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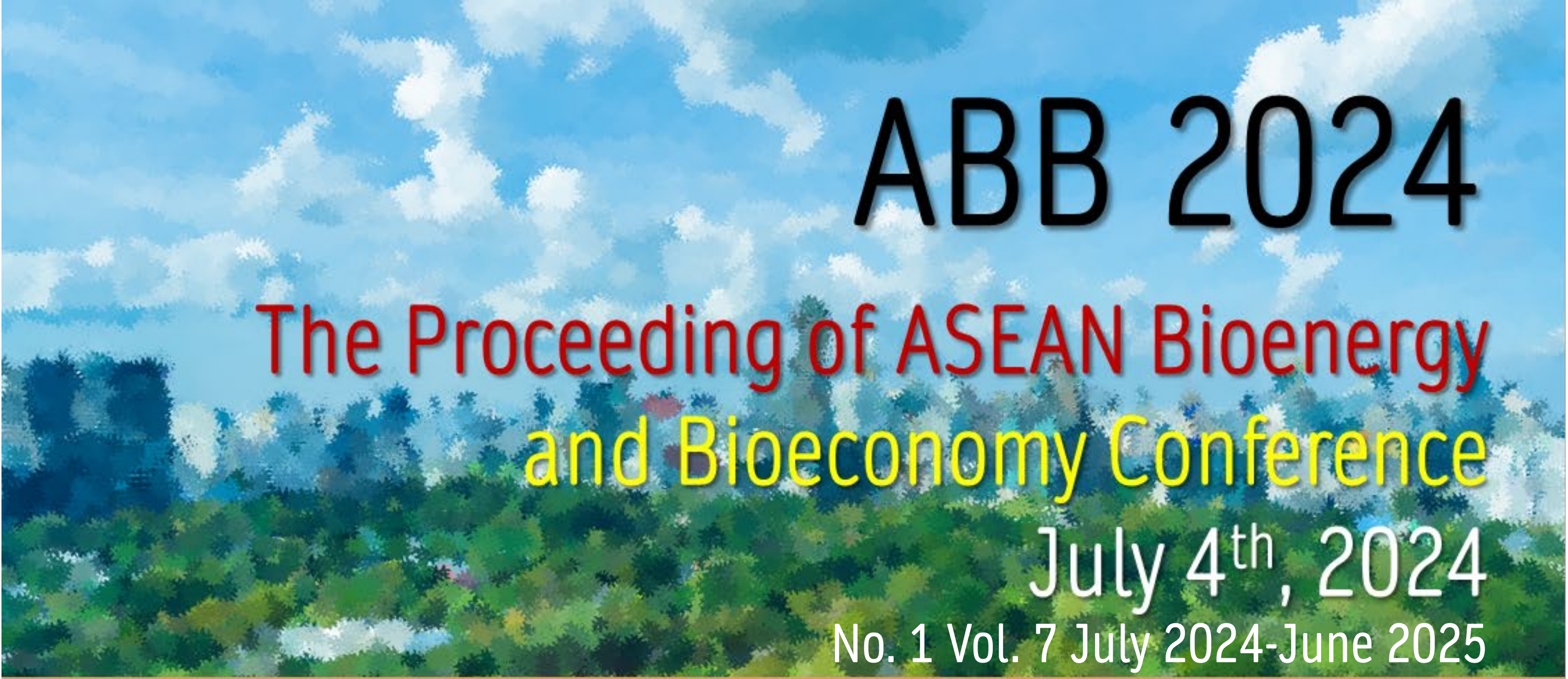

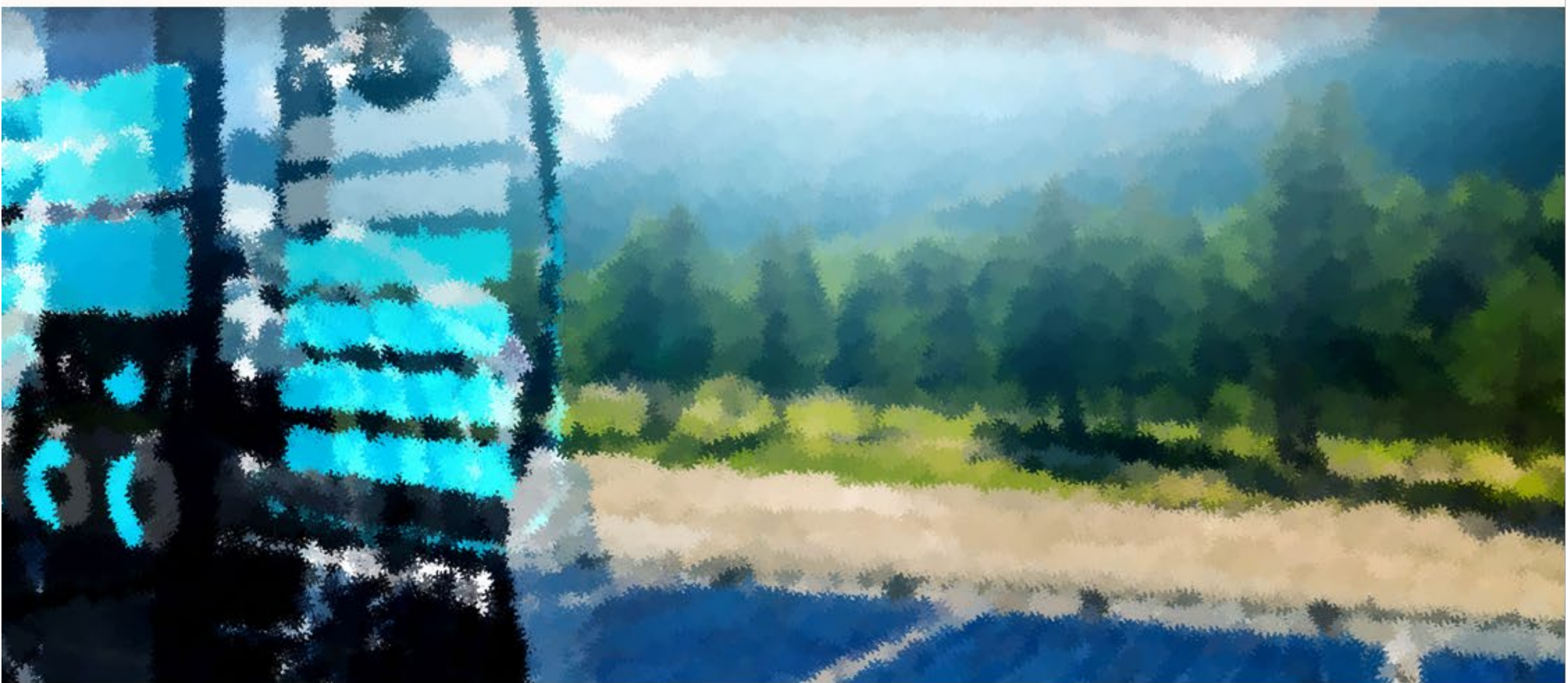

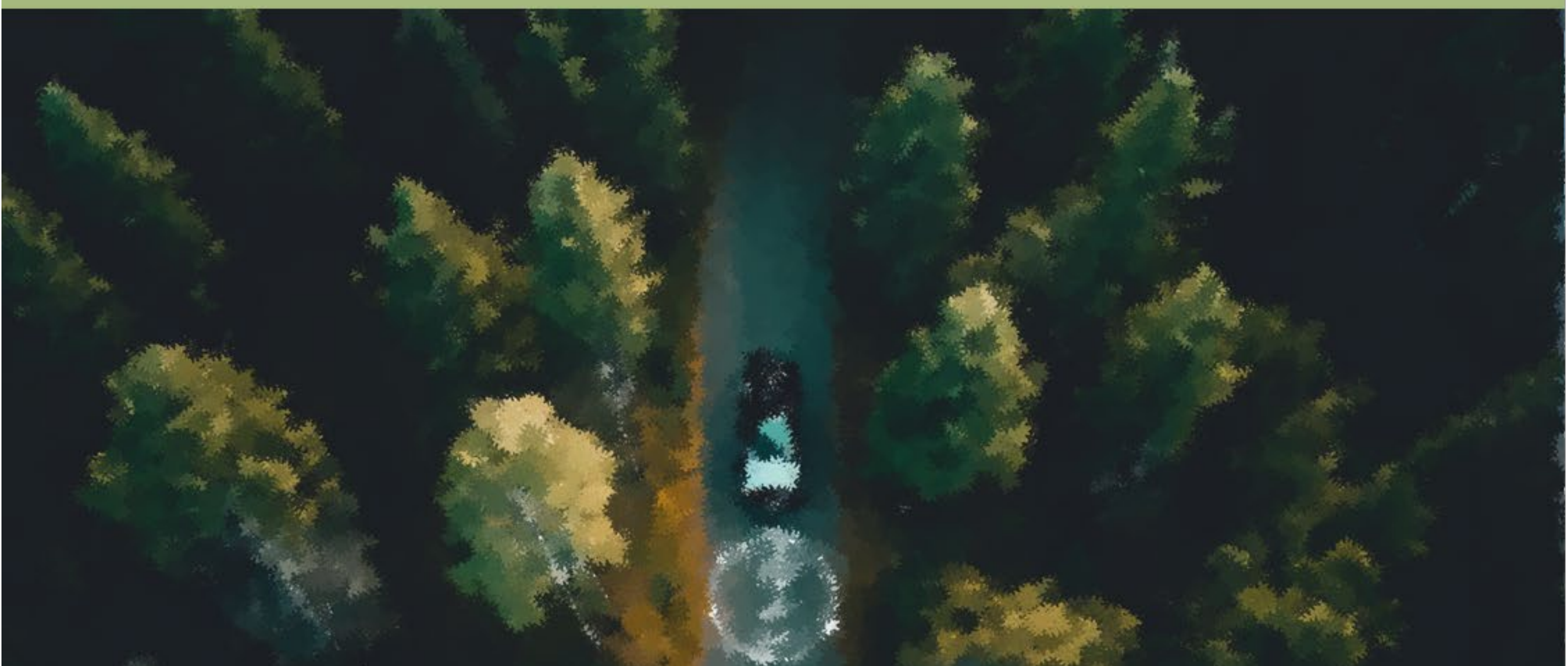

ASEAN Bioenergy and Bioeconomy Conference 2024:

Sustainable Bioresources for Green Energy and Economy

July 4th, 2024

Queen Sirikit National Convention Centre (QSNCC)

Bangkok, THAILAND

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Kasetsart Agricultural and Agro-Industrial Product Improvement Institute (KAPI),

Kasetsart University, Bangkok, THAILAND

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EDITED BY

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The 8th ASEAN Bioenergy and Bioeconomy Conference (ABB2024): Sustainable Bioresources for Green Energy and Economy

July 4th, 2024

Queen Sirikit National Convention Centre (QSNCC), Bangkok, Thailand

The first ABB conference was organized in 2017 with focus on sustainable management and partnership. Since then, ABB conference promoted the exchange of knowledge of bioenergy and bioeconomy, providing opportunities to update database, status and situation in ASEAN countries. The conference has a strong participation of researchers, private sectors, business developers and policy makers and has been an important platform for a dialogue between academic and industrial scientists and technologists.

Objectives

1) To exchange and transfer useful information on biomass and bioenergy database, status and situation, new knowledge and technologies and innovation among ASEAN countries
2) To enhance sustainable biomass for energy production and utilization in ASEAN region to relieve environmental crisis and increase competitiveness of biomass for energy from ASEAN countries to the world market
3) To strengthen the biomass and bioenergy network within ASEAN countries

Conference Topics

Bioenergy

- Biomass, Biofuel, Biorefinery and other products, Carbon materials and applications, Feedstock production technology, Photovoltaic materials and Solar energy, Reactivity and catalysis, Sustainable solid biofuels, and The Related Topics

Bioeconomy

- Biocomposite, Biopharmaceutical, Bioprocess, Bioproduct, Plant factory, Precision agriculture, and The Related Topics

Organizing Committee

- Kasetsart Agricultural and Agro-industrial Product Improvement Institute (KAPI), Kasetsart University, Thailand
- Asian Development College for Community Economy and Technology, Chiang Mai Rajabhat University, Mae Rim Campus, Thailand
- King Mongkut's University of Technology Thonburi (KMUTT), Thailand
- Informa Markets (Thailand) Company Limited

Agenda

The 8th ASEAN Bioenergy and Bioeconomy Conference (ABB2024): Sustainable Bioresources for Green Energy and Economy

July 4th, 2024 Queen Sirikit National Convention Centre (QSNCC), Bangkok, Thailand

Opening Ceremony (ROOM MR109GH)		
Moderator:	**Dr. Natedao Musigamart,** Kasetsart Agricultural and Agro-Industrial Product Improvement Institute (KAPI), Kasetsart University, Thailand	**Page**
08.30 – 09.00	Registration	
09.00 – 09.15	**Report on the opening ceremony** Dr. Pilanee Vaithanomsat, Director of Kasetsart Agricultural and Agro-Industrial Product Improvement Institute (KAPI), Kasetsart University, Thailand	
09.15 – 09.30	**Opening ceremony** Dr. Chongrak Wachrinrat, President of Kasetsart University, Thailand	
09.30 – 10.15	**Keynote presentation** **"Driving CCUS Policies to Challenge Carbon Neutrality and Net Zero in Thailand"** Mr. Pavich Kesavawong Deputy Director General of Department of Climate Change and Environment (DCCE)	4
10.15 – 10.30	Coffee break and *separate to session rooms*	
Bioenergy Session (ROOM MR109GH)		
10.30 – 12.30	**Panel Discussion** **"Carbon Capture Utilization and Storage (CCUS): Turning a Pollutant into High-Value Products"** **Moderator: Assoc. Prof. Dr. Suneerat Fukuda** Head of Advanced Fuel Processing Laboratory, The Joint Graduate School of Energy and Environment (JGSEE), King Mongkut's University of Technology Thonburi **Panel Speakers:** • **Panel 1: Ms. Sumon Sumetchoengprachya** Director of Low Carbon Policy and Technical Support Office Thailand Greenhouse Gas Management Organization (TGO) • **Panel 2: Dr. Pramote Puengjinda** Senior Advisor Energy Project, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH • **Panel 3: Ms. Nuchanart Siri-Nguan** Senior Researcher, PTT Innovation Institute, PTT Public Company Limited (PTT) • **Panel 4: Assoc. Prof. Dr. Sirichai Koonaphapdeelert** Director of Energy Research and Development Institute-Nakornping, Chiang Mai University	20
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14.00 – 14.20	**EC-R005:** Development of A Smart Greenhouse for Spur Chili Peppers Based on Internet of Things **Leokham Phanlacktham,** School of Renewable Energy, Maejo University, Thailand	83
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15.30 – 16.00	Announcement of Presentation Awards and Closing Bioeconomy Session	

POSTER

ASEAN Bioenergy and Bioeconomy Conference 2024

POSTER

ASEAN Bioenergy and Bioeconomy Conference 2024

PREFACE

Dr. Chongrak Wachrinrat
President
Kasetsart University, Thailand

On behalf of Kasetsart University, I am pleased to extend a warm welcome to everyone attending the "ASEAN Bioenergy and Bioeconomy Conference 2024", also known as ABB2024, which arranged at the Queen Sirikit National Convention Centre (QSNCC), Bangkok, Thailand. Since 2017, we have arranged this symposium in an effort to promote knowledge sharing of bioenergy and bioeconomy with consistently excellent collaboration from a network of researchers, governments, and private sector.

I would like to extend a special welcome to the distinguished keynote speaker, Mr. Pavich Kesavawong, Deputy Director General of Department of Climate Change and Environment (DCCE), as well as to the honorable speakers who have been invited to join us during the panel discussion: Assoc. Prof. Dr. Suneerat Fukuda, Head of Advanced Fuel Processing Laboratory, The Joint Graduate School of Energy and Environment (JGSEE), King Mongkut's University of Technology Thonburi. Ms. Sumon Sumetchoengprachya, Director of Low Carbon Policy and Technical Support Office, Thailand Greenhouse Gas Management Organization (TGO), Dr. Pramote Puengjinda, Senior Advisor Energy Project, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, King Mongkut's University of Technology Thonburi, Ms. Nuchanart Siri-Nguan, Senior Researcher, PTT Innovation Institute, PTT Public Company Limited (PTT), and Associate Professor Dr. Sirichai Koonaphapdeelert, Director of Energy Research and Development Institute-Nakornping, Chiang Mai University and bioeconomy session: Asst. Prof. Dr. Helen Julian, Department of Food Engineering, Faculty of Industrial Technology, Institut Teknologi Bandung and Dr. Thidarat Nimchua Enzyme Technology Research Team, Biorefinery and Bioproduct Technology Research Group, National Center for Genetic Engineering and Biotechnology (BIOTEC), National Science and Technology Development Agency (NSTDA), Thailand. We really appreciate that you accepted our invitation despite your busy schedules.

PREFACE

We all have the same common dedication to developing Sustainable Biomass programs throughout the ASEAN community. I have confidence that this symposium will create additional avenues for scientists, technicians, and researchers to exchange knowledge, expertise, and research techniques.

Since the 2000s, everyone throughout the world has been aware of global warming caused by human activities, which release large amounts of greenhouse gases into the environment, particularly Carbon Dioxide generated by industrial plants. As a result, the temperature on Earth's surface will keep rising gradually. Currently, in an attempt to reduce these emissions, Carbon Dioxide is being stored underground and used for commercial reasons. This process was known as Carbon Capture Utilization and Storage (CCUS). Attempting to establish an appropriate holistic framework for CCUS, in technical, regulatory, commercial incentives, and stakeholder engagement terms, will lead to more success and public acceptance.

I would like to express my gratitude to the organizing committee, led by Dr. Pilanee Vaithanomsat, Director of Kasetsart Agricultural and Agro-Industrial Product Improvement Institute (KAPI), for arranging this conference and ensuring its continuity. I additionally wish to express my gratitude to Department of Climate Change and Environment (DCCE), and Informa Markets (Thailand) Co., Ltd. as well as the other companies, universities, and organizations who cooperated and contributed to this important conference. I have confidence that this symposium will achieve its goals and provide tremendous benefit to the world community. In closing, I wish you a fruitful discussion and successful symposium.

I am honored to declare this symposium officially open.

KEYNOTE Speaker

Keynote

Mr. Pavich Kesavawong

Deputy Director General
Department of Climate Change and Environment
Ministry of Natural Resources and Environment
pavich@dcce.mail.go.th, pavichk@gmail.com

Mr. Pavich Kesavawong graduated with his master degree in Master of Business Administration (Financial Management) from City University, Seattle, Washington, U.S.A. and bachelor degree in Bachelor of Political Science (Public Administration) from Thammasat University, Thailand.

He has joined the Royal Thai Government since 1998. He has been working at the Ministry of Natural Resources and Environment since the establishment of the Ministry in 2002. He previously held important posts including, the Director of Foreign Affairs Division and International Environmental Specialist at Office of the Permanent Secretary, Ministry of Natural Resources and Environment. Currently, he is the Deputy Director General of Department of Climate Change and Environment. He is designated to be Thailand delegation to attend high level meetings/forums such as UN Climate Change Conference (UNFCCC), UN Forum on Forests etc. He used to be the Chairman of the GEF Council Members of the East Asia Constituency, ASEAN Co-Chair at the Working Group on Green Economy (WGGE) Meeting under negotiations to upgrade the ASEAN – China Free Trade Agreement: ACFTA), the Secretariat of the Working Group on Protocol under the Ad hoc Sub-Committee prepares to hold a meeting of the Parties to Drive Operations on Thailand Climate Change (Thailand Climate Action Conference: TCAC) and Thai delegation in international negotiations under multilateral, regional, bilateral frameworks, including trade and environment.

INVITED presentations

Invited speaker - 1

Asst. Prof. Dr. Helen Julian

Department of Food Engineering, Faculty of Industrial Technology,
Institut Teknologi Bandung,
Sumedang, Indonesia
E-mail: helen_j@itb.ac.id

Helen Julian is an Assistant Professor in Institut Teknologi Bandung (ITB), Indonesia. After completing her undergraduate and graduate degrees (Chemical Engineering from ITB) in 2010 and 2012, she received her PhD in Chemical Engineering from University of New South Wales in 2018, where her research was coordinated in UNESCO Centre for Membrane Science and Technology. Her main research interests are membrane distillation for zero liquid discharge desalination and the application of membrane technology for the intensification of food processing.

The Role of Membrane Technology in Supporting the Bio-Based Economy

Helen Julian[1,*]

[1] Department of Food Engineering, Faculty of Industrial Technology, Institut Teknology Bandung, Sumedang, Indonesia
*E-mail: helen_j@itb.ac.id

ABSTRACT

The integration of membrane technology into the bio-based economy offers transformative potential in enhancing resource efficiency, sustainability, and economic viability across various sectors. Membranes play a vital role in creating value-added products, reducing waste, and advancing the transition towards a more sustainable model. As we navigate the challenges of the modern world and strive to achieve the SDGs, membrane technology stands out as a versatile and effective tool in supporting the bio-based economy and promoting sustainable development on a global scale. In Indonesia, the application of membrane technology in food processing, clean water production, or natural resource utilization has been evaluated. Remarkable results, in terms of product quality, energy requirement, and economic analysis are presented. The optimization of membrane processes aligns with the principles of circular economy and sustainable resource utilization, contributing to a more environmentally friendly and economically viable future.

Keywords: membrane technology, food concentration, water production, bioactive isolation

Background:

In today's global landscape, the concept of a bio-based economy has gained increasing attention and significance. The bio-based economy, often referred to as the sustainable economy, is centered around the utilization of renewable biological resources to produce goods and services, emphasizing sustainability, eco-friendliness, and reduced reliance on fossil fuels [1]. This economic model plays a critical role in addressing pressing issues faced by the world, such as climate change, resource depletion, and environmental degradation, aligning with the Sustainable Development Goals (SDGs) set by the United Nations. The bio-based economy also intersects with the water-food-energy nexus, highlighting the interconnectedness of these essential resources and the need for integrated solutions to ensure their sustainable management [2].

Membrane technology is a key enabler in supporting the bio-based economy, offering innovative solutions for various industries, including food processing. Membranes are thin, selective barriers that allow specific substances to pass through while retaining others, based on size, charge, or other properties. In the context of food processing, membrane technology is employed for clarification and concentration purposes, enhancing product quality and efficiency. Membrane processes such as ultrafiltration and nanofiltration are utilized to separate and concentrate components like proteins, sugars, and vitamins, improving the overall quality of food products [3]. Compared to conventional methods, membrane technology offers several advantages, including higher efficiency, reduced energy consumption, and minimal use of chemicals, making it a more sustainable and environmentally friendly option [4].

Furthermore, membrane technology plays a crucial role in clean water production, addressing the global challenge of water scarcity and contamination. Processes such as reverse osmosis and membrane distillation are commonly used to purify water by removing contaminants and impurities, ensuring access to safe and clean drinking water for communities worldwide [5]. These advanced membrane processes are highly effective in removing bacteria, viruses, salts, and other pollutants from water, making them indispensable in water treatment and desalination applications. Membrane technology provides a cost-effective and sustainable solution for clean water production, contributing to the achievement of SDG 6 (Clean Water and Sanitation).

In the context of Southeast Asia, a region known for its rich natural resources and biodiversity, membrane technology holds significant potential in supporting the bio-based economy. With abundant sources of biomass, agricultural waste, and marine products, Southeast Asia presents vast opportunities for the sustainable utilization of these resources through innovative membrane processes. Membrane technology can be employed to extract valuable components from natural resources, such as bioactive compounds from plants, proteins from seafood byproducts, and biofuels from agricultural waste, contributing to the development of a thriving bio-based economy in the region. By leveraging membrane technology for processing and refining natural resources, Southeast Asian countries can enhance value addition, promote circular economy practices, and foster economic growth while minimizing environmental impact. In this paper, the application of membrane technology to support the bio-based economy, particularly those which extensively studied in Indonesia, is presented.

Membrane for liquid food concentration

Low-pressure membrane technologies like Osmotic Membrane Distillation (OMD) and Forward Osmosis (FO) have gained significant attention, particularly in the food industry for concentration processes. Osmotic membrane distillation (OMD) is a separation technique that utilizes a porous hydrophobic membrane where the feed solution moves through one side of the membrane while the concentrated draw solution passes through the other side, creating a vapor pressure gradient that facilitates water vapor transport [6]. By eliminating the need for high operating pressures, OMD can achieve high concentrations in the feed solution, while OMD's low operating temperature helps preserve nutrients, aroma, and flavor in the concentrated products [7]. FO harnesses natural osmotic pressure to shift water from a less to a more concentrated solution, offering energy savings and maintaining the quality of food products. These membrane technologies are poised to revolutionize traditional practices by combining low-energy consumption with high efficiency [8]. The Technology Readiness Level (TRL) assessment of FO and MD for industrial-scale processes considers factors such as process validation, scale, membrane module type, feed source, and operating time, placing most research studies in the TRL 4 to 7 range [9].

Table 1. Vitamin C, phenolic compound, and pH of the concentrated apple juice [6].

Temperature (∘C)	[Vitamin C] (mg/L)	[Phenolic] (mg/L)	pH	$\frac{[\text{Vitamin C}]}{[\text{Vitamin C}]_0}$	$\frac{[\text{Phenolic}]}{[\text{Phenolic}]_0}$
Control juice	52.8 ± 2.49	284.21 ± 0.99	3.69 ± 0.12	1.00	1.00
30 – MD	51.04 ± 1.58	269.97 ± 2.62	3.89 ± 0.24	0.97	0.95
40 – MD	45.76 ± 2.49	252.66 ± 2.53	3.91 ± 0.02	0.87	0.89
50 – MD	44.88 ± 1.24	244.27 ± 0.72	4.11 ± 0.26	0.85	0.86
60 – Evaporation	40.7 ± 1.56	235.73 ± 4.92	3.87 ± 0.18	0.77	0.83

OMD's efficacy has been demonstrated in the concentration of apple juice (Figure 1(a)), where the impact of variables such as feed temperature (ranging from 30 to 50°C), draw solution flow rate (2 to 4 mL/s), and draw solution concentration (545 to 630 g/L) on the permeate flux was rigorously investigated. The results showed an increase in flux with rising feed temperature, draw solution flow rate, and draw solution concentration. While a noticeable deterioration in phenolic compounds and Vitamin C was observed at higher temperatures during OMD trials, the decline was less severe compared to evaporation-based methods, suggesting superior preservation qualities of OMD-treated apple juice [6] (Table 1).

Additionally, Membrane Distillation (MD) has been applied in the integrated concentration and crystallization of sugarcane juice. Long-term operation utilizing a cane sugar model solution as the feed under optimal conditions (70°C feed temperature, initial feed concentration of 50°Brix, and no feed stirring) resulted in the crystallization of sugar on the membrane surface. This phenomenon led to the formation of a porous fouling layer, which contributed to flux decline and membrane wetting. However, sugar crystallization on the membrane surface offered advantages, suggesting the potential for heterogeneous crystallization of sugar in the feed tank. In experiments involving industrial raw sugarcane juice as the feed solution, no crystal formation was observed in the bulk feed or on the membrane surface due to the lower feed concentration falling below its supersaturation threshold (Figure 1(b)). The presence of impurities in the raw sugarcane juice further hindered the nucleation and crystal growth process, emphasizing the need for further exploration into the crystallization of sugar from clarified raw sugarcane juice [10].

In a recent study focusing on the concentration of butterfly pea extract for natural food colorant production, OMD offered a promising solution. It was observed that a feed temperature of 50°C had no adverse effect on the phytonutrient characteristics of the extracting process, with retention rates of 81-93% for total phenolic content and 83-94% for antioxidant activity. Further treatment of the concentrated extracts through freeze-drying resulted in superior preservation of phenolic content, anthocyanin, and antioxidant properties. A techno-economic evaluation of natural food colorant production using OMD and freeze-drying techniques revealed a reduced manufacturing cost when the extract was first concentrated using OMD before undergoing freeze-drying (Fig. 1(c) and (d)). This approach highlighted the importance of maximizing the concentration of the feed solution to minimize production costs and enhance overall efficiency in the food processing industry.

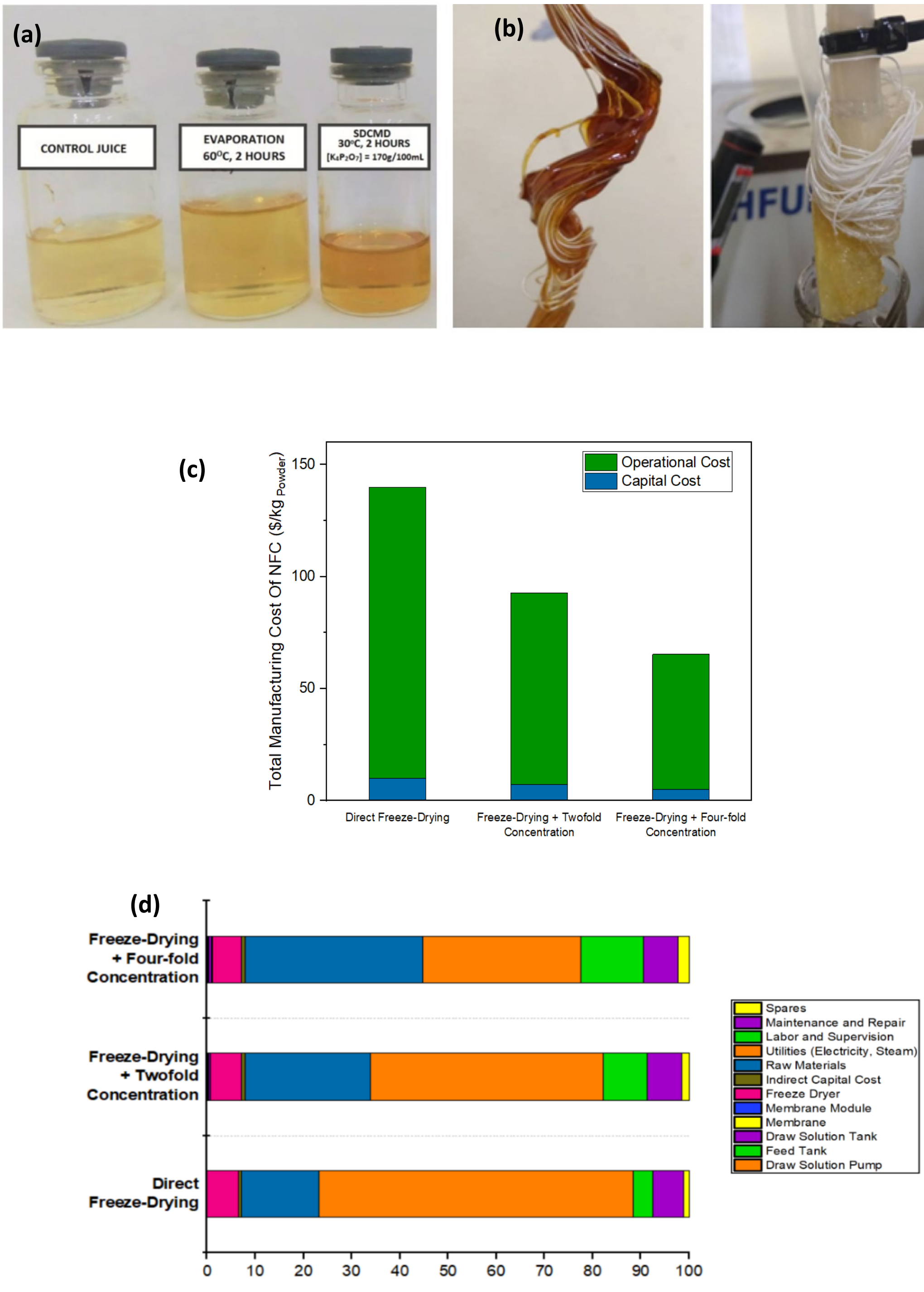

Fig. 1. (a) visualization of the heat-treated apple juice at various operation conditions [6], (b) visual observation of sugar crystal formed on the membrane surface [10], (c) comparison of total cost and (d) cost contribution of the butterfly pea concentration using OMD.

Membrane for clean water production

Water scarcity poses significant global challenges due to factors such as population growth, industrialization, and climate change, with over 33% of the world's population residing in regions experiencing water stress [11]. The demand for clean water has led to the depletion of groundwater and river systems, necessitating the adoption of desalination processes to produce fresh or potable water from saltwater sources for a sustainable living cycle. Established desalination technologies such as multi effect distillation (MED), multistage flash distillation (MSF), and reverse osmosis (RO) dominate the desalination market. Although MED and MSF, which are thermal desalination methods, produce high-quality water, their discharge temperature can harm marine ecosystems, requiring substantial energy input and prompting the exploration of alternative desalination technologies [12]. Currently, approximately 80% of desalination plants globally employ RO technology, renowned for its energy efficiency and cost-effectiveness following extensive research efforts to enhance performance. Despite advancements in RO water recovery, challenges persist, notably concerning high osmotic pressure and brine disposal associated with seawater desalination. Membrane distillation (MD) has emerged as a promising desalination solution due to its elimination of high osmotic pressure, presenting an opportunity for mineral recovery in the concentrate to achieve a zero liquid discharge (ZLD) system [13]. Studies have demonstrated MD's potential to increase freshwater recovery rates up to 90% and recover significant amounts of NaCl from RO brine, achieving NaCl crystal production with substantial water recovery in bench-scale membrane distillation-crystallization (MDC) experiments [14]. Research into submerged vacuum membrane distillation crystallization for salt recovery further supports MD's efficacy, with salt recovery ratios influenced by the initial feed concentration [15]. While MD may not currently compete economically with RO, especially regarding energy consumption, it can serve as a complementary technology to seawater reverse osmosis (SWRO) by offering advantages in overcoming osmotic pressure compared to raising feed temperatures in MD applications [16].

Economic analysis of the simultaneous production of clean water and industrial salt utilizing membrane technology was carried out based on two schemes, namely: (1) RO-MD and (2) stand-alone MD. The feed volumetric flow rate was adjusted to the small-scale seawater desalination process, which was 100 m^3/day. The purification process was carried out by the precipitation softening (PS) method with a mole ratio of precipitating agent to hardness of 1.84 and followed by separation using a UF membrane. The pretreated feed was then desalinated in the RO unit and the RO permeate had a purity of >99%, to which it can be categorized as clean water. The RO retentate was forwarded to the MD unit which was integrated with a crystallizer or refer to as membrane distillation crystallization (MDC). The RO retentate entering the MDC was concentrated until the NaCl saturation point was passed. The crystallization was carried out with the addition of 2% seeds and the crystal yield was 34% of the total feed TDS with a purity of >99%. The flow diagram and mass balance of the schemes are shown in Figure 2(a). In the stand-alone MD scheme, the operating conditions of all stages were the same as in the RO-MD scheme, but seawater as the feed was directly processed in the MDC (Fig. 2(b)).

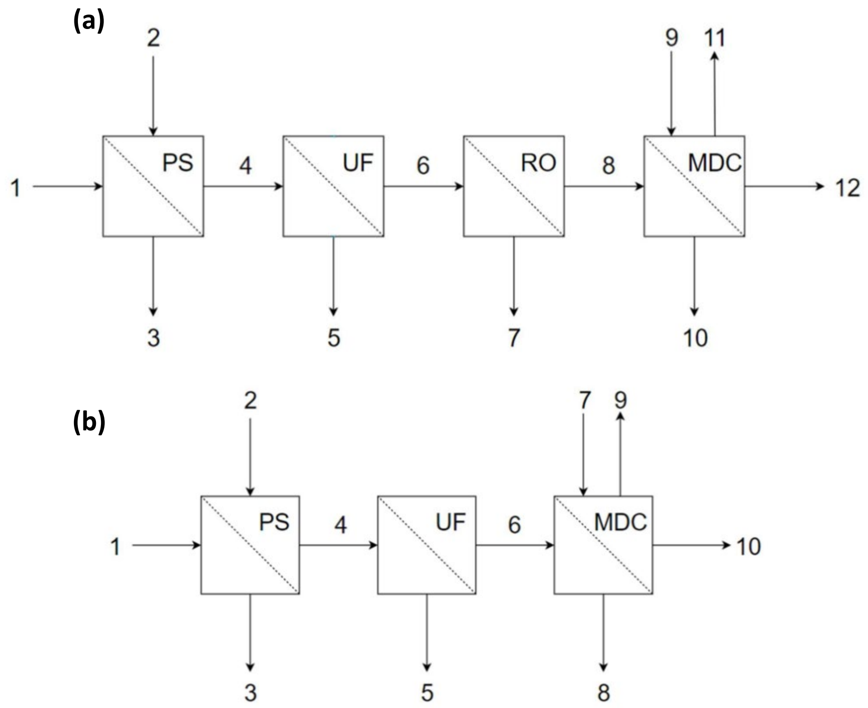

Fig. 2. Schematic flow diagram of (a) RO-MD scheme and (b) MD scheme.

Based on the technoeconomic analysis, the CAPEX required to produce clean water and salt simultaneously through the RO-MD scheme was $131,032.91/year. The largest portion of CAPEX was the RO process, which covered 69% of the total CAPEX or equivalent to $90,897.09/year, followed by the UF process (17%), MD (13%), and PS (1%). Based on OPEX calculations, the most significant operating cost was the MD operation. OPEX of MD reached 48% of total OPEX, followed by RO (21%), PS (20%), seeding (9%), and UF (2%). This was due to higher thermal/electrical energy requirements of MD than other processes. Of the total MD operating costs, the energy requirements reach 93%. As a comparison, MD energy requirements reached 39-67 kWh/m^3 while RO energy requirements were only 2-6 kWh/m^3. However, this energy requirement can be reduced by using hybrid processing that utilizes residual heat from other processes [17,18].

In the stand-alone MD scheme, there was an increase in CAPEX required for MD processing because the desalination was directly carried out by MD, which resulted in larger equipment capacity and membrane surface area. OPEX in the MD scheme showed that MD required the largest operating costs. Based on Fig. 3, the operating costs of the MD process reach 73%, followed by the PS process (17%), seeding (8%), and UF (2%). This scheme also required much greater operating costs than the RO-MD scheme.

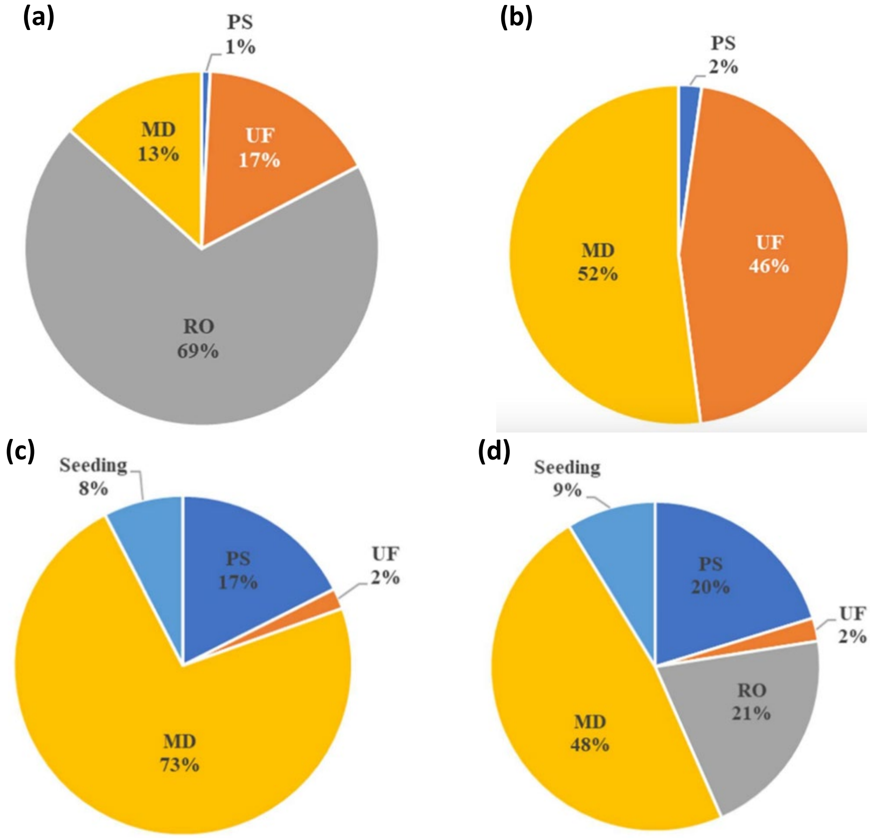

Fig. 3. (a) CAPEX of RO-MD scheme, (b) OPEX of RO-MD scheme, (c) CAPEX of MD scheme, (d) OPEX of MD scheme.

Membrane for bioactive compound isolation

Palm oil is an abundant source of carotenoids in Indonesia. Red palm oil (RPO), which is low in free fatty acids and gum, is one of the palm oil derivative products that still contains high levels of carotenoids. RPO is used as a raw material for the production of carotenoid-rich biodiesel or Red Palm Methyl Ester (RPME) through a transesterification reaction [19]. A membrane reactor (MR) made of Al_2O_3 ceramic material can be used to carry out the RPO transesterification reaction (Fig. 4(a)). In MR, the separation of RPME from the reaction feed takes place continuously throughout the transesterification reaction so that the reaction conversion can be increased and optimize the separation of carotenoids from RPO. The experimental results show that the highest reaction conversion was obtained when the MR was operated at a temperature of 60°C and a pressure of 1.5 bar with a reaction conversion of 75.25% and a carotene content in the RPME of the transesterification product of 471 ppm (Fig. 4(b)). The transesterification reaction with similar operating conditions only achieved a conversion of 39% if carried out in a conventional reactor. The RPME of the transesterification product was then processed further in a nanofiltration unit at the optimum nanofiltration pressure (1.5 bar) to separate Fatty Acid Methyl Ester with a carotene rejection value of 96.3% and an average permeate flux of 0.13 kg/m^{2}h.

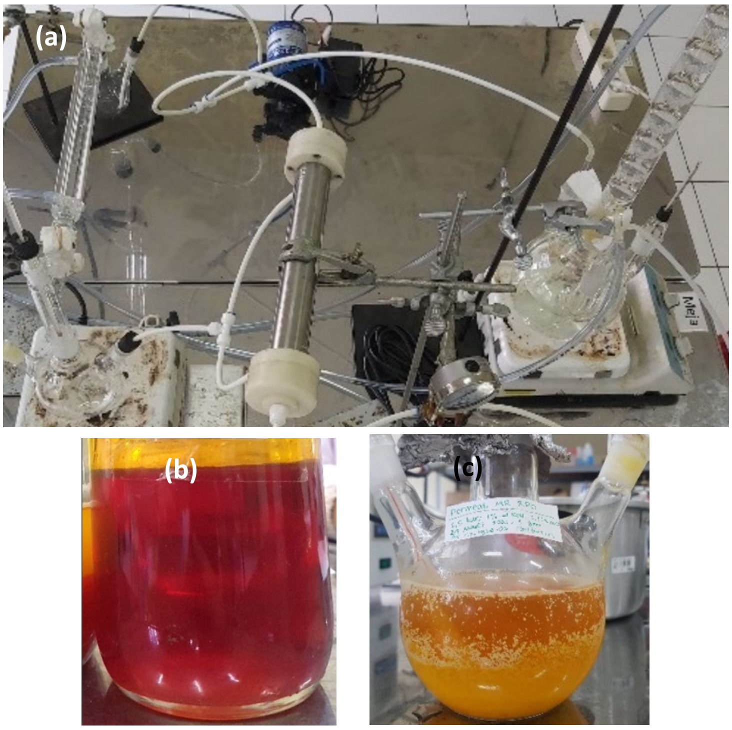

Fig. 4. (a) Experimental setup of MR, (b) product of transesterification in MR, (c) glycerol obtained in the retentate stream of MR.

Conclusion

The integration of membrane technologies in various sectors, such as liquid food concentration, clean water production, and bioactive compound isolation, has demonstrated significant advancements in efficiency, sustainability, and resource utilization. These innovative membrane processes have showcased exceptional capabilities in enhancing traditional practices by offering low-energy consumption and high efficiency. The application of OMD in food processing has resulted in improved concentration processes, with OMD's ability to achieve high concentrations at low operating pressures and temperatures preserving the nutrients, aroma, and flavor in concentrated products. In the context of clean water production, the challenges posed by water scarcity have steered the focus towards desalination processes, with membrane distillation emerging as a promising solution. Membrane distillation (MD) has shown potential in eliminating high osmotic pressure and facilitating mineral recovery in the concentrate, leading to a zero-liquid discharge (ZLD) system. The efficient recovery of fresh water and salts through MD processes highlights the technology's significance in addressing water scarcity issues and promoting sustainable water management practices. Moreover, the utilization of membrane technology for bioactive compound isolation, such as carotenoids in palm oil, exemplifies the versatile applications of membranes in extracting valuable components from natural sources. The integration of membrane reactors in the transesterification of palm oil for carotenoid-rich biodiesel production showcases enhanced reaction conversions and efficient separation strategies, contributing to improved resource utilization and product quality. Linking these advancements in membrane technology to the bio-based economy, it is evident that the integration of membranes in various processes offers substantial benefits in terms of sustainability, resource efficiency, and economic viability. By optimizing membrane processes for liquid food concentration, clean water production, and bioactive compound isolation, industries can enhance value addition, reduce waste generation, and promote circular economy practices. The use of membrane technologies contributes to the sustainable utilization of natural resources, aligning with the principles of the bio-based economy and fostering innovative solutions for a more environmentally friendly and economically viable future. The continuous research and development in membrane technologies further underscore their potential in supporting the bio-based economy through enhanced efficiency, resource conservation, and sustainable practices across different sectors.

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Invited speaker - 2

Dr. Thidarat Nimchua

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National Center for Genetic Engineering and Biotechnology, NSTDA
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Dr. Thidarat Nimchua received her BSc in Genetics from Chulalongkorn University, Thailand, and continued her studies there, receiving a PhD in Biological Science. During her PhD, she conducted research at the Department of Bioprocess Technology, Chemnitz University of Technology (2004), the Department of Microbiology and Bioprocess Technology, University of Leipzig (2006-2007), and Rutgers University, USA (2008), supported by the Royal Golden Jubilee PhD Grant and the Dennis and Linda Fenton Research Fund. Currently, she is a research team leader and senior researcher at the Enzyme Technology Laboratory, Biorefinery and Bioproduct Technology Research Group, National Center for Genetic Engineering and Biotechnology (BIOTEC), NSTDA, Thailand, focusing on the discovery and development of enzymes and bio-products for green industrial processes.

Since joining BIOTEC, Dr. Nimchua has led numerous projects as a principal investigator, securing funding from various agencies and industries. She demonstrates strong leadership and dedication, ensuring project completion. Her work is internationally recognized, with publications in peer-reviewed journals. Among the 200 Ph.D. scientists at BIOTEC, she stands out for her ability to conduct basic science and meet industry needs. With over 15 years of experience, she has led her team to win multiple national and international awards, including the National Innovation Awards 2021 from the National Innovation Agency (Public Organization), the L'Oreal-UNESCO For Women in Science Award 2019 by L'Oreal (Thailand), and the Outstanding Young Technologist Award 2018 from the Foundation for the Promotion of Science and Technology under the patronage of His Majesty the King. She is also an avid inventor, with about 30 intellectual properties (IPs) under her accountability. Recently, four of her enzyme and microbial products were licensed to companies in Thailand, currently undergoing commercialization in the bio-based fuel industry, as well as textile and cotton manufacturing markets.

Enzyme and Microbial Technology for Advancing Bio-Based Industries in the BCG Economy

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Background:

The transition towards bio-based industries within the framework of the Bioeconomy, Circular economy, and green chemistry (BCG) paradigm has gained substantial momentum in recent years. This shift is driven by increasing concerns over environmental sustainability, climate change, and resource depletion associated with traditional chemical manufacturing processes. In response to these challenges, there has been a growing interest in harnessing the potential of enzyme and microbial technologies to facilitate the development of bio-based alternatives.

Hypothesis/Purpose:

Leveraging enzyme and microbial technology will significantly contribute to the advancement of bio-based industries within the BCG economy by enabling efficient conversion of renewable feedstocks into value-added products. This will lead to enhanced process efficiency, reduced environmental footprint, and increased economic viability, facilitating the transition towards a more sustainable and resource-efficient industrial paradigm.

Keywords: BCG model, enzyme, green industrial process, microbial technology

Methods:

Enzymes, as nature's catalysts, offer unparalleled specificity and efficiency in catalyzing biochemical reactions under mild conditions. At BIOTEC, recent advances in enzyme engineering and protein design have been established to customize enzymes for a wide range of applications, including biomass conversion, biofuel production, and the synthesis of high-value biochemicals for use as bioactive ingredients in cosmetic and dietary supplement products. Similarly, microorganisms possess diverse metabolic capabilities that can be harnessed for bioprocessing various feedstocks into valuable products. Therefore, metabolic engineering and synthetic biology approaches have been applied to tailor microbial strains for efficiently utilizing renewable resources and producing target compounds with high yield and purity. Within the BCG economy framework, the integration of enzyme and microbial technologies holds immense promise for advancing the sustainable production of bio-based fuels, biochemicals, and biomaterials for use in several industries, including textile, cosmetics, healthcare products, and bio-energy.

Results:

Currently, enzyme and microbial technologies are successfully employed to optimize microbial enzymes for applications in bio-based industries. These enzymes can function under mild conditions, reducing the need for harsh chemicals and high energy inputs, thereby promoting more sustainable industrial processes. Furthermore, these technologies not only support sustainable production methods but also align with global sustainable development goals by reducing waste, lowering greenhouse gas emissions, and promoting the use of renewable resources.

Conclusion:

Enzyme and microbial technology are pivotal for propelling the growth of bio-based industries within the BCG economy. By harnessing these technologies, we can effectively convert renewable feedstocks into valuable products, thereby reducing reliance on finite fossil resources and mitigating environmental impacts. Furthermore, the circularity inherent in bio-based production systems enables efficient resource utilization and minimizes environmental footprint. Embracing enzyme and microbial technology is essential for achieving a sustainable and resource-efficient industrial paradigm within the BCG economy.

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PANEL Discussion

Moderator:

Assoc. Prof. Dr. Suneerat Fukuda

Head of Advanced Fuel Processing Laboratory
The Joint Graduate School of Energy and Environment (JGSEE)
King Mongkut's University of Technology Thonburi.

Assoc. Prof. Dr. Suneerat Fukuda is the Head of Advanced Fuel Processing Laboratory at the Joint Graduate School of Energy and Environment (JGSEE), King Mongkut's University of Technology Thonburi. She received the MSc and PhD in Chemical Engineering from Imperial College London, UK, and BSc in Chemical Technology from Chulalongkorn University, Thailand. Since joining JGSEE in 2004, Dr. Fukuda has been working extensively in the field of energy technology and management. Her major expertise is solid fuel utilization for clean energy production, especially biomass. Dr. Fukuda has led a number of research projects on biomass/waste supported by government agencies and industries and has published a number of papers in peer-reviewed journals as well as book chapters. She has also been involved in a number of projects supported by international organizations as well as projects at regional level. Dr. Fukuda served as the Director of JGSEE during 2017-2020. Currently, she is also leading the working group of "KMUTT's Race to Carbon Neutrality by 2040".

Sumon Sumetchoengprachya

Director of Low Carbon Policy and Technical Support Office
Thailand Greenhouse Gas Management Organization (TGO)

Miss Sumon Sumetchoengprachya serves as the Director of the Low Carbon Policy and Technical Support Office under the Thailand Greenhouse Gas Management Organization (Public Organization) or TGO. Her responsibilities include developing methodologies and tracking the impact of mitigation policies in Thailand, and providing valuable recommendations/suggestions for government agencies on mitigation strategies/policies.

Miss Sumetchoengprachya has held various key positions within the TGO for a span of nine years. Her roles encompassed developing TGO strategies and action plans, fostering the domestic carbon market, advocating the Carbon Labelling Scheme among public and private sectors, and representing the organization as a negotiator for Article 6 of the Paris Agreement at the UNFCCC Conference of the Parties.

Miss Sumetchoengprachya worked with the Thailand Environment Institute (TEI), an environmental non-governmental organization, as a senior research fellow on environmental and sustainable development research studies before joining TGO.

Miss Sumetchoengprachya's academic background is reflected in her Master's degree in Natural Resources and Environmental Economics from the Faculty of Economics, Chulalongkorn University, Thailand. This educational foundation further enhances her qualifications and expertise in the field of environmental policy and sustainable development.

Nuchanart Siringuan

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Working Experiences

- PTT Innovation Institute 2011–Present
- PTT Public Company Limited, Thailand
- Title: Senior Researcher

Experience/Focus

- CO_2 utilization and management, Natural gas utilizations, Process Simulation/Modelling and Collaborate with process engineers in problem solving
- for natural gas processing, such as energy conservation/natural gas value added/off gas utilizations.

Current Focus:

- Decarbonization Technology, especially CO_2 Utilization Technology (CCU), by converting to value products at the R&D and commercial levels
- Screening and analysis of technology, market and policy trends of the CCU Project, to evaluate project/select opportunity relate d to technical and economic for new investment opportunity aligned with Sustainable and Net Zero Pathway
- In House Technology Development with Partner and Expand Products to Market

Dr. Pramote Puengjinda

Senior Advisor Energy Project,
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Dr. Pramote, a hydrogen technology expert with over 15 years of experience, holds a Ph.D. in Solid-Oxide Fuel Cell (SOFC)Technology. After his doctorate, he spent 8 years researching reversible solid oxide electrolysis (r-SOEC) for green hydrogen production and power generation with high efficiency at Clean Energy Research Center in Japan. He has experience in R&D and business development within the PTT Group and now working as Senior Technical Advisor for GIZ Thailand, in International Hydrogen Ramp-up Programme or H2Uppp, which support early-stage market development of green hydrogen and PtX products in Southeast Asia. His expertise makes him a key figure in advancing clean energy technologies.

Education:

- Ph.D. (Engineering) - Department of Energy and Hydrocarbon Chemistry, Kyoto University, JAPAN [MEXT Scholarship]
- M. Eng - Department of Chemical Engineering, Chulalongkorn University, THAILAND
- Bachelor of Engineering- Department of Chemical Engineering, Chulalongkorn University, THAILAND

Work Experience:

- Senior Advisor: GIZ Thailand (International Hydrogen Ramp up program, H2Uppp)
- Researcher: PTT Innovation Institute, PTT Public Company
- Post doctoral Fellow: Clean Energy Research Center, University of Yamanashi, JAPAN
- Researcher: Department of Energy and Hydrocarbon Chemistry, Kyoto University, JAPAN

Expertise:

- Hydrogen and Fuel cell technologies
- Hydrogen vale chain and PtX technologies
- Electrolysis Technology
- Solid state reactions / Electrochemical reactions
- Nanomaterials synthesis

Assoc. Prof. Dr. Sirichai Koonaphapdeelert

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Assoc. Prof. Dr. Sirichai Koonaphapdeelert has a PhD in chemical engineering from Imperial College London and has been teaching and working in the fields of environmental engineering and renewable energy for more than 14 years. He is now the director of Energy Research and Development Institute-Nakornping which is the strategic objective driving unit (SODU) of Chiang Mai University in the area of carbon neutrality. Also, he has been involved in a number of projects related to clean energy and waste management.

ORAL Presentation

BIOENERGY

EN-R003

Overliming Detoxification of Sugarcane Bagasse Hydrolysate Improves Bioethanol Production by *Pichia stipitis* TISTR5806

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Abstract

Bioethanol is indeed one of most attractive and eco-friendly renewable energy sources particularly using agricultural waste derived from biomass materials such as sugarcane, cassava, rice straw, palm oil, etc. It becomes challenging to convert sugarcane bagasse into ethanol and detoxify inhibitory compounds. This study aimed to enhance ethanol production through the detoxification of sugarcane bagasse hydrolysate. Sugarcane bagasse was used as raw materials and pretreated by acid hydrolysis with 2%v/v of H_2SO_4 at 121ºC for 60 min. However, the liquids from hydrolysis were found to contain monomeric sugars and furans, phenolics, and organic acid compounds. These substances disrupted cell growth and decreased ethanol production. The overliming process used $Ca(OH)_2$ to remove inhibitory compounds from sugarcane bagasse hydrolysate by adjusting pH to 7.0, 10.0, and 12.0 at the reaction temperature of 30ºC for 60 min. It was found that pH 12.0 showed the highest removal of 90.41% and 70.58% of total furans and total phenolic compounds. The bioethanol fermentation of this work by *Pichia stipitis* TISTR5806 was investigated. The highest ethanol and theoretical yields were 0.27 $g_{product}/g_{substrate}$ and 53.43% obtained from detoxification by overliming pH 12.0. The ethanol yield and theoretical yield were derived from the non-detoxified hydrolysate of 0.19 $g_{product}/g_{substrate}$ and 38.93%, respectively. The overliming process of sugarcane bagasse hydrolysate showed efficient removal of inhibitory compounds, especially furan compounds, and high ethanol.

Keywords: Overliming, Detoxification, Sugarcane Bagasse, Bioethanol, *Pichia stipitis* TISTR5806

EN-R004

Production of Biocarbon from Corncob and Bamboo for CO_2 Capture

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Abstract

Global temperatures tend to increase, caused partly by the release of carbon dioxide (CO_2) and partly by the use of fossil fuels. CO_2 capture using high-altitude biocarbon is another way to reduce greenhouse gas emissions. Therefore, this research aims to prepare biocarbon for CO_2 capture within the internal surface area. The material used was biomass consisting of corn cobs and bamboo combined with a pyrolysis process at a temperature of 500°C, with nitrogen gas (N_2) as the carrier gas. We used a scanning electron microscope (SEM) to look at the structure of the porous biocarbon and pore size distribution based on surface area and porosity analysis (BET). The corn cob biocarbon has many tiny pores and a sponge-like structure with a diameter of approximately 2 µm and a pore surface area of 8.20 m^2/g. In comparison, bamboo biocarbon has a tubular structure and a diameter of roughly 1 µm. Biocarbon porousness can develop as a material for CO_2 capture, thereby reducing its release into the atmosphere.

Keywords: Bamboo, Biocarbon, CO_2 capture, Corn cob, Pyrolysis process

EN-R005

Synthesis and Characterization of Sustainable Lithium Grease from Palm Oil Derivatives

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Abstract

This study investigates the utilization of palm fatty acid distillate soap as a bio-thickener in the production of biobased lithium grease. Two lithium soaps as bio-thickener, lithium palm fatty acid distillate, and conventional lithium soap derived from stearic acid, were synthesized via saponification reaction, and characterized for functional groups, phase transition temperatures, and water content. Both lithium soaps exhibited $COO^{-}Li^{+}$ functional groups, demonstrated homogeneity with base oil at the temperature range of 200-220°C, and contained water levels below 200 ppm. Subsequently, biobased lithium greases were formulated using refined palm olein oil as the bio-lubricant base oil and employing the prefabricated soap method. The properties of both biobased lithium greases, including consistency, dropping point, oil separation, and water washout, were evaluated. These results substantiate the implementation capability of synthetic biobased lithium greases. Moreover, this palm-derived biobased lithium grease adds value to palm oil by transforming it into high-value oleochemical products with low toxicity and biodegradability nature.

Keywords: Biobased grease, Bio-lubricant base oil, Bio-thickener, Lithium grease, Palm oil

EN-R006

Technoeconomic Assessment of Torrefied Queen Pineapple Waste as Biofuel for Electricity Generation in Camarines Norte

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Abstract

Rural and missionary areas in the countryside are experiencing an energy crisis due to an insufficient electricity supply from the grid. Biochar production, a promising example of the bioeconomy concept, can be used as an alternative fuel to generate electricity. This study assessed the technical and economic performance of Queen pineapple waste (QPW) biochar as a solid fuel for electricity generation. The torrefaction method was used to produce biochar from QPW with a higher heating value of 22.34 MJ/kg. The technical performance includes the assessment of thermal and electrical parameters. The independent sample t-test result suggests that the performance of QPW biochar as fuel has no significant difference with that of the pili shell (PS) biochar, and thus can be an alternative biofuel source. Also, the economic viability of the biochar enterprise was evaluated. The stochastic analysis shows that among the uncertain parameters, labor cost has the greatest effect on the total biochar enterprise budget. Some profitability indicators such as BCR, NPV, and BEP suggest that biochar production from QPW is feasible and has economic benefits.

Keywords: Biochar, Bioeconomy, Biofuel, Bioenergy, Biomass

ORAL Presentation

BIOECONOMY

EC-R001

Smart Solar Dryers Based on Hybrid Heat Sources and Internet of Things

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Abstract

The solar dryer is an agricultural technology that is widely used in production processing. It can be used to address the problem of contaminants in drying processes. Moreover, it does not have any heating costs. However, it can be efficient and effective for about 5-6 hours per day. Furthermore, it is often inefficient and ineffective during the rainy season because this season generally has little sunlight and high humidity. For this reason, an electrical dryer is proposed. Although this dryer can be more effective and efficient than solar dryers, it generally has the heating costs in drying agricultural products. Clearly, the solar dryer and the electrical dryer still have vulnerabilities that must be addressed. Therefore, a solar dryer is based on hybrid heat sources in conjunction with a smart control system that is constructed by an Internet of Things (IoT) and the environment sensors to be proposed in this work. The heat sources of the proposed dryer are an electrical heater and the heat from sunlight. The proposed smart control system measures and controls the temperature in chambers. Moreover, it is proposed to monitor drying environments such as the humidity, the weight of drying products, and the electrical energy costs. Aside from controlling and monitoring dry environments, the proposed dryer's major aims are to continuously dry agriculture products for more than 6 hours per day. Furthermore, the cost of drying agricultural products is maintained as low as possible. The dimensions of the proposed dryer are 100 x 150 x 210 cm. To evaluate the proposed dryer, extensive experiments are proposed. From the experimental results, they show that the proposed dryer is a dryer that is more efficient and effective. Furthermore, it can be applied in agriculture as well.

Keywords: Heater dryers, Hybrid heat sources, Smart control systems, Solar dryers

EC-R003

Thermophilic Xylanase (Xyn11) from Uncultured Microbe and its Functional Characterization

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Abstract

Xylan is a major component of plant hemicellulose found in the abundant renewable biomass in agricultural industries. Enzymatic processes are considered environmentally friendly and play a big part in sustainable movement, especially when compared to chemical processes. Exploring alternative enzymes could enhance the utilization of xylan from agricultural waste. A critical enzyme for breaking down xylan structure is xylanase, the hydrolytic enzyme that hydrolyzes the β-1,4 glycosidic bond of xylan polysaccharide in the plant cell wall. The *xyn11* gene classified as glycoside hydrolase family 11 (GH11) isolated from the uncultured microbial bagasse metagenome was cloned and expressed in *Pichia pastoris* KM71 under the control of AOX1 promoter. Regarding biochemical properties characterization, recombinant Xyn11 exhibited specific activity against beechwood xylan and arabinoxylan with 4,652.71 and 179.12 U mg^{-1} protein, respectively. The highest activity was performed under 100 mM sodium phosphate buffer (pH 6.0) at 80 °C. Furthermore, Xyn11 remained at 44.5% residual activity after being incubated at 50 °C for 15 min. Based on enzyme specificity, Xyn11 had hydrolytic activity against β-1,4 glycosidic linkage of hemicellulose, with no activity on β-1,4 glycosidic linkage on celluloses, including CMC, PASC, and Avicel PH101. These suggested that Xyn11 could potentially be used for hemicellulose saccharification in various biotechnological processes.

Keywords: Expression, Lignocellulose, Metagenome, Thermophilic, Xylanase

EC-R004

Characterization of *Wickerhamomyces edaphicus* a Novel Yeast Strain for Efficient Xylitol Production

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Abstract

Xylan is a polysaccharide made up of xylose linked by β (1, 4) glycosidic linkages. Xylose is a key substrate to produce high-value substances such as xylitol. Xylitol is a sugar alcohol that tastes like sucrose but contains lower calories than normal sugar. Currently, xylitol is produced by a chemical process via hydrogenation, which requires catalysts under conditions with high temperatures and pressures, resulting in a high cost of this process. To solve this point, the bioconversion process using whole-cell biocatalysts is an alternative route. In this study, yeast that could consume xylose as a carbon source were screened. We found that *Wickerhamomyces edaphicus* was a yeast which could assimilate xylose for growth. Then, the ability of xylitol production was determined by cultivation of *W. edaphicus* at various concentrations of xylose in YPX medium, including 40, 80, 120 and 140 g/L. The *W. edaphicus* produced xylitol yield of 0.59 $g_{xylitol}/g_{xylose}$ at 30 °C for 120 h. In addition, yeast genome was investigated to gain a deep understanding of their xylitol production performance. The scope of this research is a key strategy to convert agricultural biomass via green bioprocess technology that could lead to achieve sustainable development goals with a guideline for the development of environment, social, and economic systems in the future by using agricultural waste as a substrate.

Keywords: Bioconversion, Whole-cell biocatalyst, *Wickerhamomyces edaphicus*, Xylitol, Xylose

EC-R005

Development of A Smart Greenhouse for Spur Chili Peppers based on the Internet of Things

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Abstract

The climate change problem is a long-term problem that is about shifting temperatures and weather patterns. It can pose a risk to humans and other life on Earth. The major causes of climate change problems are agricultural activities, burning fossil fuels (e.g., coal, oil, and gas), deforestation, increasing livestock farming, fertilizers containing nitrogen, and fluorinated gases. With agricultural activities, we found that their activities can affect the climate change problem, they can be grouped to be pre-harvest and post-harvest problems. In this work, we only focus on addressing the climate change problem that occurs from agricultural activities as pre-harvest problems. That is, a 3.0 x 5.0 x 2.5 m. smart greenhouse for spur chili peppers is proposed in this work such that it is based on a smart control system that is constructed by the Internet of Things (IoT) in conjunction with the environment sensors. Furthermore, the proposed greenhouse is evaluated by using extensive experiments. From the experimental results, we found that the proposed greenhouse is a greenhouse that is efficient for planting the spur chili pepper. That is, it can control the soil moisture content that is in the range between 60 % and 80%, the ambient temperature and relative humidity are in the range between 25 °C and 35 °C and between 60 %RH and 70 %RH, respectively.

Keywords: Monitoring systems, Smart control systems, Smart greenhouses, Spur chili peppers

POSTER Presentation
BIOENERGY

EN-P001

Improved Gas Production from Biomass in the 3-Stage Gasifier

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Abstract

Renewable energy from biomass has become an indispensable resource for generating electrical energy due to the increasing demand for energy consumption from renewable sources. Together with the growing concerns about energy resilience and the environment, biomass plays a crucial role in reducing the release of carbon dioxide. Gasification technology involves a thermochemical reaction to produce syngas with high efficiency and low emissions that can be used for thermal or in generators. However, the presence of tar in the gas product is a significant issue that can contaminate the product gas and cause clogging in the generator engine. The 3-stage gasification process consists of three separated zones: pyrolysis, oxidation, and reduction. The primary goal of the work is to improve gas fuel quality by using steam and simultaneously reduce tar by using a calcium oxide (CaO) catalyst. The experiment involved three conditions: wood pellets, wood pellets with the addition of steam, and wood pellets with the combination of steam and CaO. The additional steam to wood pellets resulted in the highest cold gas efficiency at 92.48% due to the higher content of CH_4 produced. Moreover, the tar content of the steam with CaO could be reduced to 144.22 mg/Nm^3, which was lower than the wood pellets with steam, owing to the further cracking of tar by CaO.

Keywords: 3-stage gasification, Biomass, Catalytic tar reforming, Steam gasification

EN-P002

Influence of Raw and Torrefied Biomass in 3-Stage Gasification Technology

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Abstract

It was widely recognized that the use of petroleum-based energy sources had environmental impacts and economic consequences for countries that heavily rely on them. Shifting to locally abundant biomass as a renewable energy source with lesser environmental impacts was a viable alternative. The torrefaction process was a way to improve the limitations of biomass by pretreating it as solid fuel. This study aimed to compare the production of synthesis gas from wood pellets and torrefied-wood pellets using 3-stage gasification technology with a 5-8 kilograms per hour feed rate, along with a wet scrubber system for gas product cleaner to product combustible gas containing heating values 4-6 MJ/Nm^3. Results of raw material properties, operating conditions, gas product properties, and yield of product and by-products were compared. After being torrefied, the wood pellets exhibited an obvious reduction in volatile substances, while fixed carbon and ash contents increased significantly. The ultimate analysis of torrefied-wood pellets indicated a decrease in nitrogen and oxygen levels. The properties of torrefied-wood pellets affected their reliable operation. Additionally, torrefied-wood pellets required less air compared to wood pellets, resulting in a higher ER ratio. The yield of syngas and by-products during torrefaction-wood pellets was lower than that of wood pellets. Moreover, regarding low volatile matter resulted in lower tar content. Tar levels in the system led to fewer shutdowns and less fouling during operation. However, the use of torrefied-wood pellets should be considered along with the increased budget required for the torrefaction process.

Keywords: 3-stage gasification, Biomass, Synthesis gas, Torrefied

EN-P003

Performance of Hybrid Solar Energy with an Auxiliary Heating Dryer for Turmeric (*Curcuma longa* L.) Drying

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Abstract

Solar energy was the appropriate technology for drying, and low-cost technology included the high solar radiation in Thailand. However, direct solar energy technology and open sun drying take a long time to dry products. This work aims to develop a hybrid drying with an intelligent device-controlled auxiliary heating system. The solar energy dryer could dry products weighing 20 kg_{fresh} and turmeric (*Curcuma longa* L.) herbs as raw materials. The drying room has a width of 3 m, a length of 2 m, and a height of 2.5 m. The auxiliary heating system uses electric heating of about 2 kW_e combined with solar energy heating. The drying maintained a temperature of 50-55°C by controlling the smart device, and the expected final moisture contents were less than 11.11%db. This temperature drying was shown to have high curcumin content. A comparison was also made between open sun drying and mixed-mode solar drying. It was found that the hybrid solar drying with an auxiliary heating dryer could decrease the moisture content of turmeric from 521.12%db to 8.05%db within 22 h when compared to open sun drying and mixed-mode solar drying, showing a drying time of 32 h at 6.74%db and 30 h at 8.18%db, respectively. The hybrid solar drying with an auxiliary heating dryer decreased drying time and improved product quality.

Keywords: Auxiliary heating, Drying, Hybrid solar drying, Turmeric

EN-P004

Synthesis of Alkyl Branched-Chain Sulfonate Surfactant from Methyl Ester

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Abstract

The methyl ester derived from vegetable oil is an appropriate starting material for synthesizing anionic surfactant. In this work, the methyl ester is converted to alkyl branched-chain sulfonate by sulfonation reaction of double bond with sodium bisulfite. The effect of the molar ratio of sodium bisulfite to methyl ester ($NaHSO_3$/ME) and the reaction time on the conversion and product yield were investigated. The results indicated that the methyl oleate achieved a conversion of 88.90% and the product yield of 83.57% with anionic active content higher than 95%., using a with $NaHSO_3$/ME molar ratio of 4 at 40 °C for 20 h. Under the same conditions, palm methyl ester exhibited a conversion of 50.02% and a product yield of 49.80%. The chemical structure of the products was confirmed by FTIR and ^{13}C NMR. The addition of sodium bisulfite offers a promising alternative approach for the production of branched-chain sulfonate surfactants.

Keywords: Alkyl branched-chain sulfonate, Anionic surfactants, Sodium bisulfite, Sulfonation

POSTER Presentation

BIOECONOMY

EC-P001

Effects of Light and Limited Water Supply on the Development, Photosynthesis, and Antioxidant Capacity of Turmeric (*Curcuma longa* var. *Daeng Siam*) from Thailand

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Abstract

Turmeric (*Curcuma longa* var. *Daeng Siam*) is a well-known medicinal herb in Thailand. It is commonly used as an ingredient in various health products due to the pharmacological effects derived from its secondary metabolites. Light and water are important factors for the biosynthesis of secondary metabolites and must be optimized to support turmeric cultivation indoors to offset the effects of fluctuating climatic conditions. To produce high-quality turmeric material indoors, turmeric plants were grown in the greenhouse under three light-emitting diodes (white light (W), white-to-red-to-blue light ratio of 3:2:1 (WRB), and red-to-blue-to-white (RBW) ratio of 3:2:1) and three drought levels (80%, 70%, and 60% field capacity (FC)) for 5 months. The different light sources and FC levels did not affect the shoot growth; however, they impacted leaf greenness, photosynthesis, rhizome mass, and curcumin accumulation. RBW decreased rhizome mass and showed a low photochemical efficiency of Photosystem II (PSII), low photosynthetic rates, low transpiration rates, and low leaf greenness. Conversely, WRB, W, and 70% FC stimulated the fresh and dried weights of the turmeric rhizome and curcumin accumulation. Nevertheless, the WRB treatment enhanced the curcumin content 1.2-fold compared to the 70% FC treatment and had high antioxidant capacity. Therefore, WRB light should be used in a controlled system for indoor turmeric cultivation.

Keywords: Curcumin, Light-emitting diode, Medicinal plant, Photosynthesis, Secondary metabolites

EC-P002

Unlocking Value-Added Biomolecules and Prebiotic Potential in Defatted Rice Bran through Deep Eutectic Solvent Extraction

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Abstract

This study investigates the phenolic acids and other biomolecules (such as phytic acid, reducing sugar, and protein) present in the extract of defatted rice bran (DFRB), as well as its primary prebiotic properties. The DFRB was extracted using a sodium propionate/glycerol (Na:Gly deep eutectic solvent (DES) at a ratio of 1:8 (w/v) at 70°C for 5 h. The results revealed that Na:Gly DES yielded soluble-bound glycosylated phenolics (47% w/w) and soluble-bound esterified phenolic acids (45% w/w), with a minor presence of free phenolic acids (8% w/w). Moreover, value-added biomolecules, including protein, reducing sugar, and phytic acid, were detected in the DFRB extract at concentrations of approximately 7.08, 4.26, and 1.14 mg/g, respectively. Additionally, a correlation between antioxidant activities and phenolic content was observed. The study also examined the main prebiotic capabilities of DFRB extract, which led to enhanced growth of *Lactobacillus plantarum* ATCC14917. Conversely, the observed growth of *Escherichia coli* ATCC 25922 is restricted, reaching statistical significance. Furthermore, the DFRB extract demonstrated the ability to inhibit *Staphylococcus aureus* ATCC 25923, as evaluated by the agar well diffusion method. In conclusion, Na:Gly DES effectively extracts bioactive compounds from DFRB, demonstrating promising prebiotic potential. These findings underscore the potential of novel green solvents for extracting valuable compounds from agricultural sources, offering opportunities for sustainable utilization and value addition across various industries.

Keywords: Bioactive compounds, Deep eutectic solvent, Defatted rice bran, Phenolic compounds, Prebiotic

EC-P003

Enhancing Skin Care Efficacy: Innovating Rock Salt Scrub Infused with Thai Herbals for Optimal Benefits

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Abstract

Rock salt, sourced from the ancient geological formations in Pandung Subdistrict, Khamthaleso District, Nakhon Ratchasima Province, stands as a geological relic, crystallized approximately 90 million years ago from the primordial waters of the Indochina Sea. This raw material undergoes a process of boiling and sun-drying to yield a mineral-rich substance. Devoid of iodine, its culinary applications are restricted, thereby instigating research into alternative avenues of utilization. In this research, local medicinal plants, turmeric rhizome and khlu leaves have been incorporated as additives to enhance the efficacy in the formulation of a salt scrub product. The sun-dried turmeric rhizome and khlu leaves, along with rock salt, were ground into fine powders to ensure a texture conducive to gentle exfoliation. Surfactants and skin conditioning agents were added to enhance the product's overall sensory appearance and efficacy. Through comprehensive evaluation encompassing physical, chemical, biological, and stability assessments, the resultant product demonstrates promising attributes. The formulation exhibits a pleasing light greenish-yellow coloration and a soft, fine texture, while maintaining a pH of 5.87 ± 0.02 and no detectable microbial contamination was observed following rigorous testing protocols. Beyond its technical merits, this endeavor extends its impact on the socio-economic landscape, by empowering local communities with knowledge transfer initiatives aimed at providing them with the necessary skills for production. Through fostering economic diversification and supplemental income generation, this initiative contributes to sustainable development goals while harnessing the inherent potential of regional resources. Essentially, this research underscores the convergence of geological heritage and botanical wisdom, culminating in a tangible manifestation of innovation with implications spanning scientific, economic, and societal domains.

Keywords: Khlu leaves, Rock salt, Salt scrub, Turmeric rhizome

EC-P004

Evolutionary Analysis of α-Glucosidase from *Priestia koreensis* HL12: A Multitask Enzyme in Carbohydrate Utilization

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Abstract

Microbial resources in Thailand are a treasure-trove of enzyme diversity used for bioindustry and bioeconomy development. Effective secreted starch degrading enzymes of *Priestia koreensis* HL12 from proteomic analysis indicated PK3177 protein up-expression level under defined condition. To in-depth characterization and investigation of its properties, the *pk3177* gene was analyzed through computational analysis and heterologously expressed in *Escherichia coli* BL21(DE3). Based on evolutionary analysis, PK3177 was identified as α-glucosidase (EC 3.2.1.20) and classified into glycosyl hydrolases family 13 (GH13), subfamily 31 (GH13_31). The overall domain arrangement of PK3177 consists of catalytic domain A found in sucrose isomerases or oligo-1,6-glucosidase with three putative catalytic residues D199, E256, and D327, a loop-rich domain B, and domain C. Compared to the most similar character α-glucosidase (PDB: 5ZCB), PK3711 showed 75.99% identity. Regarding substrate specificity, α-glucosidase presents distinct substrate specificity that can be classified into three groups: group I, which is heterogeneous substrates or homogeneous substrates preference, while groups II and III are homogeneous substrates preference. Interestingly, preliminary results demonstrated that PK3177 acted on both homogenous substrate (α-1,4 glycosidic linkage; starch-types polysaccharides) and heterogenous substrate (α-1, β-2-glycosidic linkages; sucrose). These indicated that PK3177 represents a promising novel multitask enzyme on carbohydrate utilization in food and feed that could be used in various biotechnological applications to promote bioeconomy development.

Keywords: α-glucosidase, Carbohydrate utilizing enzyme, *Priestia koreensis*

EC-P006

Effects of Storage Conditions on the Chemical Compounds and Stability of Dendrobium Extract

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Abstract

This study aimed to assess the stability of the physical properties, chemical constituents (scoparone, dendrophenol, gigantol, caffeic acid, and p-coumaric acid), and bioactivities of dendrobium extract under different storage conditions of 4, 35, and 45°C at 75% RH for a duration of 120 days. The *Dendrobium crumenatum* was extracted under the optimal condition, yielding the dendrobium extract powder. One gram of the extract was placed in aluminum foil-laminated polyethylene bags, closed, and stored under three different stress conditions. High-performance liquid chromatography (HPLC) was employed to monitor the concentration of five marker compounds. The color variation of the stored samples was evaluated using a color spectrophotometer. Antioxidation activity, alpha-glucosidase, and alpha-amylase inhibitory activities were assessed using colorimetric methods at 0, 30, 60, 90, and 120 days of storage. The results revealed that the color of the extract changed with a decrease in the L* value when the temperature and time increased. Moreover, the results demonstrated that temperature significantly influenced the main chemical compositions and their corresponding antioxidant, alpha-glucosidase, and alpha-amylase inhibitory activities over time. Retention rates exceeding 80% were observed for dendrophenol and gigantol, when stored at 4°C for 120 days. Storage temperatures at 4°C or lower than 4°C were identified as appropriate temperature for maintaining the chemical composition and bioactivity of dendrobium extract.

Keywords: Bioactivities, Chemical composition, Dendrobium extract, HPLC, Stability

EC-P008

Phytochemical Compounds and Biological Activities of Different Parts of *Dendrobium crystallinum* Rchb. f.

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Abstract

Dendrobium crystallinum Rchb. f., belonging to the family Orchidaceae, is an epiphytic orchid species. This research aimed to determine the phytochemical compounds, antioxidant, α-glucosidase inhibitory, and anti-inflammatory activities of different parts of *D. crystallinum* Rchb. f. (flower, leaf, and stem). The dried samples of flower, leaf, and stem from *D. crystallinum* Rchb. f., were extracted with 80% (v/v) methanol using the Soxhlet extraction method. The results showed that the different parts of the orchid played an important role in the extraction yield, phytochemical compounds, and biological activities. The extraction yield of the flower extract was higher than that of leaf and stem extracts, with percentage yields of 45.11±1.02%, 22.27±1.87%, and 17.24±1.55%, respectively. Similarly, the flower extract had the highest total phenolic and flavonoid contents (153.21±2.62 mg GAE/g sample and 73.41±1.36 mg CE/g sample, respectively). The extracts from the stem exhibited the highest antioxidant activity by DPPH assay, with IC_{50} values of 0.41±0.00 mg/ml, while the flower extract showed the highest FRAP value of 1,820.15±77.04 μmol of Fe (II)/g sample. In addition, the flower extract exhibited the highest α-glucosidase inhibitory activity, with IC_{50} values of 10.67±0.57 mg/ml, which was more effective than the positive control (acarbose). The anti-inflammatory activity, assessed using the protein denaturation assay, showed that the leaf extract (17.54±4.78%) demonstrated higher anti-inflammatory effects compared to the stem and flower extracts (11.71±3.08% and 11.57±1.75%, respectively). These results indicated that the flower extract is rich in phytochemical compounds and possesses high antioxidant and antidiabetic properties, while the leaf extract exhibited significant anti-inflammatory effects.

Keywords: Antioxidant activity, Anti-inflammatory, *Dendrobium crystallinum* Rchb. f., Phytochemical, α-Glucosidase inhibition activity

EC-P009

Improving the Flame Retardancy of Corn Stalk Fiber Composite Reinforced with Recycled Polyethylene Terephthalate (PET) Fiber

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Abstract

The growing focus on sustainability necessitates the exploration of natural fibers as replacements for synthetic materials. However, natural fibers are inherently flammable. This study investigated the flame-retardant performance of corn stalk fiber (CF) treated with three flame retardants: borax, magnesium hydroxide (MH), and disodium hydrogen phosphate (DHP) at concentrations of 3% and 6% w/v on corn stalk fibers. CF were immersed in these flame retardants for 5 hours at room temperature. After that, treated corn stalk fibers were cured and dried at 100 °C in a hot air-oven for 5 hours. In order to evaluate flame retardancy testing following ISO 11925 standard, the treated CF was blended with recycled polyethylene terephthalate (*r*PET) with binding of low melt polyethylene terephthalate (LPET) at a ratio of CF:*r*PET:LPET at 86:4:10 in a carding machine to form nonwoven at basis weight of 900 g/m^2. These composites (called CCPF) were pressed at 150 °C for 5 min with a mold compression before flame retardancy testing. Vertical burning times of 3% and 6% MH treated CCPF was 258.5 and 626 seconds, respectively. The CCPF composites treated with 6% borax, 3% borax, and 6% DHP exhibited the shortest vertical burning times (76.50, 106.0, and 122.0 seconds, respectively) Similarly, horizontal burning times were shortest for composites treated with 6% borax (53.50 seconds), 6% DHP (64.0 seconds), 3% borax (136.0 seconds). Among treated CCPF composites, 3% MH treated CCPF exhibited the longest horizontal burning times (293.5 seconds). While the 6% borax treatment offered the highest self-extinguishing ability (about 8.5 minutes shorter burning time as compared with untreated fiber), it resulted in brittle and easily breakable fibers. Conversely, 6% DHP treatment effectively enhanced flame retardancy without compromising fiber integrity. These results suggested that DHP holds significant promise for improving the flame-retardant properties of CCPF composites.

Keywords: Composite fiber, Corn stalk fiber, Flame retardants, Natural fiber, Recycled polyethylene terephthalate

EC-P011

Optimization of Bioactive Compounds Extracted from *Cymbopogon citratus*: A Response Surface Methodology Approach

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Abstract

Cymbopogon citratus is a type of herbal plant known for its sustainable profile, harboring valuable bioactive compounds such asA phenolics. that exhibit antioxidant properties. Therefore, the objective of this research is to study the optimum conditions for extracting bioactive compounds from *Cymbopogon citratus* using the response surface methodology. To determine the optimum conditions using a central composite experimental design, two factors were considered: the ratio of *C. citratus* powder to the ethanol amount (1:20-30 g/ml) and the required extraction time (30-90 min). The total number of experiments conducted was 11. The optimum extraction conditions were achieved with a ratio of *C. citratus* to ethanol of 1:25 g/ml and an extraction time of 60 min. The amount of phenolic compounds obtained was 334.31 mg gallic acid equivalent (GAE)/100 g extract, with a decision coefficient (R^2) of the mathematical model being equal to 0.9522. The value obtained from this experiment closely approximates the predicted value of 336.82 mg GAE/100 g extract.

Keywords: Bioactive Compounds, *Cymbopogon citratus*, Extraction, Phenolic Compounds, Response Surface Methodology

EC-P012

Green Extraction for Enhancing Yield of Bioactive Compounds from Morning Glory

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Abstract

Morning glory (*Ipomoea aquatica*) is a sustainable source of phytochemicals, primarily comprising vitamins, minerals, proteins, glycosides, carotene, flavonoids, phenolics, and polyphenols. This study involved analyzing bioactive compounds from various parts of the morning glory plant, including its leaves and stems. Various factors were investigated, including the morning glory to 70% ethanol ratio (1:10, 1:20, 1:30, 1:40, 1:50, and 1:60 w/v), and the duration of extraction time (2, 4, 6, and 8 h), to assess their influence on phenolic and flavonoid contents. The optimal leaf extraction ratio was determined to be 1:50 for 4 h, resulting in the highest phenolic content of 21.80±0.64 mg GAE/g and the highest flavonoid content of 10.50±0.34 mg CE/g. Under optimal conditions for stem extraction (ratio of 1:30 for 8 h), the phenolic and flavonoid contents obtained were 5.08±0.06 mg GAE/g and 1.35±0.04 mg CE/g, respectively. A comparison between the leaf and stem parts revealed that the leaves contain approximately 4 times more phenolic compounds than the stems, emphasizing the antioxidant potential of morning glory.

Keywords: Antioxidation, Extraction, Flavonoid, Morning glory, Phenolics

EC-P016

Exploring Potent Thermophilic Lignocellulose-Degrading Bacteria in Tropical Biomass and Soils for Biorefinery Application

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Abstract

Lignocellulosic biomass constitutes a significant byproduct in agriculture industries post-harvest or production, particularly in countries like Thailand, renowned for their agro-industrial prowess and global agricultural product exports. This abundance of biomass generates substantial waste, posing environmental concerns. Consequently, the primary objective of biomass utilization is to enhance its value while mitigating environmental impact, striving for zero waste utilization of every biomass component. Moreover, industrial processes predominantly operate at elevated temperatures, driving demand for thermostable enzymes. This study sought to identify thermophilic lignocellulose-degrading bacteria exhibiting robust degradation capabilities. Isolates were sourced from tropical decayed biomass and soils, then directly inoculated into a Czapek medium with a pH of 7.0 containing 2% (w/v) cellulose as the carbon source under aerobic conditions. After 7 days of incubation at 50°C, 55°C, and 60°C, isolates S3-3, HLBS1-2, and S6-2 demonstrated cellulose degradation rates of 76.16%, 57.71%, and 52.04%, respectively. Among them, the crude enzyme profile of S3-3 revealed 26 visual protein bands (20-198 kDa) on sodium dodecyl sulfate-polyacrylamide gel electrophoresis (SDS-PAGE) post-CBB staining. Zymogram analysis identified eight cellulases, six xylanases, and one mannanase produced by isolate S3-3. Notably, S3-3 exhibited high xylanase activity (519.20 $U.g^{-1}$ protein) and cellulase activity (113.07 $U.g^{-1}$protein), indicating its potential for efficient lignocellulosic biomass degradation at elevated temperatures and production of industrially relevant enzymes.

Keywords: Cellulase, Lignocellulosic biomass, Lignocellulose-degrading bacteria, Mannanase, Thermophilic bacteria, Xylanase

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