for the production of enzyme with increased transglycosylation potential

Solution	KH_2PO_4 (g/L)	Inoculum size (%)	CMC (%)	pH	Predicted Ty (g/L)	Observed Ty (g/L)
1	*4.00*	*14.44*	*1.00*	*5.37*	6.61	6.09 ± 0.02
2	*4.00*	*14.66*	*1.02*	*4.53*	6.71	6.91 ± 0.47

अनुसंधान योजना और व्यवसाय विकास प्रभाग

अनुसंधान योजना और व्यापार विकास प्रभाग(आर पी बी डी)साइंटिस्ट्स और एडमिनिस्ट्रेशन के अलग-अलग विंग्स के बीच लेन-देन करता है जिसमें सीएसआईआर, हेडक्वार्टर और अन्य प्रायोजन एजेंसियां भी शामिल हैं।आर पी बी डीकार्यक्रम समन्वय, परियोजना निगरानी और मूल्यांकन, समीक्षा और रिपोर्टिंग, सीएसआईआर और अन्य बाहरी स्रोतों से प्राप्त वित्तीय संसाधनों के प्रबंधन, प्रौद्योगिकी हस्तांतरण और व्यावसायीकरण में शामिल है। डिवीजन आविष्कार और आईपी / पेटेंट संरक्षण से संबंधित एसएंडटी समर्थन गतिविधि में शामिल है।

विभाजन विशेष रूप से बुनियादी ढांचे और एसएंडटी प्रबंधन आवश्यकताओं के संदर्भ में समय पर कार्रवाई के लिए वार्षिक बजट तैयार करने में शामिल है। उपरोक्त के अलावा, सी एस आई आरके आर&डीकार्यक्रमों की भी निगरानी की जाती है और समीक्षा रिपोर्ट समय-समय पर सी एस आई आरको भेजी जाती हैं। समूह प्रयोगशाला में धन के आवंटन और उपयोग के संबंध में निगरानी अभ्यास भी करता है।

प्रभाग अनुसंधान परिषद और प्रबंधन परिषद दस्तावेजों को तैयार करने में मदद करता है, सी ए जी और सीएसआईआर ऑडिट टीम द्वारा उठाए गए परियोजनाओं से संबंधित ऑडिट पैरा यदि कोई होतो परियोजना के नेताओं, परियोजना समन्वयकों और संबंधित वर्गों के प्रमुख के साथसमन्वय करकेउत्तर प्रदान करता है।

आर पी बी डीने 2021-22 में 131 बाह्य वित्त पोषित परियोजनाओं और सी एस आई आरसे 21 परियोजनाओं के सफल निष्पादन की सुविधा प्रदान की। आरपीबीडी ने छह प्रौद्योगिकी हस्तांतरण और कई निजी उद्योगों के साथ अनुसंधान एवं विकास सहयोग किया।समूह वार्षिक रिपोर्ट 2020-21 और संस्थान के द्विभाषी समाचार पत्र एन आई आई एस टी समाचार और ब्रोशर के प्रकाशन के साथ-साथ प्रयोगशाला को पेश करने के हिस्से के रूप में विभिन्न प्रदर्शनियों का आयोजन करने में शामिल था। इस समूह ने सहयोगी अनुसंधान और विकास के लिए विभिन्न उद्योगों के साथ गठबंधन करने के लिए एक आर एंड डी उद्योग बैठक का आयोजन किया है।

RESEARCH PLANNING AND BUSINESS DEVELOPMENT

The Research Planning and Business Division (RPBD) liaises between the Scientists and different wings of administration including accounts and also with the CSIR, Headquarters and other sponsoring agencies. RPBD is involved in the programme coordination, project monitoring and evaluation, reviewing and reporting, management of financial resources received from CSIR and other external sources, technology transfer and commercialization. The division is involved in S&T support activity relating to inventions and IP/Patent Protection.

The division is involved in the preparation of annual budget for timely action particularly with reference to infrastructure and S & T Management requirements. In addition to the above, R & D programmes of CSIR are also monitored and the review reports are periodically sent to CSIR. The group also does the monitoring exercise with respect to allocation and utilization of funds in the laboratory.

The division helps in the preparation of Research Council and Management Council documents, providing reply to Audit para raised by CAG and CSIR Audit team if any, related to projects in consultation with project Leaders, project Coordinators and Head of the respective sections.

RPBD facilitated the successful execution of 131 externally funded projects and 21 projects from CSIR 2021-22. RPBD catalyzed six technology transfers and R & D collaboration with a good number of private industries. The group was involved in bringing out the Annual Report 2020-21 and Publication of Institute's Bilingual Newsletter *NIIST SAMACHAR* and brochures as well as conducting various exhibitions as part of projecting the laboratory. The group has organized a R & D Industry Meet, to forge alliance with various industries for collaborative Research and Development.

CONTRACT RESEARCH PROJECTS 2021-22

Sl No	PROJECT TITLE	CLIENT	PROJECT LEADER
AGRO PROCESSING & TECHNOLOGY DIVISION			
1	Coconut nera sugar and its Glycemic index (GI) and Glycemic load (GL) studies	Coconut Development Board	Dr M V Reshma
2	Design and development of an eco-friendly post-harvest technology for simultaneous dehydration and disinfection of agro crops	DST	Mr T Venkatesh
3	Design and fabrication of a cooling die to control the microstructure of plant- based meat analogues	SERB	Dr Vasanth Raghavan
4	Development and validation of nutritional products with cordyceps	M/s Adhinidhi Nutriment products Pvt Ltd	Dr S Priya
5	Development of edible and bio degradable food packaging containers and cutleries from senile coconut wood, coconut milk residue and coconut de-oiled cake	Coconut Development Board	Dr Anjineyalu Kothakota
6	Development of guar gum nano particle based mitochondrial antioxidants for cardiac hyper trophy	DHR	Dr R S Soumya
7	Development of novel leads for anti-obesity from North East traditional system through chemistry biology interphase	DBT	Dr K G Raghu
8	Development of pineapple leaf based biodegradable straw and paper food packaging containers (tea, coke, ice cream cups & popcorn box)	Ministry of Food Processing Industries (MoFPI)	Dr Anjineyalu Kothakota
9	Exploration of exosomal and non- exosomal micron as from grapes against triple negative breast cancer	SERB	Dr S Priya
10	Investigation of resveratrol based compounds from Dipterocarpaceae family for their anti-diabetic potential	KSCSTE	Dr P Jayamurthy
11	Modernization of jaggery production units initiative towards energy efficient hygienic jaggery production	DST	Mr T Venkatesh
12	Novel antibacterial compounds from marine streptomyees strains associated with four mangrove species from selected regions of Kerala coast for curbing resistant acquired pathogens with special reference to methicillin resistant staphylococcus aureus	MoES	Dr B S Dileepkumar
13	Phytochemical evaluation of pretreated samples	M/s Pankajakasthuri Herbal Foundation, Kattakada	Dr P Nisha

14	Process development for oil/fat to powder by encapsulation for food and nutritional application	DST	Dr P Nisha
15	Product development and stability for milk based herbal extract formulation	M/s Arya Vaidya Pharmacy	Mr V V Venugopal
16	Prospecting iminosugars from tubers of Kerala: Identification, isolation, characterization and their role in glycemic control and antiinfection	SERB	Dr M V Reshma
17	Setting up processing unit for dehydrated fruits and vegetables	HORTICORP	Dr P Nisha
18	Significance of mitochondria associated ER membrane (MAM) in the genesis of diabetic cardiomyopathy	DHR	Ms Anupama Nair
19	Spice essential oil based nanoencapsulates as natural preservatives	Spices Board	Dr P Nisha
20	Technological intervention for value addition of polyherbal spent materials ayurvedic industries	DST	Dr P Nisha
21	Technology development & incubation activities for processing of traditional millets & herbs	Directorate of Agriculture	Mr V V Venugopal
22	Technology development for value addition/preservation of coconut water	Coconut Development Board	Mr V V Venugopal
MICROBIAL PROCESSES &TECHNOLOGY DIVISION			
23	Quantifying molecular transport in membrane proteins using novel optofluidic assay	DBT	Dr Harsha Bajaj
24	Assembly of synthetic cell in a microfluidic system with tunable membrane potential	DST	Dr Harsha Bajaj
25	Starch based edible film preparation	M/s Nourish Foods Tech Pvt Ltd	Dr K Madhavan Nampoothiri
26	Development of a bioprocess for the commercial production of the plant growth stimulant Gibberellic acid GA3	BIRAC	Dr K Madhavan Nampoothiri
27	Biotechnological approaches promising grains and food free of Fusarium mycotoxins	DST	Dr K Madhavan Nampoothiri
28	Investigation on identification and biochemical validation of selenoproteins from Nannochloropsis oceanica CASA CC201 as functional food/ feed supplements	SERB	Dr Muthu Arumugam
29	Microbiome analysis of saline tolerant Pokkali rice varieties of coastal agri saline fields(Pokkali and Kaippad tract) of Kerala and evaluating their core endophyte beneficial rhizobacteria for enhancing rice growth under saline conditions	DBT	Dr N Rameshkumar

30	Edible oil production from fungus using sorghum juice and/ or biomass	M/s Farmsow Pvt Ltd	Dr P Binod
31	Fermentation of fresh turmeric and production of fermented turmeric powder (FTP) with better solubility, and improved palatability	M/s Abrin Aldrich Agronic Products Pvt Ltd	Dr Rajeev K Sukumaran
32	Integrated bio refinery for converting paper mill waste into chemical wealth	DBT INDO UK	Dr P Binod
33	Quantification of substrate across membrane proteins	DBT	Dr Harsha Bajaj
34	Deciphering interacting partners of PAMPs / Effectors of collechotrichium falcatum that trigger innate immunity in sugarcane	DBT	Dr Rajeev K Sukumaran
35	Investigation of the dynamics & mechanism of flocculation by polymers and biopolymers for separation of solid particles of high rate thickeners in mineral processing industries	Ministry of Mines	Dr Rakesh Kumar Yasarla
36	Molecular and functional characterization of active saline adapted nitrogen fixing plant growth promoting bacteria of native grown coastal saline tolerant rice varieties (Pokkali) of kerala	SERB	Dr N Ramesh Kumar
CHEMICAL SCIENCES & TECHNOLOGY DIVISION			
37	Activity guided screening of phospho diestrease inhibitors from Indian medicinal plants to treat erectile dye function	ICMR	Dr A Kumaran
38	An integrated target specific inhibition of Acetylcholinesterase, phosphodiesterase-5 and Amyloid-Beta aggregation for Alzheimer's disease through phytotherapeutic approach	ICMR-DHR	Dr Anand Ganapathy
39	Antimicrobial Formulations and Coatings on Cotton Substrates for Biodegradable Paper-based Masks	LaFabrica Crfts Pvt Ltd	Dr Sreejith Shankar Pooppannal
40	Base controlled diversity synthesis of spiro-indolinone hybrids of medicinal relevance	SERB	Dr B S Sasidhar
41	Biocompatible combined polymer polysaccharide core-shell VEGF-Targeted Nano-Carrier for sustained Intraocular pharmacotherapy towards diabetic retinopathy	DBT	Dr K K Maiti
42	Design and development of bio-based novel liquid crystalline conductive electrodes and electrolytes for high performing flexi-energy storage devices	DST	Dr Saju Pillai
43	Design and development of efficient, stable and cost effective organic dyes for application in dye-sensitized solar cells	SERB	Dr A Ajayaghosh
44	Design and development of Novel Nucleoside analogues as broad spectrum viral RNA polymerase inhibitors	AICTE	Dr Jubi John

45	Design and synthesis of novel iminosugar variants and their cationic amphiphiles as antiviral therapeutics against Dengue Virus (DENV)	DBT	Dr L Ravishankar
46	Development of a sandwich model magnetic capture system for the detection of pancreatic cancer biomarkers in serum by SERS based immune assay	DHR	Dr Vishnu Priya Murali
47	Development of advanced thermoelectric modules with superior performance in TEG and TEC modes	GAIL(India) Ltd	Dr Biswapriya Deb
48	Development of Knowledge base on pharmaceutical formulations	Kerala State Drugs Pharmaceuticals Limited (KSDPL)	Dr A Kumaran
49	Development of quantum chemical descriptor (QCD) based method for screening	DST-SERB	Dr C H Suresh
50	Digitally connected tribal colonies	Medical Electronics & Health Informatics Division	Dr Yoosaf Karuvath
51	Discovery & pre-clinicaldevelopment of antivirals for COVID-19 & other diseases	CSIR	Dr Jubi John
52	Disinfection-Solidification system for pathogenic medical waste Disposal	Bio Vastum Sloutions Pvt Ltd	Dr Sreejith Shankar Pooppannal
53	Dynamic molecular, supramolecular and surface chemistry for spatiotemporal modulation of smart advanced functional materials	DST	Dr Sreejith Shankar Pooppannal
54	Dynamic molecular, supramolecular and surface chemistry for spatiotemporal modulation of smart advanced functional materials	DST	Dr Sreejith Shankar Pooppannal
55	Engineering intelligent theranostic nanocarrier for targeted therapy and diagnosis of Cancer	DST-SERB	Dr K K Maiti
56	Engineering Nanostructured surfaces for Developing SERS Sensing Platform	DBT	Dr Yoosaf Karuvath
57	Experimental and theoretical investigation on lead free perovskites for opto electronic applications	SERB	Dr C Vijayakumar
58	Exploration of the structures and bioactivities of semi-synthetic and glycoside derivatives of abundant natural products from the Western Ghats of India and East Java, Indonesia	SERB	Dr L Ravishankar
59	Fluorescent molecules and assemblies for sensing and imaging(J C Bose Fellowship)	DST	Dr A Ajayaghosh
60	Large area opto-electronics for Australia and India : From materials to advanced devices	DST	Dr A Ajayaghosh
61	Lead free hybrid perovskites incorporated with organic charge-transfer complexes for photovoltaic application	SERB	Dr C Vijayakumar

62	Microfluidic two-photon lithography Raman Spectroscopy (μTPL-RS) system for 3D printing functional micro devices	DST	Dr Yoosaf Karuvath
63	Mixed-dimensional and hybrid bilayered perovskites for high stability and high efficiency photovoltaic devices	DST Indo Israel	Dr Ishita Neogi
64	Nano mechanical response in organic crystals: Molecular basis of mechanically induced structural transformations	SERB	Dr Sunil Varughese
65	Nature Inspired chemical entities for healthcare applications	SERB	Dr B S Sasidhar
66	New therapeutics against SARS Cov2: analyzing small molecule chemical libraries by establishing targeted cell based assays for inhibitors of viral entry & viral protease	DBT	Dr L Ravishankar
67	Novel strategies for the generation of long lived photo induced charge separated states in donor-acceptor systems	SERB	Dr Karunakaran Venugopal
68	Organic- inorganic hybrid nanomaterials for non-conventional energy technologies	Nano Mission, DST	Dr Sujatha Devi P
69	Phytotherapeutic approach for the management of Benign prostatic hyperplasia: A multifaceted target-specific inhibition of selective alpha -adrenergic receptor, 5-alpha-reductase and phosphodiesterase type 5	ICMR	Dr A Kumaran
70	Probing interfacial device dynamics in highly efficient copper electrolyte based dye-sensitized solar cells for indoor photovoltaics	SERB	Dr Suraj Soman
71	Revealing the interaction mechanism of the protein with lipids in the apoptosis process: electronic, vibrational and confirmational relaxation dynamics of the heme in the liposomes	DBT	Dr Karunakaran Venugopal
72	Solar potential analysis of Dome and Flat-panel PV	M/s Archaid Architects	Dr Adersh Asok
73	Sustainable utilization of abundant natural resources: Synthetic transformations of zerumbone and germacrone towards chemically diverse sesquiterpenoid architectures	SERB, DST	Dr K V Radhakrishnan
74	Synthesis and photo physical study of hybrid perovskite materials for high efficiency electronic and optoelectronic devices	KSCSTE	Dr C Vijayakumar
75	Synthesis of a novel lipid-linked oligosaccharride and its evaluation as vaccine adjuvant	SERB	Dr L Ravishankar
76	Towards cost-effective fabrication of white OLEDS for solid-state lighting: How to address process complexity and optimal usage of materials	SERB	Dr Narayanan Unni
77	Tuning electrochemical pathways in new- generation electrochromic materials for secondary energy-sourcing	SERB	Dr Biswapriya Deb

MATERIALS SCIENCE & TECHNOLOGY DIVISION			
78	Adsorbents for gas and vapour molecules. Rational design of materials , porous nano structures and surface chemistry	NORITAKE	Dr U S Hareesh
79	Advanced near net shape manufacturing technology of aluminium alloy and composite components for thermal management applications	DST	Dr T P D Rajan
80	Automation and AI/ML assisted development of solid state battery technology (WP:NMC cathode for Li-ion batteries)	DST	Dr Rakhi R B
81	Bleaching studies of Kaolin mineral resource in Karnataka State Region	Karnataka State Minerals Corporation Ltd	Dr S Ananthakumar
82	Centre of Excellence for light weight material technologies	WABCO India Ltd	Dr T P D Rajan
83	CFD and kinetic modeling of CVD reactor for TiO2 deposition on float glass at atmospheric pressure	Asahi India Glass Ltd, Mumbai	Dr Adersh Asok
84	Chemical functionalization of Si with 2D structures: Anode materials for lithium ion battery with significantly improved volumetric capacity	DST	Dr Saju Pillai
85	Copper coating on poxy carbon composite for radio frequency reflector antennas	ISRO	Dr T P D Rajan
86	Dark-catalytic and planar solar-concentrator based reactors for removal of organic pollutants from textile effluents	DST	Dr Satyajit Shukla
87	Design and development of bioactive and biodegradable rare earth free Mg based alloys and coatings for third generation bio-implant application	ASEAN-DST	Dr A Srinivasan
88	Design and development of flexible polymer/biopolymer based aerogels for thermal and acoustic insulation	SERB	Dr E Bhoje Gowd
89	Design and development of near net shape manufacturing process for light weight high strength aluminium composite and engineering components by squeeze infiltration technique for automotive and aerospace applications	IGSTC	Dr T P D Rajan
90	Development of wearable electronic -skin patch for real -time monitoring of human health parameters and tactile sensing	DST	Dr Achu Chandran
91	Development of additive manufacturing /3D printing technique or polyurethane encapsulation of conformal array hydrophone	NPOL, DRDO	Dr K I Suresh
92	Development and evaluation of materials for the selective removal of carbon dioxide from flue gases and natural gas streams	ONGC	Dr U S Hareesh

93	Development and in-vitro Characterization of magnesium alloys for biocompatible and biodegradable implant applications	SERB-DST	Dr A Srinivasan
94	Development and invitro characterization of rare earth phosphate coatings for biodegradable and biocompatible magnesium based temporary implants	ICMR	Dr A Srinivasan
95	Development of a miniaturized and portable laser induced breakdown spectroscopy LIBS set up for fast identification and sorting of different plastic classes	DST	Dr E Bhoje Gowd
96	Development of binder less coir boards: A greener alternative product to wood panels for building applications	NCRMI	Dr Sushanta Kumar Sahoo
97	Development of disposable plates using coconut husk	Mr T P Aboobacker Sundus Villa, Sripushkaram P O,	Dr K I Suresh
98	Development of graphene based membranes from graphite ore for desalination	Ministry of Mines	Dr S S Sreejakumari
99	Development of Iridium coating over carbon-carbon composites for space applications	ISRO	Dr S S Sreejakumari
100	Development of iron aluminide coated high performance steels	DST	Dr K Jayasankar
101	Development of LTCC tapes and compatible gold pastes for space application	ISRO	Dr K P Surendran
102	Development of polymer coir composites for electrical insulation	NCRMI	Dr Bhoje Gowd
103	Development of sustainable pressure sensitive adhesives from bio-sourced pre-polymers: A green alternative for semi-structural applications	SERB	Dr Sushanta Kumar Sahoo
104	Development of ZrB2-SiC-HfC and ZrC-SiC-HfC Super strong materials by thermal plasma process for temperatures exceeding 2000 degree Celsius	ISRO	Dr K Jayasankar
105	Green Synthesis of Warm White Light Emitting Single Phase Oxyfluoride Phosphors for Thermally Stable, Energy Efficient, and Elevated color Rendering LED Lamps.	SERB-DST	Dr Subrata Das
106	Improvement of Flux Pinning in Bi-based superconductor Tapes	SERB-DST	Dr Manoj Raama Varma
107	Indigenization of printable conductive gold technologies for electronic applications	DST	Dr K P Surendran
108	Indigenous development of Aluminium- Silicon carbide metal matrix composites	ADE	Dr T P D Rajan
109	Induction melting of lead alloy with oxygen purging	M/s Metal Trade, Mumbai	Mr J Venkatesan

110	Investigation of Zintl phases as efficient thermoelectric materials for energy conversion	DST, SERB	Dr Manoj Raama Varma
111	Large-Scale Production of Coir/Polymer Composites for Acoustic Applications	NCRMI	Dr V S Prasad
112	Low-cost conductive inks for affordable RFID Applications	SERB	Dr K P Surendran
113	Manufacturing of building bricks from foundry sand waste	Autokast Ltd	Dr S Ananthakumar
114	Material evaluation using advanced surface characterization (XPS)	M/s Momentive Performance Materials Pvt Ltd	Dr Saju Pillai
115	Nanowire white LEDs based on innovative nano phosphors	DST	Dr Subratadas
116	Pilot scale manufacturing of innovative building materials from industrial solid wastes	M/s Star Clays	Dr S Ananthakumar
117	Pilot scale processing of high Strength Al-Si-Cu-Mg-Sr alloy and prototype flange, suspension arm and knuckle component manufacturing by squeeze casting	Sri Kaliswari Metal Powders Pvt Ltd	Dr M Ravi
118	Pilot scale squeeze casting technology development of high strength aluminium alloy products for strategic and automotive applications	Ministry of Science & Technology	Dr M Ravi
119	Process development for precision planar optics patterning in the float glass surface via hot forming	Asahi India Glass Ltd, Mumbai	Dr Adersh Asok
120	Production of polymer/coir composites for furniture Application	NCRMI	Mr M Brahmakumar
121	Recovery of metal values extraction from ferrochrome (Fe-Cr) slay	M/s Tata Steel	Dr K Jayasankar
122	Recovery of Scandium , TiO2 and Iron from red mud wastes of aluminum industries	SERB	Dr Jayasankar
123	Recovery of scandium metal from acid leach liquor from titanium mineral industries	Ministry of Mines	Dr M Sundararajan
124	Self-powered electro-optical memory devices for next generation display and data storage application	SERB	Dr Achu Chandran
125	SMART FOUNDARY (SMART= Sustainable Metal casting using Advanced Research and Technology	DST	Dr S Savithri
126	Synthesis and characterization of broad spectrum ultraviolet filter with visible light emission and antioxidant activity: A potential multifunctional active ingredient with multitude of applications	DST	Dr Adersh Asok
127	Synthesis and development of multifunctional benzoxazines from agro residues and its polymer composites as high performance materials	DBT	Dr K I Suresh

128	Technical feasibility evaluation of the offers received for ARP modification	KMML	Dr S Savithri
129	Technical support to flow + solver code of Autokast XI	3D Foundry Tech Pvt Ltd	Dr S Savithri
130	X-ray photoelectron spectroscopy (XPS) of metallic powder samples of VSSC, Thumba, Trivandrum (2018)	VSSC	Dr Saju Pillai
ENVIRONMENTAL TECHNOLOGY DIVISION			
131	Field demonstration and performance evaluation of integrated bio-physical system for generating drinking water from perchlorate contaminated ground water	KSCSTE	Mrs Jasmine G Russel
132	Implementation of a sustainable bioenergy based model effluent treatment plant desiccated coconut industries	DST	Mr Dhani Babu.T
133	Pilot scale demonstration of a comprehensive approach to recover high value products from waste banana pseudo stem	DST	Dr B Krishnakumar
134	Pilot scale demonstration of a technology for remediating community well water contaminated with an emerging & endocrine disrupting micro pollutant perchlorate	Jal Jeevan Mission	Dr B Krishnakumar
135	Process development for control of volatile emissions and odour from spray painting units	Kerala State Pollution Control Board	Dr Parthakundu
136	Random verification of annual inventory on hazardous waste management	CPCB	Dr Parthakundu
137	Upgradation of Food testing laboratory (MoFPI-FTL)	Ministry of Food Processing Industries (MoFPI)	Dr K P Prathish

Consultancy Programmes

Sl No	PROJECT TITLE	CLIENT	PROJECT LEADER
1	Assessment of plastic contaminated soil vis-à-vis recommendations for its reuse at Cella Space Ltd	M/s Cella Space Ltd	Mr Akshay Shende
2	Baseline data generation: LULC & Noise monitoring and impact analysis for Jamnagar mining project, Gujarat	NEERI	Mr Saurabh Sakhre
3	Biodegradable cutlery from apple prunes	M/s HIMJOY Enterprises Pvt Ltd	Dr Anjineyalu Kothakota
4	EIA study for Block-III_ext	KMML	Mr Saurabh Sakhre
5	EIA study for KMML I V VII Phase II	KMML	Dr J Ansari
6	Evaluation of composting inoculum	Suchitwa mission	Dr B Krishnakumar
7	Fermentation and scale up trials melanin production at 150L scale	M/s Avisa Biotech Pvt Ltd	Mr M Kiran Kumar
8	Impact assessment studies for carrying out mining of Beach sand minerals on either side along the TS canal situated in IREL Block IV EE, Chavara, Kollam	Indian Rare Earth Ltd.	Mr Saurabh Sakhre
9	Inventory of Electrical and Electronic Equipment's(EEE) waste under Guidelines on implementation of E waste Management	Kerala State Pollution Control Board	Mr Saurabh Sakhre
10	Manufacturing of biodegradable tableware using rice bran and rice husk	M/s Marikar Green Earth Pvt Ltd	Dr Saju Pillai
11	Method development and analysis of heavy metals in tissues	SCTIMST, Poojappura	Dr K P Prathish
12	Microstructure analysis of industrial yarns	M/s SRF Ltd	Dr E Bhoje Gowd
13	Optimization studies on disinfection solidification systems for pathogenic biomedical waste disposal	M/s Bio Vastum Sloutions Pvt Ltd	Dr Sreejith Shankar
14	Pre commercial feasibility studies on flocculent based disinfection systems and modifications of the process	M/s CML Biotech Pvt Ltd	Dr A Ajayaghosh
15	Preparation of technical feasibility report on citric acid production from cassava and cassava waste	M/s Trinity Pharmaceuticals and Foods (P) Ltd	Dr P Binod
16	Setting up processing unit vegetable processing unit	Samurdhi, BLFO	Dr P Nisha

17	Study on Dioxins & Furans in ambient air and residual ash samples from Brahmapuram	KSPCB,TVM	Dr K P Prathish
18	Study on dioxins and furans emissions in air, ash/soil samples in small incinerators	NEERI	Dr K P Prathish
19	Study on dioxins, furan and dioxin-like PCBs in corn samples	M/s Nawal Analytical Laboratories	Dr K P Prathish
20	Study on dioxins, furan and dioxin-like PCBs in fish samples	M/s Marine Products Exports Development Authority	Dr K P Prathish
21	Study on dioxins, furan and dioxin-like PCBs in fish samples	M/s Marine Products Exports Development Authority	Dr K P Prathish
22	Technical feasibility evaluation of the offers received for ARP modification	KMML	Dr S Savithri
23	Training in Dioxins & PCBs analysis in food samples	M/s Fare Labs Pvt Ltd	Dr K P Prathish
24	Training on analysis and interpretation of dioxins, furans and dioxin like PCB's	M/s Nawal Analytical Laboratories	Dr B Krishnakumar
25	Wheat Bran Waste Processing	M/s Aura Exim	Dr Anjineyalu Kothakota

Technology Transfer Agreements during the period 2021-22

Sl No	Title	Name of the firm/firms with whom the MoU/Agreement is entered into	Project leader
1	The system for pathogenic biomedical waste disposal.	M/s Bio Vastum Solutions Pvt. Ltd., Thrissur	Dr A Ajayaghosh
2	Manufacturing building bricks utilizing waste foundry mould sand generated by Autokast Ltd, Cherthala	M/s Autokast Ltd, Alappuzha	Dr S Ananthakumar
3	Setting up of manufacturing unit for making biodegradable cutleries from apple tree prunes	M/s HIMJOY Enterprises Pvt Ltd, Shimla	DrAnjineyalu Kothakota
4	Value added products from Jackfruit	M/s Apex Coco and Solar Energy Ltd, Tamil Nadu	Dr P Nisha
5	Simultaneous production of protein enriched dietary fiber and virgin coconut oil from coconut floor/ low fat desiccated coconut	Arakuzha Agro Producers Co Operative Society Limited Ernakulam	Dr P Nisha
6	Setting up of plant for manufacturing biodegradable from agro waste	M/s Bio choice Sustainability Solutions Private Limited, Mohali	Dr Anjineyalu Kothakota
7	Setting up biodegradable products unit from pineapple wastes	M/s Vazhakulam Agro and fruit Processing Company Ltd,, Ernakulam	Dr Anjineyalu Kothakota
8	Plant oil based Bio-resin synthesis for paper coating	M/s Varsya Eco Solutions Pvt Ltd, Kazhakoottam	Dr Sushanta Kumar Sahoo
9	Production of Bio based packaging materials from agro residue and further development and optimization of material quality and production process	M/s Varsya Eco Solutions Pvt Ltd, Kazhakoottam	Dr Anjineyalu Kothakota

Other MoUs/Agreements Signed

Sl No	Title	Nature of the MoU	Name of the firm/firms with whom the MoU/Agreement is entered into	Project leader
1	Manufacture of edible & biodegradable products from wide range of agro residues	Non-Disclosure Agreement	M/s Nature's Solution, Noida,	Dr. Anjineyalu Kothakota
2	Investigating the surface chemistry of their samples using XPS	Non-Disclosure Agreement	M/s Momentive Performance Materials (India) Private Limited, Bangalore	Dr Saju Pillai
3	Synthesis of Molnupiravir	Agreement	M/s Suven Pharmaceuticals Limited, Telangana	Dr Jubi John
4	Security deposit cm warranty bond	Indemnity Bond	DRDO	Dr S Savithri
5	Establishment of biodegradable products & research in the area of Biodegradable food packaging materials	Non-Disclosure Agreement	ITC Limited, Kolkata	Dr Saju Pillai
6	Preparation of technical feasibility report on citric acid production from cassava and cassava wastes	Agreement for Consultancy	M/s Trinity Pharmaceuticals and Foods Pvt Ltd, Mumbai	Dr P Binod
7	Microstructure analysis of industrial yarns	Agreement for consultancy Project	M/s SRF Limited, Delhi	Dr E Bhoje Gowd
8	Confidentiality agreement with Ferenta Biotech Limited	Mutual Confidentiality Agreement	Ferenta Biotech Limited, Maharashtra	Dr Muthu Arumugam
9	Developing nutritional products with Cordyceps as the base ingredient and nutritional analysis, shelf-life studies and in vitro biochemical activity assays	Agreement for Sponsored Research	M/s Adhinidhi Nutriment Products Private Limited, Palakkad	Dr R Venkatesh
10	Fermentation of fresh turmeric and production of fermented turmeric powder (FTP) with better solubility, and improved palatability	Agreement for Sponsored Research	M/s AbrinAldrichAgronic Products Pvt Ltd, Ernakulam	Dr R Venkatesh
11	Evaluation of different modified inorganic particles for enhancement of properties of high performance polymer composites	Reciprocal Confidentiality Agreement	M/s Solvay Specialties India Pvt Ltd, Mumbai	Dr E Bhoje Gowd

12	Process development for control of volatile emissions and other from spray painting units	Agreement	Kerala State Pollution Control Board, Thiruvananthapuram	Dr Partha Kundu
13	Exploring the feasibility of antimicrobial coatings on cotton inserts in biodegradable paper masks	Mutual Non-Disclosure Agreement	Lafabrica Craft Private Limited, South Goa	Dr Sreejith Shankar
14	Exploring the feasibility of antimicrobial coatings on cotton inserts in biodegradable paper masks	Research & Development Collaboration Agreement	Lafabrica Craft Private Limited South Goa,	Dr Sreejith Shankar
15	Development of additive manufacturing/3D printing technique for polyurethane encapsulation of conformal array hydrophone	Agreement	Naval Physical & Oceanographic Laboratory,Kochi	Dr K I Suresh
16	Starch based edible film Preparation	Agreement for Sponsored Research	M/s Nourish Foods Tech Private Ltd, Bangalore	Dr Madhavan Nampoothiri
17	Development of brown fused alumina from the Non-metallurgical grade bauxite of Indian origin & its characterization	Agreement of R & D Project	M/s Hindalco Industries Limited, Mumbai	Dr Ananthakumar S
18	Solar potential analysis of Dome and Flat-panel PV	Agreement for Data Generation	M/s Archaid Architects, 1008, 2nd Cross, Bangalore	Dr Adresh Asok
19	Implementation of a sustainable bio- energy based model effluent treatment plant for desiccated coconut industries	MoU	M/s Vittal Agro Industries, Kasargod	Dr B Krishnakumar
20	Fermentation and scale up trials of melanin production	Agreement for Consultancy project	M/s Avisa Biotech Pvt Ltd, Mumbai	Mr Kiran Kumar
21	Study on the emission of dioxins, furans,PCBs and heavy metals	MoU	Kerala State Pollution Control Board, Thiruvananthapuram	Dr K P Prathish
22	Pilot scale feasibility trials on bioethanol production from Starch	Agreement for Consultancy project	M/s SPAC Starch Products(India) Pvt Ltd, Erode	Dr Rajeev K Sukumaran
23	Prospecting iminisugars from tubers of Kerala :identification, isolation, characterization and their role in glycemic control and anti-infection	Agreement for Collaborative Research	Amala Cancer Research Centre, Thrissur	Dr M V Reshma

Patents

Granted in India

Patent No	Title	Grant Date	Inventors
370789	Semiconductor-Oxides Nanotubes-Based Composite Particles Useful For Dye-Removal And Process Thereof	30-Jun-21	Shukla Satyajit Vishnu, Padinhattayil Hareesh, Narayani Harsha, Jose Manu, Karunakaran Remya
377711	An Improved Anaerobic Process And Horizontal Twin Tube Processing Device For The Extraction Of Fibres From Biomass	23-Sep-21	Vattackatt Balakrishnan Manilal
389782	Process For The Surface-Modification Processes For Flyash And Industrial Applications Thereof	20-Feb-22	Shukla Satyajit Vishnu, Warrier Krishna Gopakumar, Kizhakkelikoodayil Baiju Vijayan, Thachan Shijitha

Granted in Abroad

Patent No	Title	Grant Date	Inventors
1-2010-502017	A Method For Anaerobic Process Coupled Separation And Refining Of Plant Materials	20-May-21	Vattackatt Balakrishnan Manilal, Ajit Haridas
6912483	A Thermo-Laminated Multi-layered Zircon Based High Temperature Co-Fired Ceramic (HTCC) Tape And The Process Thereof	12-Jul-21	Kuzhichalil Peethambharan Surendran, Mailadil Thomas Sebastian, Jobin Varghese
6916108	Lanthanum Phosphate Based Coatings And Monoliths As Non-Reactive Surfaces For Molten Metals	19-Jul-21	Sankar Sashidharan, Rajesh Komban, Abdul Azeez Peer Mohamed, Solaiappan Anathakumar, Unnikrishnan Nair Saraswathy Hareesh, Krishna Gopakumar Warrier
3783148	A Process For The Preparation Of Functionalized Weather-Resistant And Slow-Decaying Geotextiles	9-Mar-22	Vadakkethonippuathu Sivankuttynair Prasad, Padinjareveetil Anju, Methalayil Brahmakumar, Das Anitha Ravindranath, Sebastian Sumy
3783148	A Process For The Preparation Of Functionalized Weather-Resistant And Slow-Decaying Geotextiles	9-Mar-22	Vadakkethonippuathu Sivankuttynair Prasad, Padinjareveetil Anju, Methalayil Brahmakumar, Das Anitha Ravindranath, Sebastian Sumy
3783148	A Process For The Preparation Of Functionalized Weather-Resistant And Slow-Decaying Geotextiles	9-Mar-22	Vadakkethonippuathu Sivankuttynair Prasad, Padinjareveetil Anju, Methalayil Brahmakumar, Das Anitha Ravindranath, Sebastian Sumy

Filed in India

Title	Inventors	File No	Filing Date
A High Performance CO_2 Absorbent Material For CO_2 Capture At Medium Temperatures And The Method For Production Thereof	Balgopal N Nair, Visakh Vijayan, Devika Surendran, Abdul Azeez Peer Mohamed, Unnikrishnan Nair Saraswathy Hareesh	202121018578	22-Apr-21
A Short And Cost Effective Synthetic Route Towards Anti-Viral Drug Molnupiravir (EIDD-2801) From D-Ribose	John Jubi, Kokkuvayil Vasu Radhakrishnan, Lankalapalliravi Shankar, Doddamani Shridevi, Puthiyaparambathu Sharathna, Panikkassery Ravi Nitha, Ayyappanpillai Ajayaghosh	202111019499	11-Jun-21
Synergistic Composition Of Malabaricone B And Conventional Antibiotics Against Multidrug Resistant Staphylococcus Aureus Infections	Radhakrishnan Kokkuvayil Vasu, Neethu Sivadas, Sidharth Chopra, Grace Kaul, Manjulika Shukla, Mathew Dan, Govind Murugan Govindakurup	202111044825	01-Oct-21
Temperature Programmable Small Molecules And Prototypes For Thermoresponsive Smart Windows And Applications Thereof	Ajayaghosh Ayyappanpillai, Dipak Patra, Sreejith Shankar Pooppanal	202113045339	04-Oct-21
An Improved Disinfection-Solidification Process For Pathogenic Medical Waste Disposal	Sreejith Shankar Pooppanal, Sruthi Surendran Nair, Suja Pottath, Hareesh Unnikrishnan Nair Saraswathy, Rajeev Kumar Sukumaran, Savithri Sivaraman, Parukkuttyamma Devi Sujatha, Ajayaghosh Ayyappanpillai	202111045340	04-Oct-21
Disinfection And In Situ Flocculation-Solidification Process For Pathogenic Medical Waste Disposal	Sreejith Shankar Pooppanal, Sruthi Surendran Nair, Achu Radhakrishnakurup, Visakh Vijayan, Peer Mohamed Abdul Azeez, Hareesh Unnikrishnan Nair Saraswathy, Rajeev Kumar Sukumaran, Savithri Sivaraman, Parukkuttiamma Devi Sujatha, Ajayaghosh Ayyappanpillai	202111045341	04-Oct-21
A Photometric Device And Methodology For Easy Detection And Quantification Of Components From The Binary Mixtures	KaruvathYoosaf, Nair Raji Bhaskaran, Emmanuel Neethu	202111045354	04-Oct-21
An Improved Process For The Preparation Of Nitazoxanide And Intermediates Thereof	Sasidhar Balappa Somappa, Praveen Kumar Valmiki, Basavaraja Durugappa	202111045217	05-Oct-21
Self-Sterilizing Printed Fabric Heaters For Application In Reusable Personal Protective Equipment And Method Of Preparing The Same	Chandran Achu, Kuzhichalil PeethambharanSurendran, Sukumaran Rajeev Kumar, Sivan Pillai Adarsh, Varghese Harris, Velayudhanpillai Prasannakumari Adarsh, Puthiyamadam Anoop	202111046365	11-Oct-21
A Short And Cost Effective Synthetic Route Towards Anti-Viral EIDD-1931 And Its Hydrate Polymorphs	Jubi John, Sunil Varughese, Radhakrishnan Kokkuvayil Vasu, Ajayaghosh Ayyappanpillai, Jagadeesh Krishnan, Divya Indira Soman, AbhijithBalan, Akhil Krishnan Radhakrishnapillai, Priyadarshini Thoppe Sivakumar	202111047808	20-Oct-21
A Raman Signal Enhancing Substrate (Sensor) For Trace Level Detection And A Method Of Fabrication Thereof	Karuvath Yoosaf, Kavil Narayanan Narayanan Unni, Pulassery Sanoop, Manikandan Sajitha, Soman Anjaly, Abraham Bini	202111049956	29-Oct-21

Pyrazole Amide Based Compounds And Uses Against Breast Cancer Thereof	Sulochana Priya, Sasidhar Balappa Somappa, Kozhiparambil Gopalan Raghu, Sreerenjini Lakshmi, Kizhakkan Thiruthi Ashitha	202111052657	16-Nov-21
A Process For The Synthesis Of BCX-1777 And BCX-4430	Ravi Shankar Lankalapalli, Anitha Krishnakumar Karunakaran, Sanjay Varma Suresh, OmanakuttanYadhukrishnan Velickakathu, Sangeeth Kapiya, Shihas Ahammed Chekrain Valappil, Prabha Bernard, Arun Kumar Thangarasu, Doddamani Shridevi Doddramappa, Jubi John, Vasu Radhakrishnan Kokkuvayil, Ajayaghosh Ayyappanpillai	202111061664	29-Dec-21
A Smart Covalent Organic Framework And A Process For Carbon Dioxide Adsorption Induced Switchable Antibacterial Activity Therefrom	Ayyappanpillai Ajayaghosh, Mal Arindam, Mishra Kumar Rakesh, Bhaskaran Nair Saraswathy Amma Dileep Kumar, Jacob Jubi, Shankar Pooppanal Sreejith	202211000696	06-Jan-22
Porous Silica Material And Method Of Producing The Same	Balgopal N Nair, Radhakrishnakurup Achu, Visakh Vijayan, Nadukkandy Minju, Devika Surendran, Abdul Azeez Peer Mohamed, Solaiappan Ananthakumar, Sivaraman Savithri, Unnikrishnan Nair Saraswathy Hareesh	202221013820	14-Mar-22
A Process For Production Of Uttroside From Plants	Ravi Shankar Lankalapalli, Arun Kumar Thangarasu, Dehannath KottaramInduja, Mullan Velandy Reshma	202211018238	28-Mar-22

Filed Abroad

Title	Inventors	File No	Filing Date
Organic Selenium Enriched Edible Marine Microalgal Biomass	Muthu Arumugam, Ragini Reshma	PCT/IN2021/050483	19-May-21
A Diagnostic Screening Kit For Simultaneous Detection Of Clinically Relevant Biomakers From Breast Cancer Tissue Samples Using Surface Enhanced Raman Scattering Platform And Process For The Preparation Thereof	Maiti Kaustabh Kumar, Kunjuraman Sujathan, Murali Vishnu Priya, Karunakaran Varsha, Selvakumar Deepika, Murali Madhukrishnan, Valliamma Neelakantapillai Saritha, Lekshmi Asha	183/2021	13-Jun-21
A Diagnostic Screening Kit For Simultaneous Detection Of Clinically Relevant Biomakers From Breast Cancer Tissue Samples Using Surface Enhanced Raman Scattering Platform And Process For The Preparation Thereof	Maiti Kaustabh Kumar, Kunjuraman Sujathan, Murali Vishnu Priya, Karunakaran Varsha, Selvakumar Deepika, Murali Madhukrishnan, Valliamma Neelakantapillai Saritha, Lekshmi Asha	PCT/IN2021/050577	14-Jun-21
Electrochromic Bi-Layered Devices For Dynamic Light Throughput Control And A Process For The Preparation Thereof	Deb Biswapriya, Prabhu Thulichal Ganesh Prabhu Gayathri, Venugopal Ranjana	PCT/IN2021/050772	11-Aug-21

A Thermoresponsive Self-Assembled Organic Material As Photonic Ink And A Process Of Making Thereof	Ayyappanpillai Ajayaghosh, Cherumukkil Sandeep, Chakkooth Vijayakumar	PCT/IN2021/050860	6-Sep-21
A Superhydrophobic Composite And Multifunctional Applications Thereof	Shankar Pooppanal Sreejith, Nirmala Anjali, Unnikrishnan Nair Saraswathy Hareesh, Ayyappanpillai Ajayaghosh	PCT/IN2021/050878	8-Sep-21
A Transparent Gel Electrolyte System And Fast Switching Electrochromic Devices Thereof	Deb Biswapriya, Ayyappanpillai Ajayaghosh, Venugopal Ranjana, Prabhu Thulichal Ganesh Prabhu Gayathri, Shankar Pooppanal Sreejith	17/595970	30-Nov-21
A System And Method For Onsite Wastewater Treatment And Resource Recovery	Bhaskaran Krishnakumar	PCT/IN2021/051166	13-Dec-21
A Transparent Gel Electrolyte System And Fast Switching Electrochromic Devices Thereof	Deb Biswapriya, Ayyappanpillai Ajayaghosh, Venugopal Ranjana, Prabhu Thulichal Ganesh Prabhu Gayathri, Shankar Pooppanal Sreejith	289394	26-Dec-21
A Transparent Gel Electrolyte System And Fast Switching Electrochromic Devices Thereof	Deb Biswapriya, Ayyappanpillai Ajayaghosh, Venugopal Ranjana, Prabhu Thulichal Ganesh Prabhu Gayathri, Shankar Pooppanal Sreejith	2022-506441	28-Jan-22
A Transparent Gel Electrolyte System And Fast Switching Electrochromic Devices Thereof	Deb Biswapriya, Ayyappanpillai Ajayaghosh, Venugopal Ranjana, Prabhu Thulichal Ganesh Prabhu Gayathri, Shankar Pooppanal Sreejith	21753477.5	8-Feb-22
Thermo-Responsive Molecules For Controlled Heat And Light Transmission Windows And Applications Thereof	Ayappanpillai Ajayaghosh, Das Satyajit, Soman Suraj, Asok Adersh, Shankar Pooppanal Sreejith	---	17-Mar-22
Thermo-Responsive Molecules For Controlled Heat And Light Transmission Windows And Applications Thereof	Ayappanpillai Ajayaghosh, Das Satyajit, Soman Suraj, Asok Adersh, Shankar Pooppanal Sreejith	---	25-Mar-22
Thermo-Responsive Molecules For Controlled Heat And Light Transmission Windows And Applications Thereof	Ayappanpillai Ajayaghosh, Das Satyajit, Soman Suraj, Asok Adersh, Shankar Pooppanal Sreejith	---	28-Mar-22
Isoprenyl Natural Scaffold Against MDR Staphylococcus Aureus And Synergistic Compositions Thereof	Kokkuvayil Vasu Radhakrishnan, Murugan Thulasi Meenu, Sidharth Chopra, Grace Kaul, Manjulika Shukla	PCT/IN2022/050315	29-Mar-22

KNOWLEDGE RESOURCE CENTRE

Knowledge Resource Centre

The Knowledge Resource Centre has undertaken a wide range of activities to provide required information and information technology support for the institute's R & D efforts.

Information resources & services

Being an integral part of supporting the R & D efforts of the institute, KRC expanded its collection with digital and print resources, comprising books, journals, technical reports, standards, patents, theses, as well as other resources, including academic databases and online tools for academic writing. KRC procured 180 new books during 2021-22, including 108 books that were received as gifts.

As a member of the National Knowledge Resource Consortium (NKRC), the KRC has continued to have full-text articles from the American Chemical Society, Royal Society of Chemistry, American Institute of Physics, Institute of Physics, Springer Nature, Oxford University Press, Taylor & Francis, etc., as well as a subscription to specialised databases such as SciFinder-n, Web of Science, ASTM Standards, and Qpat, in addition to e-journals that are subscribed directly. DSpace, the institutional repository software, and Koha, the library automation software, have both been upgraded to the recent versions.

Subscription to the research writing support tool Grammarly premium continued for ensuring error-free manuscripts. The software iThenticate subscribed for scholars to examine their original works for plagiarism.The works are in the final stage for upgrading the KRC security with Radio Frequency Identification System (RFID).

The institute website, social media sites, VIDWAN database, and institutional Repository (IR) are all maintained and updated. The IR currently has 2920 journal publications and 606 other documents, including doctoral theses and news items. KRC regularly provided training on Sci-Finder discovery services, Grammarly premium, Web of Science, reference management software, literature searches, prior art searches, open access etc.

Information Technology Infrastructure and Enabled Services

KRC is continuously envisaging the information needs of the laboratory and setting up efficient and reliable infrastructure for the smooth functioning, speed and security of the communication network. The laboratory is linked with two internets leased lines of 100 Mbps from NKN and a backup line of 100 Mbps from BSNL respectively to fulfill the internet requirements of the laboratory. All the buildings are interconnected through a gigabit fiber optic backbone. There are around 1150+ internet connections through the wired and wireless networks. Separate VLANs have been maintained to improve network performance. Server-grade antivirus and Security Firewall has been deployed for a secured environment.

Apart from managing the internet connectivity, the IT infrastructure also includes a data center comprising of servers, storage and network devices. KRC have implemented online recruitment portals for recruiting staff to permanent positions and also for recruiting the Project Assistants. Another portal is developed for receiving online applications for skill development programs. The modification and revamping of the Institute website as per the Government of India guidelines is in progress.

KRC ensures the smooth functioning of AADHAR enabled biometric attendance system installed at different locations. The Face Recognition devices are installed for secured access to the main building. Digital Display systems are maintained at various locations for exhibiting research outcomes, notices etc. The printing and Scanning facility is provided to users through a wide range of Heavy Duty Color Laser Printers and A3/A4 Scanners. KRC issues institutional identity cards for the staff members, research scholars and pensioners.

List of Publications

1. AAZEM (I), RATHINAM (P), PILLAI (S), HONEY (G), VENGELLUR (A), BHAT (S G), SAILAJA (G S) 'Active bayerite underpinned Ag_2O/Ag: an efficient antibacterial nanohybrid combating microbial contamination 'Metallomics; 13(8); 2021

2. ABDUL HAKKEEM (H M), BABU (A), PAL (S K), PEER MOHAMED (A), GHOSH (S K), PILLAI (S) 'Cellulose nanocrystals directed in-situ assembly of Au@Ag nanostructures with multifunctional activities' Microchemical Journal; 168:106393; 2021

3. ABHILASH (T K), VARGHESE (H), CZERWINSKI (M), CZUPRYNSKI (K), CHANDRAN (A) 'Probing the effect of chiral dopant fluorination on dielectric and electro-optical properties of the ferroelectric liquid crystalline mixture' Journal of Molecular Liquids; 341:117392; 2021

4. ABRAHAM (M), KUNTI (A K), THEJAS (K K), MENDEZ (N A), GOGNEAU (N), NISHANTH (K G), TCHERNYCHEVA (M), DAS (S) 'The elevated colour rendering of white-LEDs by microwave-synthesized red-emitting (Li, Mg)3RbGe8O18:Mn4+ nanophosphors 'Dalton Transactions; 50(8):3044-3059; 2021

5. AGARWAL (P B), THAKUR (N K), SHARMA (R), SINGH (P), JOSEPH (J), TRIPURA (C) 'Chemical-free and scalable process for the fabrication of a uniform array of liquid-gated CNTFET, evaluated by KCl electrolyte ' Scientific Reports; 11(1); 2021

6. AHMAD (S), PANDEY (M K), DAS (S), MISHRA (A), NAGARAJAN (R) 'Morphology controlled green synthesis of photoluminescent LaPO4: Ce3+-Tb3+ nanorods' Chemical Physics Letters; 776:138704; 2021

7. AKHIL (K R), BABU (S A), NITHA (P R), JAGADEESH (K), JUBI (J) 'Synthesis of Benzothienobenzofurans via Annulation of Electrophilic Benzothiophenes with Phenols' Organic Letters; 23(5):1814-1819; 2021

8. AKHIL (M G), ARSHA (A G), MANOJ (V), RAJAN (T P D), PAI (B C), HUBER (P), GRIES (T) 'Metal fiber reinforced composites [Book Chapter]' Fiber Reinforced Composites; 479 to 513; 2021

9. AKHIL (M G), ARSHA (A G), MANOJ (V), VISHNU (R L), RAJAN (T P D), PAI (B C) 'Squeeze Infiltration Processing and Structural Characteristics of Lightweight Aluminum-Carbon Metal Matrix Composites' Transactions of the Indian National Academy of Engineering; https://doi.org/10.1007/s41403-020-00172-0; 2021

10. AKSHAY (V R), ARUN (B), MUKESH (M), CHANDA (A), VASUNDHARA (M) 'Tailoring the NIR range optical absorption, band-gap narrowing and ferromagnetic response in defect modulated TiO_2 nanocrystals by varying the annealing conditions' VACUUM; 184:109955; 2021

11. ALPHY (M P), ANJALI (K B), VIVEK (N), THIRUMALESH (B V), SINDHU (R), PUGAZHENDI (A), PANDEY (A), BINOD (P) 'Sweet sorghum juice as an alternative carbon source and adaptive evolution of Lactobacillus brevis NIE9.3.3 in sweet sorghum juice and biodiesel derived crude glycerol to improve 1, 3 propanediol production' Journal of Environmental Chemical Engineering; 9(5):106086; 2021

12. AMITH (A), SHAJI (P), JOBY (J), PRAMOD (S), JACOB (K C), SINDHU (R), PANDEY (A), BYOUNG IN (S), KOCHUPURACKAL (J) 'Growth promoting activities of antagonistic bacterial endophytes from Heveabrasiliensis (Willd. ex A.Juss.) Müll.Arg.' Indian Journal of Experimental Biology; 59(12); 2021

13. AMITH (A), SHAJI (P), JOBY (J), PRAMOD (S), JACOB (K C), SINDHU (R), PANDEY (A),BYOUNG IN (S), KOCHUPURACKAL (J) 'Bioengineered biochar as smart candidate for resource recovery toward circular bio-economy: a review' Bioengineered; 12(2):10269 - 10301; 2021

14. AMOBONYE (A), BHAGWAT (P), RAVEENDRAN (S), SINGH (S), PILLAI (S) ' ENVIRONMENTAL IMPACTS OF MICROPLASTICS AND NANOPLASTICS: A CURRENT OVERVIEW' FRONTIERS IN MICROBIOLOGY; 12; 2021

15. ANANTHI (V), BALAJI (P), SINDHU (R), KIM (S H), PUGAZHENDHI (A), ARUN (A) 'A critical review on different harvesting techniques for algal

based biodiesel production' Science of The Total Environment; 780:146467; 2021

16. ANILA (S), SURESH (C H) 'Endo-and exohedral chloro-fulleride as η5 ligands: a DFT study on the first-row transition metal complexes' Physical Chemistry Chemical Physics; 23(5):3646-3655; 2021

17. ANILA (S), SURESH (C H) 'Guanidine as a strong CO_2 adsorbent: a DFT study on cooperative CO2 adsorption' Physical Chemistry Chemical Physics; 23(24):13662-13671; 2021

18. ANILA (S), SURESH (C H) 'Imidazolium–fulleride ionic liquids – a DFT prediction' Physical Chemistry Chemical Physics; 23(36):20086-20094; 2021

19. ANJALIKRISHNA (P K), GADRE (S R), SURESH (C H) 'Antiaromaticity–Aromaticity Interplay in Fused Benzenoid Systems Using Molecular Electrostatic Potential Topology' Journal of Physical Chemistry A; 125(27):5999 - 6012; 2021

20. ANJANA (P M), SARATH KUMAR (S R), RAKHI (R B) 'Direct growth of Mn(OH)2/Co(OH)2 nanocomposite on carbon cloth for flexible supercapacitor electrodes' Journal of Energy Storage; 33:102151; 2021

21. ANJANA (P M), SARATH KUMAR (S R), RAKHI (R B) 'MnCo2O4 nanoneedles self-organized microstructures for supercapacitors' Materials Today Communications; 28:102720; 2021

22. ANTONY (A M), KANDATHIL (V), KEMPASIDDAIAH (M), SASIDHAR (B S), PATIL (S A), PATIL (S A) 'Hexagonal Boron Nitride Supported N-Heterocyclic Carbene-Palladium(II): A New, Efficient and Recyclable Heterogeneous Catalyst for Suzuki–Miyaura Cross-Coupling Reaction' Catalysis Letters; 151(5):1293 - 1308; 2021

23. ANTONYRAJ (C A), CHENNATTUSSERY (A J), HARIDAS (A) '5-(Chloromethyl)furfural production from glucose: A pioneer kinetic model development exploring the mechanism' International Journal of Chemical Kinetics; 53(7):825-833; 2021

24. ARUMUGAM (M), UDAYAN (A), SABAPATHY (H), ABRAHAM (B) 'Plant growth regulator triggered metabolomic profile leading to increased lipid accumulation in an edible marine microalga' Journal of Applied Phycology; 33(3):1353-1365; 2021

25. ARUN (K B), MADHAVAN (A), SINDHU (R), EMMANUAL (S), BINOD (P), PUGAZHENDHI (A), SIROHI (R), RESHMY (R), AWASTHI (M K), GNANSOUNOU (E), PANDEY (A) 'Probiotics and gut microbiome – Prospects and challenges in remediating heavy metal toxicity' Journal of Hazardous Materials; 420:126676; 2021

26. ASWATHI (A), PANDEY (A), MADHAVAN (A), SUKUMARAN (R K) 'Chlorpyrifos induced proteome remodelling of Pseudomonas nitroreducens AR-3 potentially aid efficient degradation of the pesticide' Environmental Technology & Innovation; 21:101307; 2021

27. ASWATHI (K), LEKSHMI (P N), VALANT (M), MIHELJ (M V), VARMA (M R) 'Exotic magnetic behavior with intrinsic and extrinsic magnetodielectric effects in Pr2CuMnO6' Journal of Alloys and Compounds; 867:159123; 2021

28. ASWATHY (B A), RAO (P P), SUCHITHRA (V G), AHIRA (K V R) 'New narrow orange-emitting phosphors in 1:2 B-site cation ordered Eu3+ doped triple perovskite Ba3CaNb2O9' Journal of Materials Science - Materials in Electronics; 32(9):12671-12680; 2021

29. ASWATHY (M), BANIK (K), PARAMA (D), SASIKUMAR (P), HARSHA (C), JOSEPH (A G), SHERIN (D R), THANATHU (M K), KUNNUMAKKARA (A B), RADHAKRISHNAN (K V) 'Exploring the Cytotoxic Effects of the Extracts and Bioactive Triterpenoids from Dilleniaindica against Oral Squamous Cell Carcinoma: A Scientific Interpretation and Validation of Indigenous Knowledge' ACS Pharmacology & Translational Science; 4(2):834-847; 2021

30. ATHIRA (K J), GOPIDAS (K R) 'Photoinduced Electron Transfer in a Self-Assembled Bis(β-cyclodextrin)-Linked Pyrene/Bis (adamantane)-Linked Methyl Viologen Donor–Acceptor System in Aqueous Solution' Journal of Physical Chemistry B; 125(17):4428-4437; 2021

31. ATHIRA (K V R), RAO (P P) 'Intense Blue Chromophores in Cobalt Doped Phenacite-Type Zinc Germanate System through Jahn-Teller Distortion of Co Tetrahedron' ChemistrySelect; 6(41):11344 - 11351; 2021

32. AWASTHI (M K), FERREIRA (J A), SIROHI (R), SARSAIYA (S), KHOSHNEVISAN (B), BALADI (S), SINDHU (R), BINOD (P), PANDEY (A), JUNEJA (A), KUMAR (D), ZHANG (Z Q), TAHERZADEH (M) 'A critical review on the development stage of biorefinery systems

towards the management of apple processing-derived waste' Renewable and Sustainable Energy Reviews; 143:110972; 2021

33. AWASTHI (M K), SARSAIYA (S), WAINAINA (S), RAJENDRAN (K), AWASTHI (S K), LIU (T), DUAN (Y), JAIN (A), SINDHU (R), BINOD (P), PANDEY (A), ZHANG (Z), TAHERZADEH (M J) 'Techno-economics and life-cycle assessment of biological and thermochemical treatment of bio-waste' Renewable and Sustainable Energy Reviews; 144:110837; 2021

34. BABU (S A), RAJALEKSHMI (A R), NITHA (P R), OMANAKUTTAN (V K), RAHUL (P), VARUGHESE (S), JOHN (J) 'Unprecedented access to functionalized pyrrolo[2,1-a]isoquinolines from the domino reaction of isoquinoliniumylides and electrophilic benzannulated heterocycles' Organic & Biomolecular Chemistry; 19(8):1807-1817; 2021

35. BALAKRISHNAN (M), GAYATHIRI (S), PREETHA (P), PANDISELVAM (R), JEEVARATHINAM (G), ANIESRANI DELFIYA (D S), KOTHAKOTA (A) 'Microencapsulation of bixin pigment by spray drying: Evaluation of characteristics' LWT- Food Science and Technology; 145:111343; 2021

36. BASAVANNA, V; NINGAIAH, S; CHANDRAMOULI, M; SOBHA, A; DODDAMANI, S 'Quinolinyl-pyrazoles: synthesis and pharmacological evolution in the recent decennial' JOURNAL OF THE IRANIAN CHEMICAL SOCIETY; 18(7):1479-1522; 2021

37. BASAVARAJA (D), AJAY KRISHNA (M S), KRISHNAN (J), ATHIRA (C S), AMRUTHA (R R), SURESH (E), SASIDHAR (B S) 'Base-enabled access to diastereoselectivespirofuranoxindoles and γ-functionalized allenoates' Chemical Communications; 57(14):1746 - 1749; 2021

38. BEHERA (D), THIYAGARAJAN (S), ANJALIKRISHNA (P K), SURESH (C H), GUNANATHAN (C) 'Ruthenium(II)-Catalyzed Regioselective 1, 2-Hydrosilylation of N-Heteroarenes and Tetrel Bonding Mechanism' ACS Catalysis; 11(10):5885 - 5893; 2021

39. BHAVYA (A S), VARGHESE (H), CHANDRAN (A), SURENDRAN (K P) 'Massive enhancement in power output of BoPET-paper triboelectric nanogenerator using 2D-hexagonal boron nitride nanosheets' Nano Energy; 90:106628; 2021

40. BIJI (M), PRABHA (B), LANKALAPALLI (R S), RADHAKRISHNAN (K V) 'Transition Metal/Lewis Acid Catalyzed Reactions of Zerumbone for Diverse Molecular Motifs' The Chemical Record; 21(12):3943-3953; 2021

41. BIJI (M), RADHAKRISHNAN (K V), LANKALAPALLI (R S) 'Tandem Photoisomerization and Transannular Cyclizations of Zerumbone Epoxide: A Model for Diversity-Oriented Synthesis Using Abundant Natural Products' Organic Letters; 23(15):5871 - 5875; 2021

42. BINOD (P), SINDHU (R), PANDEY (A) 'Introduction to biodegradable polymers and composites: process engineering to commercialization [Book Chapter]' Biomass, Biofuels, Biochemicals; 3 to 10; 2021

43. CHANDA (A), JOSHI (S R), AKSHAY (V R), VARMA (S), SINGH (J), VASUNDHARA (M), SHUKLA (P) 'Structural and optical properties of multilayered un-doped and cobalt doped TiO2 thin films' Applied Surface Science; 536:147830; 2021

44. CHANDRAN (A), CHOUDHARY (A), GANGWAR (L K), ABHILASH (T K), ATHIRA (B S), BIRADAR (A M) 'Resolving the isolated nature of Goldstone mode in ferroelectric liquid crystals at room temperature' Journal of Molecular Liquids; 340:117194; 2021

45. CHANDRASEKARAN (P O), ASWATHY (A), JAMES (K), KALA (K), RAGI (M T), MANOJ (N) 'A molecular chameleon: Fluorometric to Pb2+, fluorescent ratiometric to Hg2+ and colorimetric to Ag+ ions' Journal of Photochemistry and Photobiology A - Chemistry; 407:113050; 2021

46. CHRISTOPHER (M), PRAJEESH (K V), ATHIRARAJ (S R), SUKUMARAN (R K) 'Repurposing proteases: An in-silico analysis of the binding potential of extracellular fungal proteases with selected viral proteins' Bioresource Technology Reports; 15:100756; 2021

47. DARSHAN (V), RAJEEV (V R), NARAYANAN UNNI (K N) 'Enhanced performance of room temperature ammonia sensors using morphology-controlled organic field-effect transistors' Organic Electronics; 98:106280; 2021

48. DAS (G), CHERUMUKKIL (S), PADMAKUMAR (A), BANAKAR (V B), PRAVEEN (V K), AJAYAGHOSH (A) 'Tweaking a BODIPY Spherical Self-Assembly to 2D Supramolecular Polymers Facilitates Excited-State Cascade Energy Transfer' Angewandte Chemie-International Edition; 133(14):7930-7938; 2021

49. DAS (P P), ROY (A), SUJATHA DEVI (P), LEE (Y) 'Sea urchin-like Ni encapsulated with BaTiO3 to form multiferroic core-shell structures for room

temperature magnetoelectric sensors' Current Applied Physics; REVATHY (R), RAHUL (M T), KALARIKKAL (N), VARMA (M R), SURENDRAN (K P); 2021

50. DAS (P P), ROY (A), SUJATHA DEVI (P), LEE (Y) 'Solution processed Al-doped ZnO and its performance in dye sensitized solar cells' Current Applied Physics; 30:69 - 76; 2021

51. DEVULAPALLY (K), REDDY (G), PRASANTHKUMAR (S), JAGADEESH (A), SOMAN (S), GIRIBABU (L) 'Effect of auxiliary acceptor on D-π-A based porphyrin sensitizers for dye sensitized solar cells' Journal of Porphyrins and Phthalocyanines; 25:407-417; 2021

52. DHANYA (S R), NAIR (M S), DILEEP KUMAR (B S), SANKAR (V) 'Chemical constituents from Chonemorphafragrans roots and antibacterial activity studies of sarcorucinine D' Natural Product Research; 44317; 2021

53. DHARMALINGAM (B), GIRI NANDAGOPAL (M S), THULASIRAMAN (V), KOTHAKOTA (A), KUMAR (R) 'Short Food Supply Chains to Resolve Food Scarcity During Covid-19 Pandemic—An Indian Model' Advances in Food Security and Sustainability; 35-63(Pages); 2021

54. DIVYA (I S), AMRUTHA (S), SEETHALEKSHMI (S), VARUGHESE (S) 'Molecular salts of quinine: a crystal engineering route to enhance the aqueous solubility' CrystEngComm; 23(39):6942 to 6951; 2021

55. DIVYA (S), DAS (S) 'New red pigments based on Li3AlMnO5 for NIR reflective cool coatings' Ceramics International; 47(21):30381-30390; 2021

56. DIVYA (V V), SURESH (C H) 'Design and DFT study of nitrogen-rich donor systems for improved photovoltaic performance in dye-sensitized solar cells' New Journal of Chemistry; 45(26):11585-11595; 2021

57. DIVYA (V V), SURESH (C H) 'Tuning the donating strength of dye sensitizers using molecular electrostatic potential analysis' New Journal of Chemistry; 45(5):2496-2507; 2021

58. EL-SENDUNY (F F), ALTOUHAMY (M), ZAYED (G), HARSHA (C), JALAJA (R), SASIDHAR (B S), NAIR (M S), KUNNUMAKKARA (A B), ALSHARIF (F M), BADRIA (F A) 'Azadiradione-loaded liposomes with improved bioavailability and anticancer efficacy against triple negative breast cancer' Journal of Drug Delivery Science and Technology; 65:102665; 2021

59. EMMANUEL (N), NAIR (R B), ABRAHAM (B), YOOSAF (K) 'Fabricating a Low-Cost Raman Spectrometer to Introduce Students to Spectroscopy Basics and Applied Instrument Design' Journal of Chemical Education; 98(6):2109-2116; 2021

60. EVELINE M. ANTO, ANAGA NAIR, JAYAMURTHY PURUSHOTHAMAN 'Emerging Role of Circulating Tumour DNA in Treatment Response Prognosis in Colon Cancer [Book Chapter]' Colon Cancer Diagnosis and Therapy; 257 to 270; 2021

61. GADRE (S R), SURESH (C H), MOHAN (N) 'Electrostatic Potential Topology for Probing Molecular Structure, Bonding and Reactivity' Molecules; 26(11):3289; 2021

62. GANAPATHY (A A), HARI PRIYA (V M), KUMARAN (A) 'Medicinal plants as a potential source of Phosphodiesterase-5 inhibitors: A review' Journal of Ethnopharmacology; 113536 (pp); 2021

63. GANESAN (R), MANIGANDAN (S), SHANMUGAM (S), CHANDRAMOHAN (V P), SINDHU (R), KIM (S H), BRINDHADEVI (K), PUGAZHENDHI (A) 'A detailed scrutinize on panorama of catalysts in biodiesel synthesis' Science of The Total Environment; 777:145683; 2021

64. GANGADHAR (P S), JAGADEESH (A), GEORGE (A S), REDDY (G), PRASANTHKUMAR (S), SOMAN (S), GIRIBABU (L) 'An investigation into the origin of variations in photovoltaic performance using D–D–π–A and D–A–π–A triphenylimidazole dyes with a copper electrolyte' Molecular Systems Design & Engineering; 6(10):779 to 789; 2021

65. GAYATHRI (G S), SUNDARARAJAN (M), REJITH (R G), SREELA (S R), SILAMBARASAN (S), PRUTHIVIRAJ (N) 'Texture and Mineralogy of Beach Sediments of Chavara and Manavalakurichi, South India - A Comparative Analysis' Indian Journal of Geo-Marine Sciences; 50:203-211; 2021

66. GEORGE (G), SHYNI (G L), ABRAHAM (B), NISHA (P), RAGHU (K G) 'Downregulation of TLR4/MyD88/p38MAPK and JAK/STAT pathway in RAW 264.7 cells by Alpinia galanga reveals its beneficial effects in inflammation' Journal of Ethnopharmacology; 275:114132; 2021

67. GEORGE (M E), AKHIL (T), REMYA (R), RAFEEQUE (M K), SURESH BABU (D S) 'Submarine groundwater discharge and associated nutrient flux from

southwest coast of India' Marine Pollution Bulletin; 162:111767; 2021

68. GHOSH, P; ROY, A; MUKHOPADHYAY, S; NARJINARY, M; SUNDARAM, S; SEN, S; DEVI, PS 'A New Functional Composite for Photovoltaic and Sensor Applications' ADVANCED ELECTRONIC MATERIALS; 7(3):2000785; 2021

69. HAQUE (A), DAS (R), GHOSH (D), VASUNDHARA (M), GAYEN (A), KUNDU (A K), MOTIN SEIKH (M D) 'Observation of Predominant Long-Range Ordering by Overcoming the Magnetic Frustration in Cu-Doped La2MnCoO6' Journal of Physical Chemistry C; 125(5):3088-3101; 2021

70. HAQUE (A), DAS (R), VASUNDHARA (M), GHOSH (D), GAYEN (A), MAHATA (P), KUNDU (A K), SEIKH (M M) 'Ambient pressure synthesis and magnetic properties of La[Cu3−xMnx][Mn4−yTiy]O12 (x = 0 & 1; y = 0.5 & 1) quadruple perovskite' Journal of Alloys and Compounds; 875:159984; 2021

71. HARIDAS (R), VELORE (J), PRADHAN (S C), VINDHYASARUMI (A), YOOSAF (K), SOMAN (S), UNNI (K N N), AJAYAGHOSH (A) 'Indoor Light-harvesting Dye-sensitized Solar Cells Surpassing 30% Efficiency Without Co-sensitizers' Materials Advances; 2(23):7773-7787; 2021

72. HEEBA (S), NISHA (P) 'Fermented Foods in Aging and Longevity [Book Chapter]' Healthy Ageing and Longevity; 179 to 192; 2021

73. HIREMATH (S D), GAWAS (R U), DAS (D), NAIK (V G), BHOSLE (A A), MURALI (V P), MAITI (K K), ACHARYA (R), BANERJEE (M), CHATTERJEE (A) 'Phthalimide conjugation turns the AIE-active tetraphenylethylene unit non-emissive: its use in turn-on sensing of hydrazine in solution and the solid- and vapour-phase' RSC Advances; 11(35):21269 - 21278; 2021

74. IGNATIOUS (V), RAVEENDRAN (N), PRABHAKARAN (A), PULI (Y T), CHAKKOOTH (V), DEB (B) 'MWCNT/Thienothiophene based All-Organic thermoelectric composites: Enhanced performance by realigning of the Fermi level through doping' Chemical Engineering Journal; 409:128294; 2021

75. ISHWARYA (S P), ANANDHARAMAKRISHNAN (C) 'Nanospray Drying: Principle and Food Processing Applications [Book Chapter]' Innovative Food Processing Technologies; 605-633 (Pages); 2021

76. ISHWARYA (S P), NISHA (P) 'Foaming agents from spent coffee grounds: A mechanistic understanding of the modes of foaming and the role of coffee oil as antifoam' Food Hydrocolloids; 112:106354; 2021

77. ISHWARYA (S P), NISHA (P) 'Unraveling the science of coffee foam – a comprehensive review' Critical Reviews in Food Science and Nutrition; https://doi.org/10.1080/10408398.2020.1765136; 2021

78. JALAJA (R), LEELA (S G), MOHAN (S), NAIR (M S), GOPALAN (R K), SOMAPPA (S B) 'Anti-hyperlipidemic potential of natural product based labdane-pyrroles via inhibition of cholesterol and triglycerides synthesis' Bioorganic Chemistry; 108:104664; 2021

79. JANA (A), JOSEPH (M M), MUNAN (S), SHAMNA (K), MAITI (K K), SAMANTA (A) 'A single benzene fluorescent probe for efficient formaldehyde sensing in living cells using glutathione as an amplifier' Journal of Photochemistry and Photobiology B: Biology; 214:112091; 2021

80. JANA (P P), ECKERT (J), DAS (J) 'Effect of Cold Rolling on the Pressure Coefficient of Glass Transition Temperature in Bulk Metallic Glasses ThermochimicaActa; 706:179071; 2021

81. JANAKIRAM (V), BHASKAR (K L), JAYASANKAR (K), BHARGAVA (N R M R), MUKHERJEE (P S) 'Plasma Processing of Chlorinated Iron Oxide Waste for Fe Recovery' IEEE Transactions on Plasma Science; 49(2):491-496; 2021

82. JEEVAN (A K), GOPIDAS (K R) 'Self-Assembly and Photochemistry of a Pyrene-Methyl Viologen Supramolecular Fiber System' Journal of Physical Chemistry B; 125(30):8539 - 8549; 2021

83. JEEVARATHINAM (G), PANDISELVAM (R), PANDIARAJAN (T), PREETHA (P), BALAKRISHNAN (M), THIRUPATHI (V), KOTHAKOTA (A) 'Infrared assisted hot air dryer for turmeric slices:Effect on drying rate and quality parameters' LWT- Food Science and Technology; 144:111258; 2021

84. JIBIN (K), VICTOR (M), SARANYA (G), SANTHAKUMAR (H), MURALI (V), MAITI (K K), JAYASREE (R S) 'Nanohybrids of Magnetically Intercalated Optical Metamaterials for Magnetic Resonance/Raman Imaging and In Situ Chemodynamic/Photothermal Therapy' ACS Applied Bio Materials; 4(7):5742 to 5752; 2021

85. JOSE (J), JOSE (S P), PRASANKUMAR (T), SHAJI (S), PILLAI (S), SREEJA (P B) 'Emerging ternary

nanocomposite of rGO draped palladium oxide/ polypyrrole for high performance supercapacitors' Journal of Alloys and Compounds; 855:157481; 2021

86. JOSEPH (N), KAIPAMANGALATH (A), VARMA (M R), THOMAS (S) 'Size controlled growth of barium hexaferrite platelets using salt assisted sol-gel technique' Materials and Manufacturing Processes; 272:124971; 2021

87. KAAVYA (R), PANDISELVAM (R), ABDULLAH (S), SRUTHI (N U), JAYANATH (Y), ASHOKKUMAR (C), KHANASHYAM (A C), KOTHAKOTA (A), RAMESH (S V) 'Emerging non-thermal technologies for decontamination of Salmonella in food' Trends in Food Science & Technology; 112:400-418; 2021

88. KAMENAN (K A), JAGADEESH (A), KRE (N R), ASSANVO (E F), SOMAN (S), UNNI (K N N) 'Natural rubber (Hevea Brasiliensis)-based quasi-solid electrolyte as a potential candidate for arresting recombination and improving performance in aqueous dye-sensitized solar cells' Journal of Materials Science - Materials in Electronics; 32(11):14207-14216; 2021

89. KANDATHIL (V), VEETIL (A K), PATRA (A), MOOLAKKIL (A), KEMPASIDDAIAH (M), SOMAPPA (S B), ROUT (C S), PATIL (S A) 'A green and sustainable cellulosic-carbon-shielded Pd–MNP hybrid material for catalysis and energy storage applications' Journal of Nanostructure in Chemistry; 11(3):395 - 407; 2021

90. KARUNAKARAN (V), SARITHA (V N), RAMYA (A N), MURALI (V P), RAGHU (K G), SUJATHAN (K), MAITI (K K) 'Elucidating Raman Image-Guided Differential Recognition of Clinically Confirmed Grades of Cervical Exfoliated Cells by Dual Biomarker-Appended SERS-Tag' Analytical Chemistry; 93(32):11140-11150; 2021

91. KASHYAP (V), ANEESH KUMAR (R), SAHARUBA (P M), SAURABH (S), ANSARI (J) 'Impacts of placer mining on groundwater and air quality in the Chavara coastal stretch of Kerala [Book Chapter]' Remote Sensing of Ocean and Coastal Environments; 83-98 (PageNo); 2021

92. KEMPASIDDAIAH (M), KANDATHIL (V), DATEER (R B), SASIDHAR (B S), PATIL (S A), PATIL (S A) 'Palladium-catalyzeddenitrogenative cross-coupling of aryl halides with arylhydrazines under mild reaction conditions 'Transition Metal Chemistry; 46(4):273-281; 2021

93. KEMPASIDDAIAH (M), SREE RAJ (K A), KANDATHIL (V), DATEER (R B), SASIDHAR (B S), YELAMAGGAD (C V), ROUT (C S), PATIL (S A) 'Waste biomass-derived carbon-supported palladium-based catalyst for cross-coupling reactions and energy storage applications' Applied Surface Science; 570:151156; 2021

94. KERI (R S), PATIL (M), BUDAGUMPI (S), SASIDHAR (B S) 'An efficient, multicomponent synthesis of aminoalkylnaphthols via Betti reaction using ZSM-5 as a recoverable and reusable catalyst' Applied Organometallic Chemistry; 35(9); 2021

95. KOOLOTH-VALAPPIL (P), CHRISTOPHER (M), SREEJA-RAJU (A), MATHEW (R M), KUNI-PARAMBIL (R), ABRAHAM (A), SANKAR (M), PANDEY (A), SUKUMARAN (R K) 'Draft genome of the glucose tolerant β-glucosidase producing rare Aspergillus unguis reveals complete cellulolytic machinery with multiple beta-glucosidase genes' Fungal Genetics and Biology; 151:103551; 2021

96. KOTHAKOTA (A), PANDISELVAM (R), SILIVERU (K), PANDEY (J P), SAGARIKA (N), SRINIVAS (C H S), KUMAR (A), SINGH (A), PRAKASH (S D) 'modeling and optimization of process parameters for nutritional enhancement in enzymatic milled rice by multiple linear regression (mlr) and artificial neural network (ann)' foods; 10(12):2975; 2021

97. KOTIAN (S Y), SHRIDEVI (D), NINGAIAH (S), MERLO (A A), VIEIRA (A A), BECHTOLD (I H), LOKANATHA RAI (K M) 'When hydrogen bond tailors molecular packing in non-anisometric molecules. The case study of N-alkyl 1,3-diphenyl-4,5-dihydro-1H-pyrazole-5-carboximidamides' Liquid Crystals; 48(3):395-404; 2021

98. KOTTAYINTAVIDA (R), GOPALAN (N K) 'PdAu alloy nano wires for the elevated alcohol electro-oxidation reaction' ElectrochimicaActa; 384:138405; 2021

99. KRISHNAMOORTHY (J), MATHEW (A), VALAPPIL (P K), ADARSH (V P), PUTHIYAMADAM (A), PANDEY (A), SUKUMARAN (R K) 'Ethanol production by a filamentous fungal strain Byssochlamysfulva AM130 under alternating aerobic and oxygen-limited conditions 'Systems Microbiology and Biomanufacturing; 1(1):111-121; 2021

100. KRISHNAMOORTHY (S), AJALA (F), MOHAMMED (S M), ASOK (A), SHUKLA (S) 'High adsorption and high catalyst regeneration kinetics observed for Flyash-Fe3O4-Ag magnetic composite for efficient removal of industrial azo reactive dyes from aqueous solution via persulfate activation' Applied Surface Science; 548:149265; 2021

101. KRISHNAN (V G), JOSEPH (A M), SURENDRAN (K P), GOWD (E B) 'Nanoporous Crystalline Aerogels of Syndiotactic Polystyrene: Polymorphism, Dielectric, Thermal, and Acoustic Properties' Macromolecules; 54(22):10605 to 10615; 2021

102. KUMAR (D), MISHRA (A), TARAFDAR (A), ANWAR (A), SALAGRAM (A), ALAM (S), SAHOO (A K), SINDHU (R), BADGUJAR (P C) 'Protease Catalyzed Production of Spent Hen Meat Hydrolysate Powder for Health Food Applications' Journal of Food Quality; 2021:1-9; 2021

103. KUMAR (R), GHOSHAL (G), GOYAL (M) 'Biodegradable composite films/coatings of modified corn starch/gelatin for shelf life improvement of cucumber' Journal of Food Science and Technology; 58(4):1227-1237; 2021

104. KUMAR (R), GHOSHAL (G), GOYAL (M) 'Effect of basil leaves extract on modified moth bean starch active film for eggplant surface coating' LWT- Food Science and Technology; 145:111380; 2021

105. KURIEN (A M), SHENDE (A D), POPHALI (G R) 'Development of Techno-economical Treatment System for Bulk Milk Cooler Effluent in India' Environmental Engineering & Management Journal; 20(8):1361-1370; 2021

106. LAKSHMI (N M), BINOD (P), SINDHU (R), AWASTHI (M K), PANDEY (A) 'microbial engineering for the production of isobutanol: current status and future directions' bioengineered; 12(2):12308-12321; 2021

107. LAKSHMI (N M), BINOOP (M), SALINI (C N), VIVEK (N), SINDHU (R), PANDEY (A), BINOD (P) 'Isobutanol production by Candida glabrata – A potential organism for future fuel demands' Fuel; 306:121634; 2021

108. LAKSHMI (S), RENJITHA (J), SASIDHAR (B S), PRIYA (S) 'Epoxyazadiradione induced apoptosis/anoikis in triple-negative breast cancer cells, MDA-MB-231, by modulating diverse cellular effects' Journal of Biochemical and Molecular Toxicology; 35(6):1 - 17; 2021

109. LAKSHMI S, HUGHES T A, PRIYA S 'Exosomes and Exosomal RNAs in Breast Cancer : A status update' European Journal of Cancer; 144:252-268; 2021

110. LIU (H M), QIN (S Y), SIROHI (R), AHLUWALIA (V), ZHOU (Y W), SINDHU (R), BINOD (P), SINGHNIA (R R), PATEL (A K), JUNEJA (A), KUMAR (D), ZHANG (Z Q), KUMAR (J), TAHERZADEH (M J), AWASTHI (M K) 'Sustainable blueberry waste recycling towards biorefinery strategy and circular bioeconomy: A review' Bioresource Technology; 332:125181; 2021

111. LIU (H), KUMAR (V), JIA (L), SARSAIYA (S), KUMAR (D), JUNEJA (A), ZHANG (Z), SINDHU (R), BINOD (P), BHATIA (S K), AWASTHI (M K) 'Biopolymer poly-hydroxyalkanoates (PHA) production from apple industrial waste residues: A review' Chemosphere; 284:131427; 2021

112. LIU (H), KUMAR (V), YADAV (V), GUO (S), SARSAIYA (S), BINOD (P), SINDHU (R), XU (P), ZHANG (Z), PANDEY (A), AWASTHI (M K) 'Bioengineered biochar as smart candidate for resource recovery toward circular bio-economy: a review' Bioengineered; 12(2):10269-10301; 2021

113. MADHAVAN (A), ARUN (K B), BINOD (P), SIROHI (R), TARAFDAR (A), RESHMY (R), AWASTHI (M K), SINDHU (R) 'Design of novel enzyme biocatalysts for industrial bioprocess: Harnessing the power of protein engineering, high throughput screening and synthetic biology' Bioresource Technology; 325:124617; 2021

114. MADHAVAN (A), ARUN (K B), SINDHU (R), BINOD (P), PANDEY (A), SIROHI (R), TARAFDAR (A), RESHMY (R) 'Biomedical applications of microbial polyhydroxyalkanoates [Book Chapter]' Biomass, Biofuels, Biochemicals; 495 to 513; 2021

115. MADHAVAN (A), ARUN (K B), SINDHU (R), KRISHNAMOORTHY (J), RESHMY (R), SIROHI (R), PUGAZHENDI (A), AWASTHI (M K), SZAKACS (G), BINOD (P) 'Customized yeast cell factories for biopharmaceuticals: from cell engineering to process scale up' Microbial Cell Factories; 20(1); 2021

116. MAHATO (A K), BAG (S), SASMAL (H S), DEY(K), GIRI (I), MOREAU (M L), CARBONELL (C), FALCARO (P), GOWD (E B), VIJAYARAGHAVAN (R K), BANERJEE (R) 'Crystallizing Sub 10 nm Covalent Organic Framework Thin Films via Interfacial–Residual Concomitance' Journal of the American Chemical Society; 143(49):20916-20926; 2021

117. MANGALATH (S), BABU (P S S), NAIR (R R), MANU (P M), KRISHNA (S), NAIR (S A), JOSEPH (J) 'Graphene Quantum Dots Decorated with Boron Dipyrromethene Dye Derivatives for Photodynamic Therapy' ACS Applied Nano Materials; 4(4):4162-4171; 2021

118. MANIARASU (S), KARTHIKEYAN (V), KORUKONDA (T B), PRADHAN (S C), SOMAN (S), RAMASAMY (E), VEERAPPAN (G) 'Ambient processed perovskite sensitized porous TiO2 nanorods for highly efficient and stable perovskite solar cells' Journal of Alloys and Compounds; 884:161061; 2021

119. MATHEW (G M), HUANG (C C), SINDHU (R), BINOD (P), SIROHI (R), AWSATHI (M K), PILLAI (S), PANDEY (A) 'Enzymatic approaches in the bioprocessing of shellfish wastes' 3 Biotech; 11(8); 2021

120. MATHEW (G M), MADHAVAN (A), ARUN (K B), SINDHU (R), BINOD (P), SINGHANIA (R R), SUKUMARAN (R K), PANDEY (A) 'Thermophilic Chitinases: Structural, Functional and Engineering Attributes for Industrial Applications' Applied Biochemistry and Biotechnology; 10.1007/s12010-020-03416-5; 2021

121. MATHEW (G M), PUTHIYAMADAM (A), SASIKUMAR (K), ASHOOR (S), SUKUMARAN (R K) 'Biological treatment of prawn shell wastes for valorization and waste management' Bioresource Technology Reports; 15:100788; 2021

122. MATHEW (G M), RAINA (D), NARISETTY (V), KUMAR (V), SARAN (S), PUGAZHENDI (A), SINDHU (R), PANDEY (A), BINOD (P) 'Recent advances in biodiesel production: Challenges and solutions' Science of The Total Environment; 794:148751; 2021

123. MATHEW (G M), SUKUMARAN (R K), SINDHU (R), BINOD (P), PANDEY (A) 'Green remediation of the potential hazardous shellfish wastes generated from the processing industries and their bioprospecting' Environmental Technology & Innovation; 24:101979; 2021

124. MATHEW (G M), ULAETO (S B), RESHMY (R), SUKUMARAN (R K), BINOD (P), PANDEY (A), SINDHU (R) 'Chitosan Derivatives: Properties and Applications [Book Chapter]' Polysaccharides; 135 to 161; 2021

125. MCGREGOR (S K M), GOVIND (C), WOOD (M K R), SHUKLA (A), LIM (H), LEPAGE (R), KRENSKE (E H), UNNI (K N N), AJAYAGHOSH (A), KARUNAKARAN (V), NAMDAS (E B), LO (S C) 'Structural Integration of Carbazole and Tetraphenylethylene: Ultrafast Excited-State Relaxation Dynamics and Efficient Electroluminescence' Advanced Photonics Research; 2(4):2000144; 2021

126. MEENU (M T), CHERIAN (A R), SHERIN (D R), NAIR (A R), MANOJKUMAR (T K), RADHAKRISHNAN (K V), VARGHESE (A) 'A protoberberine alkaloid based ratiometric pH-responsive probe for the detection of diabetic ketoacidosis' Dyes and Pigments; 194:109636; 2021

127. MEENU (M T), KAUL (G), SHUKLA (M), RADHAKRISHNAN (K V), CHOPRA (S) 'Cudraflavone C from Artocarpushirsutus as a Promising Inhibitor of Pathogenic, Multidrug-Resistant S. aureus, Persisters, and Biofilms: A New Insight into a Rational Explanation of Traditional Wisdom' Journal of Natural Products; 84(10):2700 - 2708; 2021

128. MENG (D), GONG (C), SUKUMARAN (R K), DIONYSIOU (D D), HUANG (Z), LI (R), LIU (Y), JI (Y), GU (P), FAN (X), LI (Q) 'Production of polyhydroxyalkanoates from propylene oxide saponification wastewater residual sludge using volatile fatty acids and bacterial community succession' Bioresource Technology; 329:124912; 2021

129. MINJU (N), NAIR (B N), SAVITHRI (S) 'Sodium silicate-derived aerogels: effect of processing parameters on their applications' RSC Advances; 11(25):15301-15322; 2021

130. MOHAMMED (A N), PADMA ISHWARYA (S), NISHA (P) 'Nanoemulsion Versus Microemulsion Systems for the Encapsulation of Beetroot Extract: Comparison of Physicochemical Characteristics and Betalain Stability' Food and Bioprocess Technology; 14(1):133-150; 2021

131. MOHAN (S), GEORGE (G), RAGHU (K G) 'Vanillic acid retains redox status in HepG2 cells during hyperinsulinemic shock using the mitochondrial pathway' Food Bioscience; 41:101016; 2021

132. MOHATA (S),DEY (K), BHUNIA (S), THOMAS (N), GOWD (E B), AJITHKUMAR (T G), REDDY (C M), BANERJEE (R) 'Dual Nanomechanics in Anisotropic Porous Covalent Organic Framework Janus-Type Thin Films' Journal of the American Chemical Society; 144(1):400–409; 2021

133. MOORKOTH (D), NAMPOOTHIRI (K M), NAGARAJAN (S), GIRIJA (A R), BALASUBRAMANIYAN (S),

SAKTHI KUMAR (D) 'Star-Shaped Polylactide Dipyridamole Conjugated to 5-Fluorouracil and 4-Piperidinopiperidine Nanocarriers for Bioimaging and Dual Drug Delivery in Cancer Cells' ACS Applied Polymer Materials; 3(2):737-756; 2021

134. MUKKATT (I), NIRMALA (A), MADHAVAN (N D), SHANKAR (S), DEB (B), AJAYAGHOSH (A) 'Ligand-Controlled Electrochromic Diversification with Multilayer Coated Metallosupramolecular Polymer Assemblies' ACS Applied Materials & Interfaces; 13(4):5245-5255; 2021

135. MUSLIM (M), ALI (A), NEOGI (I), DEGE (N), SHAHID (M), AHMAD (M) 'Facile synthesis, topological study, and adsorption properties of a novel Co (II)-based coordination polymer for adsorptive removal of methylene blue and methyl orange dyes' Polyhedron; 210:115519; 2021

136. MUTHU (C), PIOUS (J K), THANKACHAN (T), KRISHNA (N), VIJAYAKUMAR (C) 'Stable and Efficient White Photoluminescence from Cesium Lead Halide Perovskite Nanocrystals/Polyfluorene Organogel Composite by Suppressing of Halide Ion Migration' Advanced Optical Materials; 9(19):2100601; 2021

137. MUTHU (C), RESMI (A N), PIOUS (J K), DAYAL (G), KRISHNA (N), JINESH (K B), VIJAYAKUMAR (C) 'Resistive switching in formamidinium lead iodide perovskite nanocrystals: a contradiction to the bulk form' JOURNAL OF MATERIALS CHEMISTRY A; 9(1):288-293; 2021

138. NABEELA (K), THORAT (M N), BACKER (S N), RAMACHANDRAN (A M), THOMAS (R T), PREETHIKUMAR (G), MOHAMED (A P), ASOK (A), DASTAGER (S G), PILLAI (S) 'Hydrophilic 3D Interconnected Network of Bacterial Nanocellulose/Black Titania Photothermal Foams as an Efficient Interfacial Solar Evaporator' ACS Applied Bio Materials; 4(5):4373 - 4383; 2021

139. NAIR (A), ANTO (E M), PURUSHOTHAMAN (J) 'Probiotics in Colon Cancer: A Therapeutic Approach [Book Chapter]' Colon Cancer Diagnosis and Therapy; 421 to 434; 2021

140. NAIR (K S), HAREESH (U S), SURENDRAN (K P) 'Oleic acid mediated solvothermal synthesis of (K0.5Na0.5)NbO3 nanoparticles' Materials Letters; 287:129300; 2021

141. NAIR (K S), MOHANAN (G), BAJAJ (H) 'Constructing Bacterial Membrane-Mimicking Vesicle Models as a Tool to Monitor Uptake of Molecules' Biophysical Journal; 120(3):225a; 2021

142. NAIR (R V), CHANDRAN (P R), MOHAMED (A P), PILLAI (S) 'Sulphur-doped graphene quantum dot based fluorescent turn-on aptasensor for selective and ultrasensitive detection of omethoate' Analytica ChimicaActa; 1181:338893; 2021

143. NANCY, POOJITHA (B), SHUKLA (R), VASUNDHARA (M), MOHAMMED RASI (U P), GANGINENI (R B), SAHOO (S C), CHOUDHARY (R J), BITLA (Y), PATRA (A K) 'Unveiling the magnetic and transport properties of La0.5Sr0.5Co1−xVxO3−δ (x = 0, 0.01, 0.02 and 0.1)' Journal of Magnetism and Magnetic Materials; 530:167851; 2021

144. NANDHU LAL (A M), PRINCE (M V), KOTHAKOTA (A), PANDISELVAM (R), THIRUMDAS (R), MAHANTI (N K), SREEJA (R) 'Pulsed electric field combined with microwave-assisted extraction of pectin polysaccharide from jackfruit waste' Innovative Food Science & Emerging Technologies; 74:102844; 2021

145. NARAYANAN (A P), UNNI (K N N), SURENDRAN (K P) 'Aerogels of V2O5 nanowires reinforced by polyaniline for electromagnetic interference shielding 'Chemical Engineering Journal; 408:127239; 2021

146. NARAYANAN (N), KIM (J H), SANTHAKUMAR (H), JOSEPH (M M), KARUNAKARAN (V), SHAMJITH (S), SARANYA (G), SUJAI (P T), JAYASREE (R S), BARMAN (I), MAITI (K K) 'nanotheranostic probe built on methylene blue loaded cucurbituril [8] and gold nanorod: targeted phototherapy in combination with sers imaging on breast cancer cells' journal of physical chemistry b; 125(49):13415 -13424; 2021

147. NARISETTY (V), AMRAOUI (Y), ABDULLAH (A), AHMAD (E), AGRAWAL (D), PARAMESWARAN (B), PANDEY (A), GOEL (S), KUMAR (V) 'High yield recovery of 2,3-butanediol from fermented broth accumulated on xylose rich sugarcane bagasse hydrolysate using aqueous two-phase extraction system' Bioresource Technology; 337:125463; 2021

148. NARISETTY (V), CASTRO (E), DURGAPAL (S), COULON (F), JACOB (S), KUMAR (D), AWASTHI (M K), PANT (K K), PARAMESWARAN (B), KUMAR (V)` 'High level xylitol production by Pichia fermentans using non-detoxified xylose-rich sugarcane bagasse and

olive pits hydrolysates' Bioresource Technology; 342:126005; 2021

149. NAUSHIN, S; SARDANA, V; UJJAINIYA, R; BHATHEJA, N; KUTUM, R; BHASKAR, AK; PRADHAN, S; PRAKASH, S; KHAN, R; RAWAT, BS; TALLAPAKA, KB; ANUMALLA, M; CHANDAK, GR; LAHIRI, A; KAR, S; MULAY, SR; MUGALE, MN; SRIVASTAVA, M; KHAN, S; SRIVASTAVA, A; TOMAR, B; VEERAPANDIAN, M; VENKATACHALAM, G; VIJAYAKUMAR, SR 'Insights from a Pan India Sero-Epidemiological survey (Phenome-India Cohort) for SARS-CoV2' eLife; 10; 2021

150. NAYANA (N), ABRAHAM (L M), ISHWARYA (S P), NISHA (P) 'Spray-dried microcapsules of red palm olein-flaxseed oil blend: Development, physicochemical characterization, and evaluation of its potential applications as a fat replacer and β-carotene fortificant in cupcakes' Journal of Food Processing and Preservation; 45(9); 2021

151. NEETHU (S), GOVIND (M G), VIMALKUMAR (P S), BIJI (M), SHERIN (D R), DAN (M), RADHAKRISHNAN (K V) 'Novel Flavonoids from the aerial parts of Unexplored and Endangered Wild nutmeg Species Myristicabeddomei subsp. spherocarpa W.J. de Wilde' Phytochemistry Letters; 45:72 to 76; 2021

152. NEETHU (S), VEENA (S K), INDULEKHA (V C), EAPEN (J), RADHAKRISHNAN (K V) 'Phytoconstituents assessment and development of standardization protocol for 'NayopayamKwatha', a polyherbal Ayurvedic formulation' Journal of Ayurveda and Integrative Medicine; 12(3):489 to 499; 2021

153. NIRMALA (A), MUKKATT (I), SHANKAR (S), AJAYAGHOSH (A) 'ThermochromicColor Switching to Temperature Controlled Volatile Memory and Counter Operations with Metal–Organic Complexes and Hybrid Gels' AngewandteChemie-International Edition; 59(2–13) https://doi.org/10.1002/anie.202011580; 2021

154. NITHA (P R), SOMAN (S), JOHN (J) 'Indole Fused Heterocycles as Sensitizers in Dye-sensitized Solar Cells: An Overview' Materials Advances; 2(19):6136-6168; 2021

155. NIVEDITHA (A), PANDISELVAM (R), ARUN PRASATH (V), SINGH (S K), GUL (K), KOTHAKOTA (A) 'Application of cold plasma and ozone technology for decontamination of Escherichia coli in foods- a review' Food Control; 130:108338; 2021

156. OMANAKUTTAN (V K), JOHN (J), HOPF (H) 'Synthesis of 3(2H)-Furanones: A Review' European Journal of Organic Chemistry; https://doi.org/10.1002/ejoc.202001005; 2021

157. ORODEPO (G O), GOWD (E B), RAMAKRISHNAN (S) 'Main-chain liquid crystalline polymers bearing periodically grafted folding elements' Polymer Chemistry; 12(7):1050-1059; 2021

158. PADMA (I S), SANDHYA (R), NISHA (P) 'Advances and prospects in the food applications of pectin hydrogels' Critical Reviews in Food Science and Nutrition; 1-25 (page no.); 2021

159. PANCRECIOUS (J K), VINEETHA (S V), BILL (U S), GOWD (E B), RAJAN (T P D) 'Ni-Al polyvanadate layered double hydroxide with nanoceria decoration for enhanced corrosion protection of aluminium alloy'Applied Clay Science; 211:106199; 2021

160. PANDEY (A K), GAUR (V K), UDAYAN (A), VARJANI (S), KIM (S H), WONG (J W C) 'Biocatalytic remediation of industrial pollutants for environmental sustainability: Research needs and opportunities' Chemosphere; 272:129936; 2021

161. PANDISELVAM (R), SRUTHI (N U), KUMAR (A), KOTHAKOTA (A), THIRUMDAS (R), RAMESH (S V), COZZOLINO (D) 'Recent Applications of Vibrational Spectroscopic Techniques in the Grain Industry' Food Reviews International; 11324; 2021

162. PARVATHY (P A), AYOBAMI (A V), RAICHUR (A M), SAHOO (S K) 'Methacrylated alkali lignin grafted P(Nipam-Co-AAc) copolymeric hydrogels: Tuning the mechanical and stimuli-responsive properties' International Journal of Biological Macromolecules; 192:180-196; 2021

163. PARVATHY (P A), MOHANTY (S), SAHOO (S K) 'Cure Kinetics of Bio-epoxy Polymers, Their Blends, and Composites' Bio-Based Epoxy Polymers, Blends, and Composites; 143 to 166; 2021

164. PARVATHY (P A), SAHOO (S K) 'Hydrophobic, moisture resistant and biorenewable paper coating derived from castor oil based epoxy methyl ricinoleate with repulpable potential' Progress in Organic Coatings; 158:106347; 2021

165. PAUL (S), GOVIND (C), KARUNAKARAN (V) 'Planarity and Length of the Bridge Control Rate and Efficiency of Intramolecular Singlet Fission in Pentacene Dimers' Journal of Physical Chemistry B; 125(1):231-239; 2021

166. PILLAI (A S), CHANDRAN (A), SURENDRAN (K P) 'MWCNT Ink with PEDOT:PSS as a multifunctional additive for energy efficient flexible heating applications' Applied Materials Today; 23:100987; 2021

167. PIOUS (J K), BASAVARAJAPPA (M G), MUTHU (C), NISHIKUBO (R), SAEKI (A), CHAKRABORTY (S), TAKAI (A), TAKEUCHI (M), VIJAYAKUMAR (C) 'Self-Assembled Organic Cations-Assisted Band-Edge Tailoring in Bismuth-Based Perovskites for Enhanced Visible Light Absorption and Photoconductivity' Journal of Physical Chemistry Letters; 12(24):5758-5764; 2021

168. PODDER (A), JOSEPH (M M), BISWAS (S), SAMANTA (S), MAITI (K K), BHUNIYA (S) 'Amphiphilic fluorescent probe self-encored in plasma to detect pH fluctuations in cancer cell membranes' Chemical Communications; 57(5):607-610; 2021

169. PRABHA (B), SINI (S), SHERIN (D R), NEETHU (S), RAMESHKUMAR (K B), MANOJKUMAR (T K), JAYAMURTHY (P), RADHAKRISHNAN (K B) 'Promalabaricone B from MyristicafatuaHoutt. seeds demonstrate antidiabetic potential by modulating glucose uptake via the upregulation of AMPK in L6 myotubes' Natural Product Research; 35(5):867-872; 2021

170. PRABHAKARAN (V V), RAGHU (K G) 'Phloretin Alleviates Arsenic Trioxide-Induced Apoptosis of H9c2 Cardiomyoblasts via Downregulation in Ca2+/Calcineurin/NFATc Pathway and Inflammatory Cytokine Release' Cardiovascular Toxicology; 21(8):642 - 654; 2021

171. PRADHAN (S C), SOMAN (S) 'Effect of Thickness on Charge Transfer Properties of Conductive Polymer Based Pedot Counter Electrodes in DSSC' Results in Surfaces and Interfaces; 5:100030; 2021

172. PRAJAPATI (P), VARJANI (S), SINGHANIA (R R), PATEL (A K), AWASTHI (M K), SINDHU (R), ZHANG (Z), BINOD (P), AWASTHI (S K), CHATURVEDI (P) 'Critical review on technological advancements for effective waste management of municipal solid waste — Updates and way forward' Environmental Technology & Innovation; 23:101749; 2021

173. PRATHEESH (K), RAVI (M), GEORGE (M) 'Characterisation of tensile fracture in squeeze casted Al–Si piston alloy' International Journal of Cast Metals Research; 34(2):57-69; 2021

174. PRAVEENA (N M), NAGARAJAN (S), GOWD (E B) 'Stereocomplexation of enantiomeric star-shaped poly(lactide)s with a chromophore core' CrystEngComm; 23(10):2122 - 2132; 2021

175. PREETHA (P), PANDISELVAM (R), VARADHARAJU (N), JOHN KENNEDY (Z), BALAKRISHNAN (M), KOTHAKOTA (A) 'Effect of pulsed light treatment on inactivation kinetics of Escherichia coli (MTCC 433) in fruit juices' Food Control; 121:107547; 2021

176. PRITHVIRAJ (V), PANDISELVAM (R), BABU (A C), KOTHAKOTA (A), MANIKANTAN (M R), RAMESH (S V), SHAMEENA BEEGUM (P P), MATHEW (A C), HEBBAR (K B) 'Emerging non-thermal processing techniques for preservation of tender coconut water' LWT- Food Science and Technology; 149:111850; 2021

177. PRIYA (S), SATHEESHKUMAR (P K) 'Exosomal Biomarkers in Colorectal Cancer [Book Chapter]' Colon Cancer Diagnosis and Therapy; 101 to 122; 2021

178. PULICKALMANNATH (S), KUNDU (P), PLOTNIKOV (E), MARTEMIANOV (D) 'Performance evaluation and intensification of novel buoyant filter bioreactor with associated secondary treatment process for rice processing industries' Chemical Engineering And Processing-Process Intensification; 169:108619; 2021

179. PUTHUR (S), ANOOPKUMAR (A N), REBELLO (S), ANEESH (E M), SINDHU (R), BINOD (P), PANDEY (A) 'Toxic Effects of Pesticides on Avifauna Inhabiting Wetlands' Sustainable Agriculture Reviews; 335-349; 2021

180. RAGHUNATHAN (R), PANDISELVAM (R), KOTHAKOTA (A), KHANEGHAH (A M) 'The application of emerging non-thermal technologies for the modification of cereal starches' LWT- Food Science and Technology; 138:110795; 2021

181. RAHUL (L R), NISHY (P) 'Scientometric study of global mucormycosis (black fungus) research' Annals of Library and Information Studies; 68(4):376-388; 2021

182. RAHUL (L R), NISHY (P) ' Thymic epithelial tumours-research trends ' Annals of Library and Information Studies; 68(3):300-309; 2021

183. RAJ (N B), NAIR (K S), BAJAJ (H) 'Giant Vesicles Mimicking Outer Membrane of Gram-Negative Bacterium' BIOPHYSICAL JOURNAL; 120(3):225a-226a; 2021

184. RAKHI (R), SURESH (C H) 'Optoelectronic Properties of Polycyclic Benzenoid Hydrocarbons of Various Sizes and Shapes for Donor-π-Acceptor Systems: A DFT Study' ChemistrySelect; 6(11):2760-2769; 2021

185. RAMACHANDRAN (A M), JOSEPH (R), ASOK (A) 'Characterization techniques for morphological and physicochemical evaluation of nanomaterials [Book Chapter]' Nanobiotechnology - Microbes and Plant Assisted Synthesis of Nanoparticles, Mechanisms and Applications; 21-50; 2021

186. RAMYA (A N), ARYA (J S), MADHUKRISHNAN (M), SHAMJITH (S), VIDYALEKSHMI (M S), MAITI (KK) 'Raman Imaging: An Impending Approach Towards Cancer Diagnosis' Chemistry - An Asian Journal; 16(5):409-422; 2021

187. RANJITH (P), SREEVALSA (S), PATRA (P), SOM (S), MENON (A), JAYANTHI (K), ANNAPURNA (K), ANOOP KRISHNAN (N M), ALLU (A R), DAS (S) 'Realizing cool and warm white-LEDs based on color controllable (Sr,Ba)2Al3O6F:Eu2+ phosphors obtained via a microwave-assisted diffusion method' Physical Chemistry Chemical Physics; 23(28):15245 - 15256; 2021

188. RAVI (R), SURENDREN (S), DEB (B) 'Studies on All-Solid Electrochromic Devices Fabricated by a Bilayered Assembly of Hydrated Vanadium Pentoxide and PEDOT:PSS Coatings' Surfaces and Interfaces; 22:100860; 2021

189. REBELLO (S), ANOOPKUMAR (A N), ANEESH (E M), SINDHU (R), BINOD (P), KIM (S H), PANDEY (A) 'Hazardous minerals mining: Challenges and solutions' Journal of Hazardous Materials; 402:123474; 2021

190. REBELLO (S), NATHAN (V K), SINDHU (R), BINOD (P), AWASTHI (M K), PANDEY (A) 'Bioengineered microbes for soil health restoration: present status and future' Bioengineered; 12(2):12839-12853; 2021

191. REBELLO (S), SIVAPRASAD (M S), ANOOPKUMAR (A N), JAYAKRISHNAN (L), ANEESH (E M), NARISETTY (V), SINDHU (R), BINOD (P), PUGAZHENDHI (A), PANDEY (A) 'Cleaner technologies to combat heavy metal toxicity' Journal of Environmental Management; 296:113231; 2021

192. REJITH (R G), SUNDARARAJAN (M), GNANAPPAZHAM (L), SEENIPANDI (K), RAMASWAMY (S) 'GIS-based Machine Learning Algorithms for Mapping Beach Placer Deposits in the Southwest Coast of India using Landsat-8 Oli Images' Journal of Applied Remote Sensing; 16(1); 2021

193. REJITH (R G), SUNDARARAJAN (M), GOWTHAM (B), BALASUBRAMANIAN (A), LAWRENCE (J F) 'Characterization of weathering profile and quality of groundwater over hard rock terrain' Arabian Journal of Geosciences; 14(3); 2021

194. REJITH (R G), SUNDARARAJAN (M), VENKATESAN (S), MOHAMMED-ASLAM (M A) 'Remote sensing for exploring heavy mineral deposits [Book Chapter]' Remote Sensing of Ocean and Coastal Environments; 177-188(PageNo); 2021

195. REMADEVI (A), JOSE (S A), SREEDEVIAMMA (D K), SURENDRAN (K P) 'Electrical, thermal and microwave shielding properties of printable silver nanowires' Journal of Materials Science - Materials in Electronics; 56(28):15971 to 15984; 2021

196. RENJITH (R A), REJITH (R G), SUNDARARAJAN (M) 'Evaluation of coastal sediments [Book Chapter]' Remote Sensing of Ocean and Coastal Environments; 99-116(PageNo); 2021

197. RENJITH (R A), REJITH (R G), SUNDARARAJAN (M) 'Evaluation of coastal sediments: an appraisal of geochemistry using ED-XRF and GIS techniques [Book Chapter]' Remote Sensing of Ocean and Coastal Environments; 99 to 116; 2021

198. RENJU (U A), RAO (P P) 'Defect fluorite type phase in anion deficient rare earth zirconates, RE3Zr0.5Nb0.5O6.75 (RE = Nd, Sm, Gd, Dy, Y): Synthesis and electrical properties' Journal of Solid State Chemistry; 293:121754; 2021

199. RESHMITHA (T R), NISHA (P) 'Lycopene mitigates acrylamide and glycidamide induced cellular toxicity via oxidative stress modulation in HepG2 cells' Journal of Functional Foods; 80:104390; 2021

200. RESHMITHA (T R), SHINI (V S), NISHA (P) 'Nanotechnology Approaches for Colorectal Cancer Diagnosis and Therapy [Book Chapter]' Colon Cancer Diagnosis and Therapy; 171 to 186; 2021

201. RESHMY (R), EAPEN (P), SHERELY (P A), ARAVIND (M), RAVEENDRAN (S), PARAMESWARAN (B), ASHOK (P) 'A green biorefinery platform for cost-effective nanocellulose production: investigation of hydrodynamic properties and biodegradability of thin films' Biomass Conversion and Biorefinery;

https://doi.org/10.1007/s13399-020-00961-1; 2021

202. RESHMY (R), MADHAVAN (A), PHILIP (E), PAUL (S A), SINDHU (R), BINOD (P), PUGAZHENDHI (A), SIROHI (R), PANDEY (A) 'Sugarcane bagasse derived nanocellulose reinforced with frankincense (Boswellia serrata): Physicochemical properties, biodegradability and antimicrobial effect for controlling microbial growth for food packaging application' Environmental Technology & Innovation; 21:101335; 2021

203. RESHMY (R), PHILIP (E), MADHAVAN (A), ARUN (K B), BINOD (P), PUGAZHENDHI (A), AWASTHI (M K), GNANSOUNOU (E), PANDEY (A), SINDHU (R) 'Promising eco-friendly biomaterials for future biomedicine: Cleaner production and applications of Nanocellulose' Environmental Technology & Innovation; 24:101855; 2021

204. RESHMY (R), PHILIP (E), MADHAVAN (A), SINDHU (R), BINOD (P), BALAKUMARAN (P A), PANDEY (A) 'Potential Utilisation of Fruit and Vegetable Waste: An Overview [Book Chapter]' Sustainable Bioconversion of Waste to Value Added Products; 179 to 191; 2021

205. RESHMY (R), PHILIP (E), MADHAVAN (A), SINDHU (R), PUGAZHENDHI (A), BINOD (P), SIROHI (R), AWASTHI (M K), TARAFDAR (A), PANDEY (A) 'Advanced biomaterials for sustainable applications in the food industry: Updates and challenges' Environmental Pollution; 283:117071; 2021

206. RESHMY (R), PHILIP (E), SIROHI (R), TARAFDAR (A), ARUN (K B), MADHAVAN (A), BINOD (P), AWASTHI (M K), VARJANI (S), SZAKACS (G), SINDHU (R) 'Nanobiocatalysts: Advancements and applications in enzyme technology' Bioresource Technology; 337:125491; 2021

207. RESHMY (R), PHILIP (E), THOMAS (D), MADHAVAN (A), SINDHU (R), BINOD (P), VARJANI (S), AWASTHI (M K), PANDEY (A) 'Bacterial nanocellulose: engineering, production, and applications' Bioengineered; 12(2):11463 - 11483; 2021

208. RESHMY (R), PHILIP (E), VAISAKH (P H), RAJ (S), PAUL (S A), MADHAVAN (A), SINDHU (R), BINOD (P), SIROHI (R), PUGAZHENDHI (A), PANDEY (A) 'Development of an eco-friendly biodegradable plastic from jack fruit peel cellulose with different plasticizers and Boswellia serrata as filler' Science of The Total Environment; 767:144285; 2021

209. RESHMY (R), PHILIP (E), VAISAKH (P H), SINDHU (R), BINOD (P), MADHAVAN (A), PANDEY (A), SIROHI (R), TARAFDAR (A) 'Biodegradable polymer composites [Book Chapter] 'Biomass, Biofuels, Biochemicals; 393 to 412; 2021

210. RESHMY (R), THOMAS (D), PHILIP (E), PAUL (S A), MADHAVAN (A), SINDHU (R), BINOD (P), PUGAZHENDHI (A), SIROHI (R), TARAFDAR (A), PANDEY (A) 'Potential of nanocellulose for wastewater treatment' Chemosphere; 281:130738; 2021

211. RESHMY (R), THOMAS (D), PHILIP (E), PAUL (S A), MADHAVAN (A), SINDHU (R), SIROHI (R), VARJANI (S), PUGAZHENDHI (A), PANDEY (A), BINOD (P) 'Bioplastic production from renewable lignocellulosic feedstocks: a review' Reviews in Environmental Science and Biotechnology; 20(1):167-187; 2021

212. REVATHY (R), KALARIKKAL (N), VARMA (M R), SURENDRAN (K P) 'Exchange-spring mechanism and Griffiths-like phase in room-temperature magnetoelectric Ni–BaTiO3 composites' Materials Advances; 2(14):4702 to 4720; 2021

213. REVATHY (R), KALARIKKAL (N), VARMA (M R), SURENDRAN (K P) 'Exotic magnetic properties and enhanced magnetoelectric coupling in Fe3O4-BaTiO3 heterostructures' Journal of Alloys and Compounds; 889:161667; 2021

214. REVATHY (R), NAIR (A A), VARMA (M R), SURENDRAN (K P) 'Magnetism of cobalt during oxidative ageing: A theory supported experimental investigation' Materials Science and Engineering B - Solid State Materials for Advanced Tech; 273:115453; 2021

215. REVATHY (R), VARMA (M R), SURENDRAN (K P) 'Observation of Cluster Glass and Griffiths-like Phase in Fe 3 O 4 Nanostructures' Physica Status Solidi B-Basic Solid State Physics; 258(2):2000341; 2021

216. ROKKALA (U), BONTHA (S), RAMESH (M R), BALLA (V K), SRINIVASAN (A), KAILAS (S V) 'Tailoring surface characteristics of bioabsorbable Mg-Zn-Dy alloy using friction stir processing for improved wettability and degradation behavior' Journal of Materials Research and Technology; 12:1530-1542; 2021

217. ROSHNI (S B), ARUN S, SEBASTIAN (M T), MOHANAN (P), SURENDRAN (K P) 'Low kappa Mg2SiO4 ceramic

tapes and their role as screen printed microstrip patch antenna substrates' Materials Science and Engineering B - Solid State Materials for Advanced Tech; 264:114947; 2021

218. ROY (A), GHOSH (P), SUJATHA DEVI (P), SUNDARAM (S), MALLICK (T K) 'Efficient carbon counter electrodes for BaSnO3-based dye-sensitized solar cells' Materials Today proceedings; 45:3685 to 3691; 2021

219. RUPA RANJANI (P), ANJANA (P M), RAKHI (R B) 'Solvothermal synthesis of CuFeS2 nanoflakes as a promising electrode material for supercapacitors' Journal of Energy Storage; 33:102063; 2021

220. SABITHA (A J), KRISHNAKUMAR (K A), SURENDRAN (K P) 'Aqueous tape casting of Al2O3-BBSZ based LTCC multilayer substrates' Materials Research Bulletin; 140:111289; 2021

221. SAJENA (K S), KARUNAKARAN (V), MAITI (K K), JOSEPH (J) 'DNA Condensation Triggered by the Synergistic Self-Assembly of Tetraphenylethylene-Viologen Aggregates and CT-DNA' Frontiers in Chemistry; 9: Article Id : 716771; 2021

222. SAJITHA (M), ABRAHAM (B), NELLIYIL (R B), YOOSAF (K) 'Chemically Etched Nanoporous Copper and Galvanically Displaced Silver Nanoflowers for SERS Sensing' ACS Applied Nano Materials; 4(10):10038 to 10046; 2021

223. SAM (J), KIRANKUMAR (P S), SANATH (K), PRATHISH (K P) 'Development of saleable chloride free iron oxide from hazardous waste in titanium industries via layered double hydroxide formation' Journal of Environmental Management; 290:112566; 2021

224. SAM (S A), BALAN (A P), KAIPAMANGALATH (A), VARMA (M R), NAIR (R R), THOMAS (S) 'Nanocomposite Permanent Magnets Based on SrFe12O19-Fe3O4 Hard-Soft Ferrites' Journal of Superconductivity and Novel Magnetism; 34(12):3333-3344; 2021

225. SARASWATHI (S K), KARUNAKARAN (V), MAITI (K K), JOSEPH (J) 'DNA Condensation Triggered by the Synergistic Self-Assembly of Tetraphenylethylene-Viologen Aggregates and CT-DNA' Frontiers in Chemistry; 9; 2021

226. SASIDHARAN (S), JAGADEESH (A), PRADHAN (S C), NAIR (B N), PEER MOHAMED (A), UNNI (K N N), SOMAN (S), HAREESH (U S) 'ZnO hierarchical structures as sacrificial inclusions for enhanced performance under full sun and indoor light in bifacial dye sensitized solar cells' Solar Energy; 226:214-224; 2021

227. SASIKUMAR (K), HANNIBAL (S), WENDISCH (V F), NAMPOOTHIRI (K M) 'Production of Biopolyamide Precursors 5-Amino Valeric Acid and Putrescine From Rice Straw Hydrolysate by Engineered Corynebacterium glutamicum' Frontiers in Bioengineering and Biotechnology; 9; 2021

228. SASIKUMAR (R), RETTENMAYR (M), SAVITHRI (S), EXNER (H E) 'a model for the formation of interdendritic cavities from pores pre-existing in the melt' international journal of materials research; 92(2); 2021

229. SASMAL (A), PATRA (A), SUJATHA DEVI (P), SEN (S) 'Hydroxylated BiFeO3 as efficient fillers in poly(vinylidene fluoride) for flexible dielectric, ferroelectric, energy storage and mechanical energy harvesting application' Dalton Transactions; 50(5):1824-1837; 2021

230. SASMAL (A), PATRA (A), SUJATHA DEVI (P), SEN (S) 'Space charge induced augmented dielectric permittivity and improved energy harvesting ability of nano-Ag decorated ZnSnO3 filled PVDF based flexible nanogenerator' Composites Science and Technology; 213:108916; 2021

231. SEETHALEKSHMI (S), THAKUR (T S), VARUGHESE (S) 'Photoinstability in active pharmaceutical ingredients: Crystal engineering as a mitigating measure' Journal of Photochemistry and Photobiology C: Photochemistry Reviews; 49:100455; 2021

232. SHAIJU (S S), NATH (S), DEB (B) 'Phase Transition Studies on Solution-Processed Vanadium Dioxide Coatings Through Optical Measurements' Journal of Materials Science - Materials in Electronics; 32(2):2627-2638; 2021

233. SHARATHNA (P), ALISHA (V), SASIKUMAR (P), AJESH (V), AYISHA (F), SHIBI (I G), SIVAN (V V), MAITI (K K), LANKALAPALLI (R S), RADHAKRISHNAN (K V) 'Mirabijalones S-W, rotenoids from rhizomes of white Mirabilis jalapa Linn. and their cell proliferative studies' Phytochemistry Letters; 44:178 - 184; 2021

234. SHEELA (U B), USHA (P G), JOSEPH (M M), MELO (J S), NAIR (S T T), TRIPATHI (A) '3D printing in dental implants [Book Chapter]' 3D Printing in Medicine and Surgery; 83-104 (PageNo); 2021

235. SHEEMOL (V N), PEER MOHAMED (A P), ANANTHAKUMAR (S) 'IR Reflective LaPO 4 Ceramic Colorant Reinforced Polymer Composite Coatings on Glass and Metal Substrates for Heat Management Applications' Chemistry - An Asian Journal; 16(7):822-836; 2021

236. SHRAVANRAJ (K), REJITH (R G), SUNDARARAJAN (M) 'Evaluation of heavy metals in coastal aquifers and seawater [Book Chapter]' Remote Sensing of Ocean and Coastal Environments; 155-176 (PageNo); 2021

237. SHYNI (G L), RENJITHA (J), SASIDHAR (B S), RAGHU (K G) 'Zerumin A attenuates the inflammatory responses in LPS-stimulated H9c2 cardiomyoblasts' Journal of Biochemical and Molecular Toxicology; 35(6):1-11; 2021

238. SHYNI (G L), SAJIN (K F), MANGALAM (S N), RAGHU (K G) 'An in vitro study reveals the anti-obesity effects of 7- methoxy-3-methyl-5-((E)-prop-1-enyl)-2-(3,4,5-trimethoxyphenyl)-2,3-dihydrobenzofuran from Myristica fragrans' European Journal of Pharmacology; 173686 10.1016/j.ejphar. 2020.173686; 2021

239. SINDHU (R), MADHAVAN (A), ARUN (K B), PUGAZHENDHI (A), RESHMY (R), AWASTHI (M K), SIROHI (R), TARAFDAR (A), PANDEY (A), BINOD (P) 'Metabolic circuits and gene regulators in polyhydroxyalkanoate producing organisms: Intervention strategies for enhanced production' Bioresource Technology; 327:124791; 2021

240. SINGH (S), NEGI (T), TARAFDAR (A), SIROHI (R), PANDEY (A K), BHAT (M I), SINDHU (R) 'Microplastics in aquatic and terrestrial environment [Book Chapter]' Biomass, Biofuels, Biochemicals; 11 to 29; 2021

241. SINI FRANCIS (C F), REBELLO (S), ANEESH (E M), SINDHU (R), BINOD (P), SINGH (S), PANDEY (A) 'Bioprospecting of gut microflora for plastic biodegradation' Bioengineered; 12(1):1040-1053; 2021

242. SIROHI (R), PANDEY (J P), TARAFDAR (A), AGARWAL (A), CHAUDHURI (S K), SINDHU (R) 'An environmentally sustainable green process for the utilization of damaged wheat grains for poly-3-hydroxybutyrate production' Environmental Technology & Innovation; 21:101271; 2021

243. SIROHI (R), PANDEY (J P), TARAFDAR (A), SHARMA (P), SHARMA (P), SINDHU (R) 'Tailoring a hybrid intelligent model to predict fermentable sugar production from enzyme–catalyzed hydrolysis of damaged wheat grains' Food Bioscience; 43:101299; 2021

244. SIROHI (R), TARAFDAR (A), GAUR (V K), SINGH (S), SINDHU (R), RAJASEKHARAN (R), MADHAVAN (A), BINOD (P), KUMAR (S), PANDEY (A) 'Technologies for disinfection of food grains: Advances and way forward' Food Research International; 145:110396; 2021

245. SIROHI (R), UMMALYMA (S B), SAGAR (N A), SHARMA (P), AWASTHI (M K), BADGUJAR (P C), MADHAVAN (A), RAJASEKHARAN (R), SINDHU (R), SIM (S J), PANDEY (A) 'Strategies and advances in the pretreatment of microalgal biomass' Journal of Biotechnology; 341:63 - 75; 2021

246. SIVA (T), SREEJA KUMARI (S S), SATHIYANARAYANAN (S) 'Dendrimer like mesoporous silica nano container (DMSN) based smart self healing coating for corrosion protection performance' Progress in Organic Coatings; 154:106201; 2021

247. SIVAKALA (S), BAIG (E R), MOLJI (C), AASHISH (A), KUMAR (A S), SUDHA (J D) 'Nipping the Shape of the Nanosilver through Bio-Based Capping Strategy and Studies on Their Electrocatalytic Performance Using Electrospectrometry' Journal of The Electrochemical Society; 168(7):077504; 2021

248. SIVAKUMAR (P T), PUTHIYAPARAMBATH (S), VARMA (S S), PARAMESWARAN (S), RADHAKRISHNAN (K V) 'Organic Brønsted acid-catalyzed cycloadditions of o -quinone methides with 1, 3-dicarbonlys : Facile access to xanthenones and chromanones' Journal of Heterocyclic Chemistry; 58(10):1971 to 1982; 2021

249. SIVARANJANI (S), PRASATH (V A), PANDISELVAM (R), KOTHAKOTA (A), KHANEGHAH (A M) 'Recent advances in applications of ozone in the cereal industry' LWT- Food Science and Technology; 146:111412; 2021

250. SOLANKI (A), AWASTHI (A), UNNI (K N N), DEEPAK 'An efficient and facile method to develop defect-free OLED displays' Semiconductor Science and Technology; 36(6):065005; 2021

251. SOM (S), LU (C H), YANG (C Y), DAS (S) 'Synthesis and design of NaYF 4 microprisms via a microwave-assisted approach for highly sensitive optical thermometry applications' Journal of the

American Ceramic Society; 104(10):5168 to 5181; 2021

252. SOUMYA (M P), MADHAVAN NAMPOOTHIRI (K) 'An overview of functional genomics and relevance of glycosyltransferases in exopolysaccharide production by lactic acid bacteria' International Journal of Biological Macromolecules; 184:1014-1025; 2021

253. SOUMYA (R S), UNNI (T G), RAGHU (K G) 'Impact of COVID-19 on the Cardiovascular System: A Review of Available Reports' Cardiovascular Drugs and Therapy; 35(3):411 - 425; 2021

254. SREEDEVI (P), NAIR (J B), JOSEPH (M M), MURALI (V P), SURESH (C H), LUXMI VARMA (R), MAITI (K K) 'Dynamic self-assembly of mannosylated-calix[4] arene into micelles for the delivery of hydrophobic drugs' Journal of Controlled Release; 339:284 - 296; 2021

255. SREELEKSHMI (M), RAGHU (K G)Q 'Vanillic acid mitigates the impairments in glucose metabolism in HepG2 cells through BAD–GK interaction during hyperinsulinemia' Journal of Biochemical and Molecular Toxicology; 35(6):1-8; 2021

256. SREENA (T S), RAO (P P), AJU THARA (T R), ATHIRA (K V R) 'New lanthanide-free self-activated full-color emission phosphor in Y 3+ doped Sr 3 Bi(VO 4) 3 system for white light emitting diode applications' Luminescence; 36(3):819-825; 2021

257. SREEVALSA (S), PARVATHY (P A), SAHOO (S K), DAS (S) 'Full-color emitting crystal engineered Sr3Al1−xSixO4+xF1−x: Eu2+/3+ oxyfluorides for developing bendable lighting composites' Journal of Alloys and Compounds; 880:160483; 2021

258. SRUTHI (C R), RAGHU (K G) 'Advanced glycation end products and their adverse effects: The role of autophagy' Journal of Biochemical and Molecular Toxicology; 35(4); 2021

259. SRUTHI (N U), PREMJIT (Y), PANDISELVAM (R), KOTHAKOTA (A), RAMESH (S V) 'An overview of conventional and emerging techniques of roasting: Effect on food bioactive signatures' Food Chemistry; 348:129088; 2021

260. SUBHA (P V), NAIR (B N), VISAKH (V), ACHU (R), SHIKHILA (S), MOHAMED (A P), YAMAGUCHI (T), HAREESH (U S) 'Wet chemically derived Li4SiO4 nanowires as efficient CO2 sorbents at intermediate temperatures' Chemical Engineering Journal; 406:126731; 2021

261. SUBRAMANYAN (S), DEEPIKA (S), AJITH (A), GRACY (A J), DAN (M), MAITI (K K), LUXMI VARMA (R), RADHAKRISHNAN (K V) 'Antiproliferative labdane diterpenes from the rhizomes of Hedychiumflavescens Carey ex Roscoe' Chemical Biology & Drug Design; 98(4):501-506; 2021

262. SUJAI (P T), SHAMJITH (S), JOSEPH (M M), MAITI (K K) 'Elucidating Gold–MnO2 Core–Shell Nanoenvelope for Real Time SERS-Guided Photothermal Therapy on Pancreatic Cancer Cells' ACS Applied Bio Materials; 4(6):4962 - 4972; 2021

263. SUKUMARAN (R K), CHRISTOPHER (M), PRAJEESH (K V), ATHIRARAJ (S R), RESHMA (M M), MEENA (S), ANOOP (P), ADARSH (V P), ASWATHI (A), REBINRO (V), ABRAHAM (A), PANDEY (A) 'Addressing challenges in production of cellulases for biomass hydrolysis: Targeted interventions into the genetics of cellulase producing fungi' Bioresource Technology; 329:124746; 2021

264. SUNDARARAJAN (M), REJITH (R G), RENJITH (R A), MOHAMED (A P), GAYATHRI (G S), RESMI (A N), JINESH (K B), LOVESON (V J) 'Raman-XPS spectroscopic investigation of heavy mineral sands along Indian coast' Geo-Marine Letters; 41(2); 2021

265. SURENDREN (S), DEB (B) 'Studies on spontaneously reduced vanadium pentoxide xerogel coatings for electro-chromic applications' Electrochimica Acta; 389:138629; 2021

266. SUSMITHA (A), BAJAJ (H), NAMPOOTHIRI (K M) 'The divergent roles of sortase in the biology of Gram-positive bacteria' The Cell Surface; 7:100055; 2021

267. SUSMITHA (A), SASIKUMAR (K), RAJAN (D), ARUN (P M), NAMPOOTHIRI (K M) 'Development and characterization of corn starch-gelatin based edible films incorporated with mango and pineapple for active packaging' Food Bioscience; 41:100977; 2021

268. SUVACHAN (A), LAL (R), NAMPOOTHIRI (K M), SINDHU (R), BHASKAR (T), BINOD (P), PANDEY (A), YASARLA (R) 'Valorization of paper industry rejects by combined thermo-chemical pretreatment and biological conversion to L-lysine' Environmental Technology & Innovation; 24:101882; 2021

269. SUYANA (P), GANGULY (P), NAIR (B N), PILLAI (S C), HAREESH (U S) 'Structural and Compositional Tuning in G-C3N4 Based Systems for Photocatalytic Antibiotic Degradation' Chemical Engineering Journal Advances; 8:100148; 2021

270. TALUKDAR (V), VIJAYAN (A), KATARI (N K), RADHAKRISHNAN (K V), DAS (P) 'Recent Trends in the Synthesis and Mechanistic Implications of Phenanthridines' Advanced Synthesis & Catalysis; 363(5):1202 - 1245; 2021

271. TARAFDAR (A), SIROHI (R), GAUR (V K), SUNIL KUMAR, SHARMA (P), VARJANI (S), PANDEY (H O), SINDHU (R), MADHAVAN (A), RAJASEKHARAN (R), SIM (S J) 'Engineering interventions in enzyme production: Lab to industrial scale' Bioresource Technology; 326:124771; 2021

272. THADATHIL (D A), VARGHESE (A), RADHAKRISHNAN (K V) 'Review—Electrochemical Strategies for Selective Fluorination of Organic Compounds' Journal of The Electrochemical Society; 168(7):075503; 2021

273. THADATHIL (D A), VARGHESE (A), RADHAKRISHNAN (K V) 'The Renaissance of Electro-Organic Synthesis for the Difunctionalization of Alkenes and Alkynes: A Sustainable Approach' Asian Journal of Organic Chemistry; 10(11):2820 to 2847; 2021

274. THANGASWAMY (S J K), MIR (M A), MUTHU (A) 'Green synthesis of mono and bimetallic alloy nanoparticles of gold and silver using aqueous extract of Chlorella acidophile for potential applications in sensors' Preparative Biochemistry and Biotechnology; 1-10 (Page No); 2021

275. THANKAM (F G), SINI (S), THOMAS (S) 'Hybrid Nanoparticles in Image-Guided Drug Delivery' Gels Horizons: From Science to Smart Materials; 83 to 107; 2021

276. THASNEEMA (K K), DIPIN (T), THAYYIL (M S), SAHU (P K), MESSALI (M), ROSALIN (T), ELYAS (K K), SAHARUBA (P M), ANJITHA (T), BEN HADDA (T) 'Removal of toxic heavy metals, phenolic compounds and textile dyes from industrial waste water using phosphonium based ionic liquids' JOURNAL OF MOLECULAR LIQUIDS; 93.0729166666667; 2021

277. THEJAS (K K), ABRAHAM (M), KUNTI (A K), TCHERNYCHEVA (M), AHMAD (S), DAS (S) 'Review on deep red-emitting rare-earth free germanates and their efficiency as well as adaptability for various applications' Applied Materials Today; 24:101094; 2021

278. THEJUS (P K), KRISHNAPRIYA (K V), NISHANTH (K G) 'A cost-effective intense blue colour inorganic pigment for multifunctional cool roof and anticorrosive coatings' Solar Energy Materials and Solar Cells; 219:110778; 2021

279. THEJUS (P K), KRISHNAPRIYA (K V), NISHANTH (K G) 'NIR reflective, anticorrosive magenta pigment for energy saving sustainable building coatings' Solar Energy; 222:103-114; 2021

280. THIRUMDAS (R), KOTHAKOTA (A), PANDISELVAM (R), BAHRAMI (A), BARBA (F J) 'Role of food nutrients and supplementation in fighting against viral infections and boosting immunity: A review' Trends in Food Science & Technology; 110:66-77; 2021

281. THIYAGARAJAN (S), KHANDELWAL (P), SENTHIL (N), VELLAIKUMAR (S), ARUMUGAM (M), DUBEY (A A), KATHIRESAN (S) 'Heterologous Production of Polyunsaturated Fatty Acids in E. coli Using Δ5-Desaturase Gene from Microalga Isochrysis Sp.' Applied Biochemistry and Biotechnology; 193(3):869-883; 2021

282. THOMAS (M M), PARVATHY (R C), VIPIN (V V), MOHAMED (A P), KINGSHOTT (P), PILLAI (S) 'Core-shell based responsive colloidal photonic crystals for facile, rapid, visual detection of acetone' Reactive & Functional Polymers; 158:104779; 2021

283. THULASIRAMAN (V), GIRI NANDAGOPAL (M S), KOTHAKOTA (A) 'Need for a balance between short food supply chains and integrated food processing sectors: COVID-19 takeaways from India' Journal of Food Science and Technology; 58(10):3667-3675; 2021

284. UDAYAN (S), ELIZEBATH (D), SHERIN (D R), PRAVEEN (V K), SUNNY (S), JAYAMURTHY (P), MANOJKUMAR (T K), NAMPOORI (V P N), THOMAS (S) 'Hexamethinehemicyanine dye as a thermo-optical probe for serum albumin' Optics and Laser Technology; 143:107351; 2021

285. ULAETO (S B), PANCRECIOUS (J K), RAJAN (T P D) 'Anticorrosive Enamels: Evaluation of Nanocomposite Additives on Enamel Efficiency on Cold Rolled Steel' Journal of Materials Engineering and Performance; 30(6):4103-4116; 2021

286. UMMALYMA (S B), SAHOO (D), PUDIYAMADAM (A), ADARSH (V P), SUKUMARAN (R K), BHASKAR (T), PARIDA (A) 'Sono-Assisted Alkali and Dilute Acid Pretreatment of Phragmiteskarka (Tall Reed Grass) to Enhance Enzymatic Digestibility for Bioethanol Conversion' Frontiers in Energy Research; 8; 2021

287. UNNIKRISHNAN (B S), SEN (A), PREETHI (G U), JOSEPH (M M), MAYA (S), SHIJI (R), ANUSREE (K S), SREELEKHA (T T) 'Folic acid-appended galactoxyloglucan-capped iron oxide nanoparticles as a biocompatible nanotheranostic agent for tumor-targeted delivery of doxorubicin' International Journal of Biological Macromolecules; 168:130-142; 2021

288. VALAPPIL (P K), CHRISTOPHER (M), ATHIRARAJ (S R), MATHEW (R M), KUNI-PARAMBIL (R), ABRAHAM (A), SANKAR (M), PANDEY (A), SUKUMARAN (R K) 'Draft genome of the glucose tolerant β-glucosidase producing rare Aspergillus unguis reveals complete cellulolytic machinery with multiple beta-glucosidase genes' Fungal Genetics and Biology; 151:103551; 2021

289. VARGHESE (H), CHANDRAN (A) 'A facile mechanical energy harvester based on spring assisted triboelectric nanogenerators' Sustainable Energy & Fuels; 5(20):5287 to 5294; 2021

290. VARGHESE (H), CHANDRAN (A) 'Triboelectric Nanogenerator from Used Surgical Face Mask and Waste Mylar Materials Aiding the Circular Economy' ACS Applied Materials & Interfaces; 13(43):51132 to 51140; 2021

291. VARSHA (K K), MAHESHWARI (A P), NAMPOOTHIRI (K M) 'Accomplishment of probiotics in human health pertaining to immunoregulation and disease control' Clinical Nutrition ESPEN; 44:26 to 37; 2021

292. VARSHA (K K), NAMPOOTHIRI (K M), SHILPA (G), PRIYA (S) 'Antimicrobial activity and cytotoxicity trait of a bioactive peptide purified from Lactococcusgarvieae subsp. bovis BSN307 T' Letters in Applied Microbiology; 72(6):706-713; 2021

293. VENUGOPAL (R), GAYATHRI (P T), GANESH, BHAGYA (B S), PHILOMINA (A), LAKSHMI (V K), MADHAVAN (N D), DEB (B) 'Integrating exceptional visible modulation, near-infrared shielding and energy storage in an all-solid-electrochromic bilayer device' Chemical Engineering Journal; 423:130306; 2021

294. VIJAYAN (V), RAVI (M), PRABHU (K N) 'Effect of Ni and Sr additions on the microstructure, mechanical properties, and coefficient of thermal expansion of Al-23%Si alloy' Materials Today proceedings; 46:2732-2736; 2021

295. VIPIN (C K), SHUKLA (A), RAJEEV (K), HASAN (M), LO (S C), NAMDAS (E B), AJAYAGHOSH (A), UNNI (K N N) 'White Organic Light-Emitting Diodes from Single Emissive Layers: Combining Exciplex Emission with Electromer Emission' Journal of Physical Chemistry C; 125(41):22809 - 22816; 2021

296. VIVEK (N), HAZEENA (S H), ALPHY (M P), KUMAR (V), MAGDOULI (S), SINDHU (R), PANDEY (A), BINOD (P) 'Recent advances in microbial biosynthesis of C3-C5 diols: Genetics and process engineering approaches' Bioresource Technology; 322:124527; 2021

297. WU (Y R), NAMPOOTHIRI (K M), ZHANG (C), LIU (L) 'Biosynthesis of Amino Acids and Their Derived Chemicals From Renewable Feedstock [Book-Editorial]' Frontiers in Bioengineering and Biotechnology; 9; 2021

298. YADAV (G), MATHIMANI (T), SEKAR (M), SINDHU (R), PUGAZHENDHI (A) 'Strategic evaluation of limiting factors affecting algal growth – An approach to waste mitigation and carbon dioxide sequestration' Science of The Total Environment; 796:149049; 2021

299. YADAV (G), MISHRA (A), GHOSH (P), SINDHU (R), VINAYAK (V), PUGAZHENDHI (A) 'Technical, economic and environmental feasibility of resource recovery technologies from wastewater' Science of The Total Environment; 796:149022; 2021

300. YOOSUF (M), PRADHAN (S C), SRUTHI (M M), SOMAN (S), GOPIDAS (K R) 'Propellar shaped triple bond rigidified D-A-π-A triphenylamine dye as back electron interceptor in iodine and cobalt electrolyte DSSCs under full sun and indoor light' Solar Energy; 216:151-163; 2021

301. ZHOU (Y), QIN (S), VERMA (S), SAR (T), SARSAIYA (S), RAVINDRAN (B), LIU (T), SINDHU (R), PATEL (A K), BINOD (P), VARJANI (S), SINGHNIA (R R), ZHANG (Z), AWASTHI (M K) 'Production and beneficial impact of biochar for environmental application: A comprehensive review' Bioresource Technology; 337:125451; 2021

पीएच.डी. से सम्मानित कियागया

क्रम सं.	नाम	शोध का शीर्षक	पर्यवेक्षण गाइड	पुरस्कार की तिथी
1	अश्वती ए	बैक्टीरियल ज़ेनोबायोटिक प्रतिक्रिया - ऑर्गनोफॉस्फेट बचाव और क्षरण की प्रभावकारिता और आणविक तंत्र में अंतर्दृष्टि	डॉ राजीव के सुकुमारन/ प्रो अशोक पाण्डे	01.04.2021
2	आतीरा के जे	चार्ज ट्रांसफर और फोटो-प्रेरित इलेक्ट्रॉन स्थानांतर अनुप्रयोगों के लिए β-साइक्लोडेक्सट्रिन आधारित डोनर-स्वीकर्ता सिस्टम का डिजाइन, संश्लेषण और स्व-संयोजन	डॉ के आर गोपीदास	07.04.2021
3	रेश्मा आर	सेलेनोप्रोटीन टी की पहचान और न्यूट्रास्युटिकल अनुप्रयोगों के लिए खाद्य सूक्ष्म शैवाल से कार्बनिक सेलेनियम का संवर्धन	डॉ एम अरुमुगम	18.05.2021
4	अनुपमा नायर	डायबिटिक कार्डियोमायोपैथी के दौरान उत्तेजक मध्यस्थों का विनियमन और सिनेमिल अम्ल के साथ संभावित सुधार	डॉ के जी रघु	14.06.2021
5	मिंजु एन	सतह अभियांत्रिकी पोरस सिलिकेट और क्षय अनुप्रयोगों के लिए संकर सामग्री	डॉ सावित्री एस/ डॉ अनंतकुमार एस	14.06.2021
6	कनकांगी एस नायर	ऊर्जा संचयन अनुप्रयोगों के लिए लचीला सीसा रहित पीजोइलेक्ट्रिक नैनोकम्पोजिट का संश्लेषण और निर्माण	डॉ के पी सुरेन्द्रन	23.07.2021
7	रम्या ए एन	इंट्रासेल्युलर सेंसिंग और चिकित्सीय अनुप्रयोगों के लिए आणविक जांच और नैनो-वाहक वितरण प्रणाली का विकास	डॉ कौस्तभ कुमार मईति	03.08.2021
8	गौरब दास	फिनाइलीन एथिनिलीन और बीओडीआईपीवाई आधारित π -सिस्टम के स्व-संयोजन और ऑप्टिकल गुण	डॉ ए अजयघोष	03.08.2021
9	सजेना के एस	डीएनए-इंटरैक्शन, सेल्फ-असेंबली, और डीएनए थ्री-वे जंक्शन के फोटोफिजिकल गुण, टेम्प्लेटेड फ्लोरोसेंट सिल्वर नैनोक्लस्टर्स और फंक्शनल टेट्राफेनिथिलीन डेरिवेटिव्स	डॉ जोशी जोसफ	03.08.2021
10	प्रजीश के वी	एस्परगिलस यूनगुइस का ग्लूकोज टॉलरेंट बीटा-ग्लूकोसिडेज: इन-सिलिको कैरेक्टराइजेशन, क्लोनिंग, एक्सप्रेशन, और जीनोम/ट्रांसक्रिप्टोम प्रोफाइलिंग ताकि इसके रेगुलेशन को समझा जा सके।	डॉ राजीव के सुकुमारन	10.09.2021
11	मीनू एम टी	पारंपरिक रूप से हाइलाइट किए गए वनस्पतियों से बायोएक्टिव सेकेंडरी मेटाबोलाइट्स की पहचान और व्युत्पन्नकरण और उनके अनुप्रयोगों की खोज	डॉ राधाकृष्णन के वी	10.09.2021

12	प्रीता रानी	हाइपरग्लेसेमिया-प्रेरित कार्डियोमायोपैथी की उत्पत्ति में ईआर तनाव और संबंधित जटिलताओं की खोज और क्लोरोजेनिक एसिड के साथ संभावित सुधार	डॉ के जी रघु	10.09.2021
13	सजिता सुरेन्द्रन	इलेक्ट्रोक्रोमिक और ऊर्जा भंडारण अनुप्रयोगों के लिए वैनेडियम ऑक्साइड आधारित कोटिंग्स	डॉ बिश्वप्रिया डेब	09.11.2021
14	हज़ीना एस एच	कृषि और औद्योगिक अवशेषों से 2,3-बुटानेडियोल के उत्पादन के लिए बेहतर बायोप्रोसेस	डॉ बिनोद पी	09.11.2021
15	संदीप चक्राबोती	लाइव कोशिकाओं में पीएच सेंसिंग और इमेजिंग के लिए पाइरिलियम और पाइरिडिनियम फ्लोरोसेंट जांच	डॉ ए अजयघोष	10.12.2021
16	दिव्या वेलायुधन वी वी	डाई-संवेदी सौर कोशिकाओं में प्रयुक्त डी-π -ए सिस्टम पर घनत्व कार्यात्मक सिद्धांत अध्ययन: दाता-स्वीकर्ता प्रभाव, स्पेसर प्रभाव, और आणविक डिजाइन रणनीतियाँ	डॉ सुरेश सी एच	22.12.2021
17	जॉन पॉल के पी	बिस्मथ हलाइड पेरोव्स्काइट्स: कार्यात्मक कार्बनिक उद्धरणों का उपयोग करके ऑप्टोइलेक्ट्रॉनिक गुणों को ट्यून करना	डॉ विजयकुमार सी	27.12.2021
18	शुहाइलत	बहु-कार्यात्मक अनुप्रयोगों के लिए बोहेमाइट [ऍआईओएचएच] जैल से अकार्बनिक-कार्बनिक संकर नैनोमटेरियल्स की जांच	डॉ अनंतकुमार एस	07.01.2022
19	धन्या एम	पीएलए और पीएचबी बायो कॉपोलिमर पर आधारित दवा वितरण वाहक और मचान का डिजाइन और निर्माण	डॉ के माधवन नंपूतीरी	07.01.2022
20	शांति एस	चयनित औषधीय पौधों की केमोप्रोफाइलिंग और जैविक जांच	डॉ राधाकृष्णन के वी / आर लक्ष्मी वर्मा	20.01.2022
21	नीतू एस	संक्रामक और जीवन शैली रोगों के खिलाफ संभावित ड्रग लीड के विकास के लिए पश्चिमी घाट की दुर्लभ और स्थानिक प्रजातियों से बायोएक्टिव्स की खोज	डॉ राधाकृष्णन के वी	20.01.2022
22	स्वपना शशि यू एस	हेपजी2 सेल लाइन में स्टीटोसिस की उत्पत्ति में फ्रुक्टोज और पामिटेट की भूमिका पर इन विट्रो-आधारित यंत्रवत अध्ययन।	डॉ के जी रघु	31.01.2022
23	अश्वती के	आरई2बीएमएन06 पेरोव्स्किटेस (आरई=पीआर, एनडीऔर एसएम; बी= सीआर, एफ़ई, और सीयू) के चुंबकीय, परिवहन और मैग्नेटोट्रांसपोर्ट गुणों की जांच	डॉ मनोज रामा वर्मा	09.02.2022
24	नीतू एम्मानुएल	विश्लेषणों का तेजी से पता लगाने और मात्रा का ठहराव के लिए स्पेक्ट्रोफोटोमेट्रिक सिस्टम का डिजाइन और विकास	द्र्यूसाफ़ करुवाथ	11.03.2022
25	राजीव वी आर	उन्नत प्रदर्शन के साथ जैविक क्षेत्र-प्रभाव ट्रांजिस्टर के लिए गेट डाइलेक्ट्रिक्स और प्रक्रिया मापदंडों का अनुकूलन	डॉ नारायणन उन्नी के	11.03.2022

Ph.D. Awarded

Sl No.	Name	Thesis Title	Supervising Guide	Date of Award
1	Aswathi A.	Bacterial xenobiotic response - insights into the efficacy and molecular mechanisms of organophosphate evasion and degradation	Dr. Rajeev K Sukumaran/ Prof. Ashok Pandey	01.04.2021
2	Athira K. J.	Design, synthesis and self-assembly of β-cyclodextrin based donor-acceptor systems for charge transfer andphotoinduced electron transfer applications	Dr. K. R. Gopidas	07.04.2021
3	Reshma R.	Identification of Selenoprotein T and enrichment of organic selenium from edible microalgae for nutraceutical applications	Dr. M. Arumugam	18.05.2021
4	Anupama Nair	Upregulation of inflammatory mediators during diabetic cardiomyopathy and possible amelioration with cinnamic acid	Dr. K G Raghu	14.06.2021
5	Minju N.	Surface engineered porous silicates and hybrid materials for sorption applications	Dr.Savithri S. / Dr. Ananthakumar S.	14.06.2021
6	Kanakangi S Nair	Synthesis and fabrication of flexible lead-free piezoelectric nanocomposites for energy harvesting applications	Dr. K. P. Surendran	23.07.2021
7	Ramya A. N.	Development of molecular probes and nano-carrier delivery system for intracellular sensing and theranostic applications	Dr. Kaustabh Kumar Maiti	03.08.2021
8	Gourab Das	Self-Assembly and Optical Properties of Phenyleneethynylene and BODIPY Based π- Systems	Dr. A. Ajayaghosh	03.08.2021
9	Sajena K. S.	DNA-interactions, self-assembly and photophysical properties of DNA three-way junction templatedfluorescent silver nanoclusters and functional tetraphenylethylene derivatives	Dr. Joshy Joseph	03.08.2021
10	Prajeesh K. V.	Glucose tolerant beta-glucosidase of Aspergillus unguis: In-silico characterization, cloning, expression and genome/transcriptome profiling to understand its regulation	Dr. Rajeev K Sukumaran	10.09.2021
11	Meenu M. T.	Identification and derivatization of bioactive secondary metabolites from traditionally highlighted floras and exploring applications thereof	Dr. K. V. Radhakrishnan	10.09.2021
12	Preetha Rani	Exploration of ER stress and associated complications in the genesis of hyperglycemia induced cardiomyopathy and possible amelioration with chlorogenic acid	Dr. K. G. Raghu	10.09.2021

13	Sajitha Surendren	Vanadium oxide-based coatings for electrochromic and energy storage applications	Dr. Biswapriya Deb	09.11.2021
14	Hazeena S. H.	Improved bioprocess for the production of 2,3-Butanediol from agricultural and industrial residues	Dr. Binod P.	09.11.2021
15	Sandip Chakraborty	Pyrylium and Pyridinium Fluorescent Probes for pH Sensing and Imaging in Live Cells	Dr. A. Ajayaghosh	10.12.2021
16	Divya Velayudhan V. V.	Density Functional Theory Studies on D- π -A Systems Used in Dye-Sensitized Solar Cells: Donor-Acceptor Effect, Spacer Effect, and Molecular Design Strategies	Dr. Suresh C. H.	22.12.2021
17	John Paul K. P.	Bismuth halide perovskites: Tuning the optoelectronic properties using functional organic cations	Dr. Vijayakumar C.	27.12.2021
18	Shuhailath	Investigation on inorganic-organic hybrid nanomaterials from boehmite [AlOOH] gels for multifunctional applications	Dr. Ananthakumar S.	07.01.2022
19	Dhanya M.	Design and fabrication of drug delivery carriers and scaffolds based on PLA and PHB bio copolymers	Dr. K. Madhavan Nampoothiri	07.01.2022
20	Santhi S.	Chemoprofiling and Biological Screening of Selected Medicinal Plants	Dr. Radhakrishnan K .V. / R. Luxmi Varma	20.01.2022
21	Neethu S.	Exploration of Bioactives from Rare and Endemic Species of Western Ghats for the development of potential drug lead against Infectious and Lifestyle diseases	Dr. Radhakrishnan K. V.	20.01.2022
22	Swapna Sasi U. S.	In vitro based mechanistic study on the role of fructose and palmitate in the genesis of steatosis in HepG2 cell line	Dr. K. G. Raghu	31.01.2022
23	Aswathi K.	Investigation on magnetic, transport and magnetotransport properties of RE2BMnO6 perovskites (RE=Pr, Nd and Sm; B= Cr, Fe, and Cu)	Dr. Manoj Raama Varma	09.02.2022
24	Neethu Emmanuel	Design and Development of Spectrophotometric Systems for Fast Detection and Quantification of Analytes	Dr. Yoosaf Karuvath	11.03.2022
25	Rajeev V. R.	Optimization of gate dielectrics and process parameters for organic field-effect transistors with enhanced performance	Dr. Narayanan Unni K.N.	11.03.2022

Testing and Analytical Services Cell

CSIR-NIIST has state of the art advanced testing and analytical support facility in place housing some of the finest and sophisticated instruments which not only plays a pivotal role in its multidisciplinary research programs but also caters to the need of external R & D activities, academia, and Industries of the Country. This facility is one of the best of its kind in the southern part of the Country and is extensively used for the ongoing R & D programs of the Institute and generates a steady flow of revenue for the Lab by providing analytical support to external clientele.

The entire analytical facility PAN CSIR can now be accessed through the portal "AnalytiCSIR". This portal can be accessed worldwide and provides the much-needed interfacing platform between users of CSIR and external clients comprising of Industries and Academia. Through this portal, the sophisticated analytical instrumentation facility of entire CSIR Laboratories can be booked by registered authorized users. The facility currently running full-fledged and CSIR-NIIST has successfully migrated its major instruments to this portal. This portal had streamlined the process of booking the analytical service and had made the booking process a seamless experience with complete transparency. One of the major advantage of this facility that the user have access to the status of the analytical service availed. The usage of all major equipments can be monitored including the downtime real time through this facility.

During the reporting period, the facility generated external cash flow of ₹ 21.04 Lakh.

Activities of Vigilance, RTI and Women Cell in CSIR-NIIST

The institute has a full-time vigilance officer who deals with all vigilance matter pertaining to CSIR-NIIST, Thiruvananthapuram. The vigilance officer furnishes certain reports/returns to the Chief Vigilance Officer on regular basis. The vigilance officer is not directly associated in decision making or finalization of tenders/ purchase and audit matters. No vigilance case is pending or contemplated against any employees of CSIR-NIIST during 2021-22.

The institute has a Central Public Information Officer (CPIO) who furnishes information under Right to Information Act (RTI) 2005. During the financial year 2021-2022, we have received 96 RTI queries and all these queries have been replied. The institute submitted all the RTI quarterly returns for the year 2021-22 in the central information commission (CIC) RTI annual return information system.

CSIR-NIIST has a women cell constituted for woman welfare and to attend problems/inconveniences of women employees in CSIR-NIIST which also acts as Internal Complaints Committee (ICC) to deal with Sexual Harassment of Women at Workplace. No complaints were filed to the Women Cell during the year 2021-22.

प्रबंधन परिषद्

अध्यक्ष

निदेशक

सीएसआईआर-एनआईआईएसटी

सदस्य

डॉ एन कलैसेलवी
निदेशक, सीएसआईआर-सीईसीआरआई, कराईकुडी

डॉ पी निशि
प्रमुख, आरपीबीडी

डॉ एस अनंतकुमार
वरिष्ठप्रधान वैज्ञानिक

डॉ ए कुमारन
प्रधान वैज्ञानिक

डॉ के पी सुरेंद्रन
प्रधान वैज्ञानिक

डॉ सूरज सुमन
वैज्ञानिक

डॉ बीना जॉय
प्रधान तकनीकी अधिकारी /एफएओ सीओएफए एनआईआईएसटी

सदस्य सचिव

प्रशासन नियंत्रक/प्रशासन अधिकारी
एनआईआईएसटी

MANAGEMENT COUNCIL

CHAIRMAN

Director

CSIR-NIIST

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Director, CSIR-CECRI, Karaikudi

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Head, RPBD

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Dr A Kumaran
Principal Scientist

Dr K P Surendran
Principal Scientist

Dr Suraj Soman
Scientist

Dr Beena Joy
Principal Technical Officer
CoFA/FAO Member

MEMBER SECRETARY

CoA / AO, NIIST

पदोन्नतियाँ / PROMOTIONS

डॉ आर लक्ष्मी वर्मा/
Dr R Luxmi Varma
मुख्य वैज्ञानिक/
Chief Scientist

डॉ बी एस दिलीप कुमार/
Dr B S Dileep Kumar
मुख्य वैज्ञानिक/
Chief Scientist

डॉ सुजाता देवी/
Dr P Sujatha Devi
मुख्य वैज्ञानिक/
Chief Scientist

डॉ अनंतकुमार/
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डॉ यू एस हरीश/
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वरिष्ठ प्रधान वैज्ञानिक/
Senior Principal Scientist

डॉ ई भोजे गौड़/
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डॉ पी जयमूर्ति/
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डॉ एस प्रिया/
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डॉ एल रवि शंकर/
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डॉ सी विजयकुमार/
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Principal Scientist

डॉ सजू पिल्लई/
Dr Saju Pillai
प्रधान वैज्ञानिक/
Principal Scientist

डॉ पी बिनोद/
Dr P Binod
प्रधान वैज्ञानिक/
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डॉ एन रमेश कुमार/
Dr N Ramesh Kumar
प्रधान वैज्ञानिक/
Principal Scientist

डॉ मुत्तु अरुमुगम/
Dr Muthu Arumugam
प्रधान वैज्ञानिक/
Principal Scientist

पदोन्नतियाँ / PROMOTIONS

श्री एस बी रिबिन जोंस/
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डॉ यूसफ़ करुवाथ/
Dr Yoosaf Karuvath
प्रधान वैज्ञानिक/
Principal Scientist

डॉ दीपा बालन/
Dr Deepa Balan
वरिष्ठ वैज्ञानिक/
Senior Scientist

श्रीमती एस विजी/
Mrs S Viji
वरिष्ठ तकनीकी अधिकारी (2)
Senior Technical Officer (2)

श्री वी हरीश राज/
Mr V Harish Raj
वरिष्ठ तकनीकी अधिकारी (1)
Senior Technical Officer (1)

श्रीमती दिव्या मोहन/
Mrs Divya Mohan
वरिष्ठ तकनीकी अधिकारी (1)
Senior Technical Officer (1)

श्रीमती शाना एस नायर/
Mrs Shana S Nair
तकनीशियन/
Technician

श्री के एफ़ जोसफ/
Mr K F Joseph
प्रशासनिक अधिकारी/
Administrative Officer

श्रीमती के प्रीता/
Smt K Preetha
अनुभाग अधिकारी/
Section Officer (G)

श्रीमती नीतू एस इंदुचूडन/
Smt. Neethu Induchoodan
अनुभाग अधिकारी/
Section Officer (G)

श्री पी अरुमुगम/
Mr. P Arumugam
सहायक कार्यकारी अभियंता (सिविल)/
Assistant Executive Engineer (Civil)

श्री टी के घोष/
Mr T K Ghosh
कनिष्ठ सचिवालय सहायक/
Junior Secretariat Assistant

श्री भक्तवत्सलम/
Mr Bhaktavalsalam
लैब सहायक/
Lab Assistant

श्री पुष्पकुमार/
Mr Pushpakumar
लैब सहायक/
Lab Assistant

सेवा-निवृत्ति / Retirements

डॉ मनोज रामा वर्मा/
Dr Manoj Rama Varma
मुख्य वैज्ञानिक/
Chief Scientist

डॉ जे अंसारी /
Dr J Ansari
मुख्य वैज्ञानिक/
Chief Scientist

श्री थॉमस टी के
Sri Thomas T K
भंडार एवं क्रय नियंत्रक
Controller of Stores and Purchase

डॉ बीना जॉय/
Dr Beena Joy
प्रधान तकनीकी अधिकारी
Principal Technical Officer

डॉ वी एस प्रसाद/
Dr V S Prasad
प्रधान तकनीकी अधिकारी
Principal Technical Officer

श्री ब्रहमकुमार/
Mr Bhramakumar
प्रधान तकनीकी अधिकारी
Principal Technical Officer

श्री टी एच बशीर/
Mr T H Basheer
वरिष्ठ तकनीशियन/
Senior Technician

एनआईआईएसटी में स्थानांतरण/Transfer to NIIST

श्री एस आंटोनी पीटर राजा एस/
Mr S Antony Peter Raja
प्रशासनिक अधिकारी/
Administrative Officer

श्री के नहन्शांगश्री/
Mr K Nganhanshang
प्रशासनिक अधिकारी/
Administrative Officer

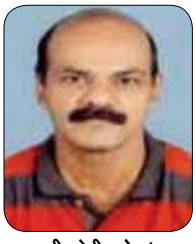
धर्मेंद्र कुमार/
Mr. Dharmendra Kumar
क्रय एवं भंडार अधिकारी/
Stores & Purchase Officer

श्री के एल राजशेखर/
Mr K L Raja Shekar
प्रधान निजी सचिव/
Principal Private Secretary

श्री कृष्णराज तुकाराम जाधव/
Mr Krishnaraj Tukaram Jadhav
क्रय एवं भंडार अधिकारी/
Stores & Purchase Officer

डॉ शेर्मी सी/
Dr Shermi C
वैज्ञानिक/
Scientist

श्री अजित प्रभाकरन/
Mr Ajit Prabhakaran
वरिष्ठ तकनीकी अधिकारी(1)/
Senior Technical Officer (1)



श्री जेड़ी जोस/
Mr Jedy Jose
वरिष्ठ तकनीकी अधिकारी(1)/
Senior Technical Officer (1)

एनआईआईएसटी में स्थानांतरण/Transfer from NIIST

श्री के नहन्शांगश्री/
Mr K Nganhanshang
प्रशासनिक अधिकारी/
Administrative Officer

धर्मेंद्र कुमार/
Mr. Dharmendra Kumar
क्रय एवं भंडार अधिकारी/
Stores & Purchase Officer

डॉ राजकुमार/
Dr. Rajkumar
वैज्ञानिक/
Scientist

हाल ही में भर्ती हुए / Recruitment

डॉ राखी आर बी/
Dr R B Rakhi

डॉ श्रीजित शंकर/
Dr Sreejith Shankar

डॉ तृप्ति मिश्रा/
Dr Tripti Mishra

डॉ पारिजात पल्लब जना/
Dr Parijat Pallab Jana

डॉ हर्षा बजाज/
Dr Harsha Bajaj

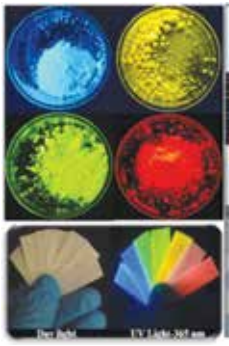
श्री श्रावन्त तंगेल्लमुडि/
Mr Sravanth Tangellamudi

डॉ नवांग चुंजी शेर्पा/
Dr Knawang Chhunji Sherpa

डॉ आशा जी नायर/
Dr Asha G Nair

पुरस्कारतथासम्मान / AWARDS AND HONOURS

CSIR Technology Award (Certificate of Merit) in Physical Sciences (incl. Engineering), 2021: Development of fluorescent molecules and ink as security markers for the protection of Indian currency and prevention of counterfeit activities.



Counterfeiting of currencies, documents, pharma products, and consumer goods is a global problem resulting in huge economic losses to the nation and companies associated with it. The incorporation of fluorescent markers, either through random distribution (fibers) or by printing (ink formulations), is among the most important anti-counterfeiting measures used worldwide. Currently, these materials are imported at inflated costs from various countries, which is a threat to national security and also results in forex depletion. In this context, the indigenous development of these materials and technologies that are difficult to duplicate is absolutely indispensable. However, the realization of printable security materials with uncompromising performance at an affordable cost is extremely challenging. We addressed this challenge by developing fluorescent molecules and pigments with appropriate fluorescence characteristics that are suitable for security printing. These are state-of-the-art and cost-effective (50-80%) materials in comparison with similar products imported to India. Our materials are non-toxic and do not pose any threat to the environment. These products would help the existing players (public and private) to reduce the expenses in terms of import costs and enable their competence in the area of fluorescence-based security solutions. It will also help to control the market and distribution of dangerous (e.g., fake medicines) and defective goods. This may lead to the overall improvement in the quality of common people's life.

CSIR AWARD FOR S&T INNOVATIONS FOR RURAL DEVELOPMENT (CAIRD)

Team with Director CSIR NIIST during 2021

The Award recognizes those outstanding S&T innovations/ solutions that have helped transform the lives of rural people or alleviated the drudgery of the rural people or have helped in generation of employment. Successful S&T innovations/solutions that are implemented at ground level thus are considered. The innovation/ solution applied for, should simultaneously have also broaden interactions among academic, R&D and rural financial institutions, industry

and commercial sectors, and rural people and provided newer vehicles for participatory developments. CSIR values purpose of innovation.

For the year 2020 (results announced in Sep 2021), CSIR NIIST won the award for the development of "**Utilization of various agro-residues for biodegradable products as an alternative to single-use plastics**". The technology includes a cash prize of INR 5,00,000 and a citation.

ISAS-Young Scientist Award-2022

ISAS-Young Scientist Award-2022, from the Indian Society for Analytical Scientists For significant contributions in the area of chemical sciences, in particular chemical intermediates and specialty chemicals.

ICT-Foundation Day Young Scientist Award

Dr. Suraj Soman awarded ICT-Foundation Day Young Scientist Award – 2021 by ICT Mumbai for contributions in the area of dye-sensitized solar cells and indoor photovoltaics. The Award carries a citation (signed by the Vice-Chancellor, ICT Mumbai), plaque, and ₹ 25,000/- cash prize.

INSA Medal for Young Scientist

Dr. Suraj Soman was selected for INSA Medal for Young Scientist (2020), CSIR Young Scientist Award (2020), Kerala State Youth Icon Award (2020), and ICT Foundation Day Young Scientist Award (2021) considering his contributions in the area of dye- sensitized solar cells mainly using new alternate earth-abundant copper electrolytes for indoor light-harvesting applications and development of indigenous module fabrication system for dye-sensitized solar modules. His research emphasized the importance and the dire need for harvesting all forms of light, particularly from artificial sources and catered to the resurgenceof dye-sensitized solar cells and emergence of Indoor Photovoltaics in the country.

CSIR-Young Scientist Award – Engineering Sciences

"CSIR-Young Scientist Award 2021 in Engineering Sciences for developing printed electronic materials and devices for strategic and societal applications"

In-line with the Atmanirbhar Bharat mission of GoI, Dr. Chandran has indigenously developed printed electronic materials

and devices for strategic and societal applications. His major contribution includes, fabrication and integration of energy efficient printed hotplates for micro-farming units at DRDO-DIHAR, customized printed sensor electrodes for DRDO-DRDE and development of self-sterilizing fabric heater using in-house prepared printable ink and its demonstration for complete annihilation of pathogens by resistive heating.

ISEES Young Scientist Award

The International Society for Energy, Environment and Sustainability has selected Dr.Achuchandran for the 'Young Scientists Award of the Society' in the year 2022, based on the scientific evaluation of his work in the area of Energy, Environment and Sustainability. His main contributions are in the area of green-mechanical energy harvesters and sensors including triboelectric nanogenerators and lead-free piezoelectric nanogenerators aiding sustainable development and circular economy. He has also developed energy efficient printed hotplates on rigid and flexible platforms for strategic and societal applications.

EVENTS AND CELEBRATION 2021-22

Due to COVID pandemic all the events were conducted through online mode.

National Technology Day

The National Technology Day was celebrated in CSIR-NIIST on May 11, 2021.Dr. A. Ajayaghosh, Director, CSIR-NIIST delivered the welcome address and introduced the Chief Guest of the day. The National Technology Day Lecture was delivered by Dr. G. Satheesh Reddy,Secretary, Department of Defence R&D and Chairman, Defence Research and Development Organisation (DRDO) Government of India, New Delhi

CSIR Foundation Day

The CSIR Foundation Day was celebrated in CSIR-NIIST on September 27, 2021. Dr. A. Ajayaghosh, Director, CSIR-NIIST delivered the welcome address and introduced the Chief Guest of the day. The CSIR Foundation Day Lecture was delivered by Prof. Samir K Brahmachari, Former Director General, CSIR.

CSIR-NIIST Foundation Day

The CSIR-NIIST Foundation Day was celebrated on October 6, 2021. Dr. A. Ajayaghosh, Director, CSIR-NIIST had delivered the welcome address and introduced the Chief Guest of the day.The CSIR-NIIST Foundation Day Lecture was delivered by Shri. Deependra Singh, Chairman and Managing Director, IREL India Limited, Mumbai. The Annual Report of 2020-2021 was released by the Chief guest.

National Science Day

The National Science Day was celebrated on February 28, 2022. Dr. A. Ajayaghosh, Director, CSIR-NIIST delivered the welcome address and introduced the Chief Guest of the day. The National Science Day Lecture was delivered by Prof. Aniruddha B Pandit, ICT Mumbai.

Hindi Day

Hindi Day was observed on 14th September 2021. Dr. Elizabeth Jacob, Chief Scientist and Chairman, Hindi Week Organizing Committee delivered the Welcome address. Dr. A. Ajayaghosh, Director, CSIR-NIIST delivered the presidential address. A special talk was delivered by MrAkshayDilip Shende Scientist, CSIR-NIIST on 'Special Properties of Ganga'. Sri. Ngahanshang, Administrative Officer, CSIR-NIIST gave the vote of thanks.

Vigilance Awareness Week

Vigilance Awareness Week was observed from 26th October to 1st November 2021. In this regard a variety of events/contests like essay writing, slogan writing etc. were conducted for staff and students of this Institute. The programme commenced on 26th October 2021 by taking Integrity Pledge by all the staff members.

The valedictory function of the Vigilance Awareness Week was conducted on 1st November 2021. The Valedictory address was given by Shri Michel Vetha Seromony IAS (Retd).

31/03/2022 तक की कर्मचारियों की सूची / STAFF LIST AS ON 31/03/2022

डॉ ए अजयघोष/Dr A Ajayaghosh
निदेशक/Director

निदेशक का कार्यालय / DIRECTOR'S OFFICE

श्री जे एस किरण/Mr J S Kiran
तकनीकी अधिकारी /Technical Officer
श्री के एल राजशेखर/Mr K L Raja Shekar
प्रधान निजी सचिव/Principal Private Secretary

कृषि प्रसंस्करण तथा प्रौद्योगिकी प्रभाग/ AGROPROCESSING & TECHNOLOGY DIVISION

श्री वी वी वेणुगोपालन/Mr V V Venugopalan
वरिष्ठ प्रधान वैज्ञानिक तथा प्रधान /Senior Principal Scientist & Head
डॉ बी एस दिलीप कुमार/Dr B S Dileep Kumar
मुख्य वैज्ञानिक/Chief Scientist
डॉ के जी रघु/Dr. K.G. Raghu
वरिष्ठ प्रधान वैज्ञानिक /Senior Principal Scientist
डॉ(श्रीमती) एम वी रेशमा/Dr (Mrs) M V Reshma
प्रधान वैज्ञानिक /Principal Scientist
डॉ(श्रीमती) पी निशा/Dr (Mrs) P Nisha
प्रधान वैज्ञानिक/Principal Scientist
डॉ पी जयमूर्ति/Dr P Jayamurthy
प्रधान वैज्ञानिक /Principal Scientist
डॉ(श्रीमती)एस प्रिया/Dr (Mrs) S Priya
प्रधान वैज्ञानिक/Principal Scientist
श्री टी वेंकटेश/Mr T Venkatesh
वैज्ञानिक /Scientist
डॉ आंजनेयुलु कोताकोटा/Dr Anjineyulu Kothakota
वैज्ञानिक /Scientist
डॉ के वसंत राघवन/Dr K Vasanth Raghavan
वैज्ञानिक /Scientist
डॉ आर वेंकटेश/Dr R Venkatesh
वैज्ञानिक /Scientist
डॉ तृप्ति मिश्रा/Dr Tripti Mishra
वैज्ञानिक /Scientist
श्री डी आर शोबन कुमार/Mr D R Soban Kumar
वरिष्ठ तकनीकी अधिकारी(2)/ Senior Technical Officer (2)
श्रीमती दिव्या मोहन/Mrs Divya Mohan
वरिष्ठ तकनीकी अधिकारी(1)/ Senior Technical Officer (1)

रासायनिक विज्ञान तथा प्रौद्योगिकी प्रभाग/ CHEMICAL SCIENCES & TECHNOLOGY DIVISION

डॉ के वी राधाकृष्णन/Dr K V Radhakrishnan
वरिष्ठ प्रधान वैज्ञानिक तथा प्रधान/Senior Principal Scientist & Head
डॉ पी सुजाता देवी/Dr P Sujatha Devi
मुख्या वैज्ञानिक /Chief Scientist
डॉ सी एच सुरेश/Dr C H Suresh
वरिष्ठ प्रधान वैज्ञानिक /Senior Principal Scientist
डॉ के एन नारायनन उन्नी/Dr K N Narayanan Unni
वरिष्ठ प्रधान वैज्ञानिक/Senior Principal Scientist
डॉ ए कुमरन/Dr A Kumaran
प्रधान वैज्ञानिक /Principal Scientist
डॉ कौस्तभ कुमारमैती/Dr Kaustabh Kumar Maiti
प्रधान वैज्ञानिक /Principal Scientist
डॉ बिस्वाप्रिय डेब/Dr Biswapriya Deb
प्रधान वैज्ञानिक /Principal Scientist
डॉ करुणाकरण वेणुगोपाल/Dr Karunakaran Venugopal
प्रधान वैज्ञानिक/Principal Scientist
डॉ जोशी जोसफ/Dr Joshy Joseph
प्रधान वैज्ञानिक/Principal Scientist
डॉ एल रवि शंकर/Dr L Ravi Shankar
प्रधान वैज्ञानिक /Principal Scientist
डॉ यूसफ़ करुवथ/Dr Yoosaf Karuvath
प्रधान वैज्ञानिक/Principal Scientist
डॉ सी विजयकुमार/Dr C Vijayakumar
प्रधान वैज्ञानिक /Principal Scientist
डॉ सुनील वरुघीस/Dr Sunil Varughese
वरिष्ठ वैज्ञानिक/Senior Scientist
डॉ वी के प्रवीण/Dr V K Praveen
वरिष्ठ वैज्ञानिक /Senior Scientist
डॉ बी एस शशीधर/Dr B S Sasidhar
वरिष्ठ वैज्ञानिक /Senior Scientist
डॉ जुबि जॉन/Dr Jubi John
वरिष्ठ वैज्ञानिक /Senior Scientist
डॉ पी श्रीजित शंकर/Dr P Sreejith Shankar
वरिष्ठ वैज्ञानिक/Senior Scientist
डॉ आदर्श अशोक/Dr Adersh Asok
वैज्ञानिक /Scientist
डॉ ईशिता नियोगी/Dr Ishita Neogi
वैज्ञानिक /Scientist
डॉ श्रीदेवी डी/Dr Shridevi
वैज्ञानिक /Scientist
डॉ सूरज सोमन/Dr Suraj Soman
वैज्ञानिक/Scientist
श्री रोबर्ट फिलिप/Mr Robert Phillip
वरिष्ठ तकनीकी अधिकारी(2)/ Senior Technical Officer (2)
श्रीमती सौमिनी मैथ्यू/Mrs Saumini Mathew
वरिष्ठ तकनीकी अधिकारी(2)/ Senior Technical Officer (2)
श्रीमती एस विजी/Mrs S Viji
वरिष्ठ तकनीकी अधिकारी (2)/ Senior Technical Officer (2)
श्री किरण मोहन/Mr Kiran Mohan
वरिष्ठ तकनीकी अधिकारी (1)/ Senior Technical Officer (1)

पर्यावरण प्रौद्योगिकी प्रभाग/ ENVIRONMENTAL TECHNOLOGY DIVISION

डॉ सी केशवाचन्द्रन/Dr C Kesavachandran
वरिष्ठ प्रधान वैज्ञानिक व प्रधान /Senior Principal Scientist & Head
डॉ(श्रीमती) एलीज़ाबेथ जेकब/Dr (Mrs) Elizabeth Jacob
मुख्य वैज्ञानिक /Chief Scientist
डॉ बी कृष्णकुमार/Dr B Krishnakumar
वरिष्ठ प्रधान वैज्ञानिक /Senior Principal Scientist
श्री बी अब्दुल हलीम/Mr B Abdul Haleem
वरिष्ठ वैज्ञानिक/SeniorScientist
डॉ पार्थाकुंडु/Dr Parthakundu
वरिष्ठ वैज्ञानिक/SeniorScientist
डॉ के पी प्रतीश/Dr K P Prathish
वरिष्ठ वैज्ञानिक /SeniorScientist

श्री सौरभ साखरे/Mr Saurabh Sakhre
वैज्ञानिक /Scientist
श्री धनी बाबू तलाकला/Mr Dhani Babu Talakala
वैज्ञानिक /Scientist
श्री अक्षय दिलीप शिंडे/Mr Akshay Dilip Shende
वैज्ञानिक /Scientist
श्री श्रावन्त तंगेल्लमुडी/Mr Sravanth Tangellamudi
वैज्ञानिक /Scientist
डॉ शेर्मी सी /Dr Shermi C
वैज्ञानिक /Scientist
श्री वी के शाजिकुमार/Mr V K Shajikumar
वरिष्ठ तकनीकी अधिकारी (2)/ Senior Technical Officer(2)
डॉ जोशी जॉर्ज/Dr Joshy George
वरिष्ठ तकनीकी अधिकारी(2)/ Senior Technical Officer(2)
श्रीमती पी एम सहरूबा/Mrs P M Saharuba
वरिष्ठ तकनीकी अधिकारी(1)/ Senior Technical Officer (1)

पदार्थ विज्ञान और प्रौद्योगिकी प्रभाग/ MATERIALS SCIENCE & TECHNOLOGY DIVISION

डॉ एम रवि/Dr M Ravi
मुख्य वैज्ञानिक व प्रधान /Chief Scientist & Head
डॉ(श्रीमती) एस सावित्री/Dr (Mrs) S Savithri
मुख्य वैज्ञानिक/Chief Scientist
डॉ एस अनंतकुमार/Dr S Ananthakumar
मुख्य वैज्ञानिक/Chief Scientist
डॉ के आई सुरेश/Dr K I Suresh
वरिष्ठ प्रधान वैज्ञानिक /Senior Principal Scientist
डॉ टी पी डी राजन/Dr T P D Rajan
वरिष्ठ प्रधान वैज्ञानिक /Senior Principal Scientist
डॉ यू एस हरीश/Dr U S Hareesh
वरिष्ठ प्रधान वैज्ञानिक /Senior Principal Scientist
डॉ ई भोजे गौड़/Dr E Bhoje Gowd
वरिष्ठ प्रधान वैज्ञानिक /Senior Principal Scientist
डॉ एस वी शुक्ला/Dr S V Shukla
प्रधान वैज्ञानिक /Principal Scientist
डॉ के जयशंकर/Dr K Jayasankar
प्रधान वैज्ञानिक /Principal Scientist
डॉ ए श्रीनिवासन/Dr A Srinivasan
प्रधान वैज्ञानिक /Principal Scientist
डॉ एम सुंदरराजन/Dr M Sundararajan
प्रधान वैज्ञानिक /Principal Scientist
डॉ के पी सुरेन्द्रन/Dr K P Surendran
प्रधान वैज्ञानिक/Principal Scientist
डॉ सजू पिल्लई/Dr Saju Pillai
प्रधान वैज्ञानिक/Principal Scientist
डॉ आर बी राखी/Dr R B Rakhi
प्रधान वैज्ञानिक /Principal Scientist
डॉ सुब्रता दास/Dr Subrata Das
वरिष्ठ वैज्ञानिक/Senior Scientist
डॉ के जी निशांत/Dr K G Nishanth
वरिष्ठ वैज्ञानिक/Senior Scientist
डॉ एस एस श्रीजाकुमारी/Dr S S Sreejakumari
वरिष्ठ वैज्ञानिक /Senior Scientist
डॉ सुशांता कुमार साहू/Dr Sushanta Kumar Sahoo
वैज्ञानिक/Scientist
डॉ अच्चु चंद्रन/Dr Achu Chandran
वैज्ञानिक/Scientist
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(वैज्ञानिक तथा औद्योगिक अनुसंधान परिषद्)

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