

**TIChE**  
**2024**



**33<sup>rd</sup> Thai Institute of Chemical Engineering and  
Applied Chemistry International Conference (TIChE2024)**

**BOOK OF ABSTRACTS**

**Smart Solution to Environmental Sustainability for Better World**

**March 7-8, 2024**

**TIChE2024, Phra Nakhon Si Ayutthaya, Thailand**





The 33<sup>rd</sup> Thai Institute of Chemical Engineering and Applied Chemistry  
International Conference (TIChE2024)

## BOOK OF ABSTRACTS

Smart Solution to Environmental Sustainability for Better World

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## **DISCLAIMER**

The abstracts in this book represent the research presented at **the 33<sup>rd</sup> Thai Institute of Chemical Engineering and Applied Chemistry International Conference (TIChE2024)**. They convey the opinions of the authors and are published in their revised form as submitted. The committee does not guarantee the accuracy, completeness, or usefulness of the information provided. Unauthorized use may infringe on privately owned patents or publication rights. For permission to reprint or use information from these manuscripts, please contact the individual author(s).

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## Message from President of TIChE

Dear Esteemed Colleagues, Distinguished Guests and Delegates of the 33<sup>rd</sup> TIChE conference

On behalf of The Thai Institute of Chemical Engineering and Applied Chemistry, I extend our heartfelt gratitude to each of you for your invaluable contributions to the success of the 33<sup>rd</sup> Annual TIChE Conference, themed "Smart Solutions to Environmental Sustainability for a Better World."

As we gather for the 33<sup>rd</sup> Annual TIChE Conference, I am also delighted to announce two significant programs that will undoubtedly enrich our event and highlight the exceptional talent within our community.

Firstly, it is with great pleasure that we will unveil the winners of the 2023-2024 National Design Project Competition. This prestigious competition serves as a platform for the senior chemical engineering students from around the nation to apply their knowledge to the real industrial design problem. The dedication and ingenuity demonstrated by participants are truly commendable, and we eagerly anticipate celebrating their achievements. This year, the competition is supported by SCG Chemicals Plc. and PTT Plc.

In addition, we are thrilled to recognize the outstanding projects submitted to the TIChE Senior Project Contest. This contest provides a platform for senior students to showcase their remarkable research and project work, reflecting their commitment to academic excellence and practical innovation. We commend the participants for their hard work, creativity, and dedication to advancing the field of chemical engineering and applied chemistry.

As we applaud the winners of these esteemed competitions, let us also extend our appreciation to all participants for their contributions and dedication to excellence. Your passion and commitment inspire us all to push the boundaries of knowledge and innovation in pursuit of a better world.

And of course, our sincere appreciation goes to the Department of Chemical Engineering, RMUTT, for their unwavering support and collaboration in organizing this esteemed gathering. Their dedication and commitment have been instrumental in bringing together professionals and scholars to exchange ideas and insights on pressing environmental challenges.

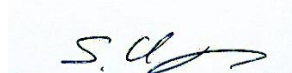
We also extend our deepest appreciation to our esteemed keynotes and plenary speakers whose expertise and passion will illuminate our discussions and inspire innovative solutions. Your invaluable contributions enrich the dialogue and propel us towards actionable outcomes in the realm of environmental sustainability.

To our sponsors, and supporters, we express our gratitude for your generous contributions and unwavering commitment to advancing the frontiers of chemical engineering and applied chemistry. Your support enables us to foster meaningful dialogue and drive impactful change in our quest for a more sustainable world.

As we convene at the enchanting Krungsri River Hotel in Ayutthaya, Thailand, I am filled with optimism and anticipation for the transformative conversations and collaborations that lie ahead. Together, we have the power to shape a brighter, greener future for generations to come.

Once again, thank you for your dedication, enthusiasm, and unwavering commitment to environmental sustainability. Your presence enriches our community and strengthens our collective resolve to build a better world.

With deepest gratitude and warm regards,



Surachate Chalothorn  
President

The Thai Institute of Chemical Engineering and Applied Chemistry



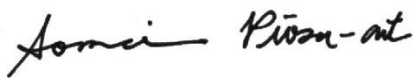
## Message from President of RMUTT

Welcome distinguished guests to the 33<sup>rd</sup> Thai Institution of Chemical Engineering and Applied Chemistry International Conference (TIChE2024) which was held on 7-8<sup>th</sup> March, 2024 at Krungsri River Hotel, Ayutthaya, Thailand. TIChE2024 was hosted by the Department of Chemical and Materials Engineering, Faculty of Engineering, Rajamangala University of Technology Thanyaburi and the Thai Institute of Chemical Engineering and Applied Chemistry in the theme of “Smart Solution to Environmental Sustainability for Better World”.



The objective of TIChE2024 is to facilitate knowledge exchange, research data and experience sharing between researchers, engineers, scientists, students, and interested audiences working in the fields of chemical engineering, applied chemistry, and related areas. The rapid development of advanced technologies in chemical engineering will be a valuable knowledge exchange between our participants as well as academic network.

On behalf of Rajamangala University of Technology Thanyaburi, I would like to express my sincere gratitude to the TIChE2024 conference participants and organizers for their tireless work during the preparation period. I am confident that the conference will serve as a productive platform for researchers and attendees to exchange knowledge, strengthening the network for upcoming national and international research initiatives.

A handwritten signature in black ink that reads "Sommai Pivsa-Art". The signature is written in a cursive, flowing style.

Sommai Pivsa-Art, Ph.D.  
President  
Rajamangala University of Technology Thanyaburi

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Asst.Prof.Dr. Attaso	Khamwichit	Walailak University, Thailand

## TECHNICAL PROGRAM

Thursday: 7 March 2024				
Room	Krungsri Ayutthaya 1			
08.00-09.00	Registration			
09.00-09.20	Opening Ceremony			
09.20-10.00	<p><b>PL-01</b>            “CO<sub>2</sub> as a feedstock could be a game changer”  <b>Ms. Kesinee Kiatpradab</b>            Technology Strategy and New Initiative Manager, SCG Chemicals Public Co., Ltd.</p>			
10.00-10.40	<p><b>PL-02</b>            “Bioproduction of 1,2-propanediol as a renewable feedstock from glucose using engineered lactic acid bacteria”  <b>Prof.Dr. Yuji ASO</b>            Department of Biobased Materials Science, Kyoto Institute of Technology</p>			
10.40-11.00	Break			
11.00-11.40	<p><b>PL-03</b>            “In-melt separation and upcycling of polymer blends”  <b>Prof.Dr. João Maia</b>            Department of Macromolecular Science and Engineering of Case Western Reserve University</p>			
11.40-13.00	Lunch			
Room	Krungsri Ayutthaya 1	Chuenchom 1	Chuenchom 2	Orchid
Session no.	1	2	3	4
Session Chair	Assoc.Prof.Dr. Fatma Yalcinkaya	Assoc.Prof.Dr. Supakij Suttiruengwong	Asst.Prof.Dr. Sakhon Ratchahat	Assoc.Prof.Dr. Pornnapa Kasemsiri
Co-chair	Assoc.Prof.Dr. Weraporn Pivsa-Art	Asst.Prof.Dr. Rinalada Sirisangsawang	Asst.Prof.Dr. Santi Chueto	Asst.Prof.Dr. Lerdluck Kaewvimol
13.00-13.30	<p><b>IN-01</b>  <b>Assoc. Prof. Dr. Fatma Yalcinkaya</b>            Institute of Mechatronics and Computer Engineering Technical University of Liberec (TUL), Liberec</p>	<p><b>IN-02</b>  <b>Assoc. Prof. Dr. Supakij Suttiruengwong</b>            Faculty of engineering and industrial technology, Silpakorn University</p>	<p><b>IN-03</b>  <b>Asst.Prof. Dr. Sakhon Ratchahat</b>            Department of Chemical Engineering, Faculty of Engineering, Mahidol University</p>	<p><b>IN-04</b>  <b>Assoc. Prof. Dr. Pornnapa Kasemsiri</b>            Sustainable Infrastructure Research and Development Center and Department of Chemical Engineering, Faculty of Engineering, Khon Kaen University</p>
13.30-14.45	SP-O-011	ET-O-010	BI-O-030	BA-O-003
	SP-O-017	ET-O-018	BI-O-031	BA-O-025
	SP-O-020	ET-O-056	BI-O-043	BA-O-026
	SP-O-039	ET-O-060	BI-O-051	BA-O-067
	SP-O-055	ET-O-065	BI-O-057	BA-O-082
10.45-16.00	TICHe Senior Project Contest 2024 (Activity area)			
14.45-15.00	Break			
Room	Krungsri Ayutthaya 1	Chuenchom 1	Chuenchom 2	Orchid
Session no.	5	6	7	8
Session Chair	Assoc.Prof.Dr. Fatma Yalcinkaya	Assoc.Prof.Dr. Supakij Suttiruengwong	Assoc.Prof.Dr. Pornnapa Kasemsiri	Assoc. Prof. Dr. Chakkrit Umpuch
Co-chair	Assoc.Prof.Dr. Weraporn Pivsa-Art	Asst.Prof. Yanyong Sookklay	Asst.Prof.Dr. Sasiradee Jantasee	Asst.Prof. Sarawut Jitpinit
15.00-16.00	BI-O-058	IT-O-061	CC-O-012	BA-O-086
	BI-O-066	IT-O-130	CC-O-013	SP-O-064
	BI-O-079	IT-O-134	CC-O-014	SP-O-068
	BI-O-080	IT-O-135	CC-O-015	SP-O-091
16.00-18.00	TICHe Award 2024			
18.00-22.00	Banquet			

Friday: 8 March 2024				
<b>Room</b>	<b>Krungsri Ayutthaya 1</b>			
8.30-9.00	<p align="center"><b>PL-04</b>            “Certification System for Marine Biodegradable Plastics: A Review”  <b>Prof. Dr. In-Joo Chin</b>            President Korean Bioplastic Association, Inha University</p>			
<b>Room</b>	<b>Krungsri Ayutthaya 1</b>	<b>Chuenchom 1</b>	<b>Chuenchom 2</b>	<b>Orchid</b>
<b>Session no.</b>	<b>9</b>	<b>10</b>	<b>11</b>	<b>12</b>
<b>Session Chair</b>	Asst.Prof.Dr. Santi Chuetor	Asst.Prof.Dr. Lerdluck Kaewvimol	Assoc.Prof.Dr. Chatchai Kunyawut	Dr. Natthawan Prasongthum
<b>Co-chair</b>	Asst.Prof.Dr. Nithinart C. Juntadec	Asst.Prof.Dr. Chaiyapop Siraworakun	Asst. Prof. Yanyong Sookklay	Asst.Prof. Sarawut Jitpinit
8.30-9.00		<p align="center"><b>IN-05</b>  <b>Prof. Dr. Yong Ku Kwon</b>            Department of Polymer Science and Engineering, Inha University</p>	<p align="center"><b>IN-06</b>  <b>Assoc. Prof. Dr. Chanatip Samart</b>            Department of Chemistry, Faculty of Science and Technology, Thammasat University</p>	<p align="center"><b>IN-07</b>  <b>Dr. Natthawan Prasongthum</b>            Expert Centre of Innovative Clean Energy and Environment, Thailand Institute of Scientific and Technological Research</p>
9.00-10.30	BA-O-089	BE-O-059	DE-O-006	CC-O-027
	BA-O-093	BE-O-071	DE-O-052	CC-O-040
	BA-O-099	BE-O-108	DE-O-054	CC-O-041
	BA-O-106	BE-O-113	DE-O-112	CC-O-044
	BA-O-107	BE-O-124	DE-O-115	CC-O-049
	BA-O-117	BE-O-127	DE-O-129	CC-O-050
10.30-10.45	Break			
<b>Room</b>	<b>Krungsri Ayutthaya 1</b>	<b>Chuenchom 1</b>	<b>Chuenchom 2</b>	<b>Orchid</b>
<b>Session no.</b>	<b>13</b>	<b>14</b>	<b>15</b>	<b>16</b>
<b>Session Chair</b>	Assoc.Prof.Dr. Chaiwat Prapainainar	Assoc.Prof.Dr. Sutasinee Neramittagapong	Asst.Prof.Dr. Suchata Kirdponpattana	Assoc.Prof.Dr. Lek Wantha
<b>Co-chair</b>	Asst.Prof.Dr. Veerayut Lersbamrungsuk	Asst.Prof.Dr. Chaiyapop Siraworakun	Dr. Wanwitoo Wanmolee	Assoc.Prof.Dr. Arthit Neramittagapong
10.45-12.15	BA-O-136	ET-O-119	ET-O-081	CC-O-084
	PE-O-007	ET-O-121	ET-O-096	BI-O-101
	PE-O-028	ET-O-132	ET-O-111	BI-O-104
	PE-O-035	ET-O-133	ET-O-114	BI-O-128
	PE-O-045	CE-O-037	ET-O-116	BI-O-008
	PE-O-053	CE-O-046	ET-O-118	BI-O-062
12.15-13.10	Lunch			
13.10-14.20	Poster presentation (Activity area)			
13.10-15.30	Head of Department meeting (Chuenchom 1)			
14.20-14.40	Break			
14.40-16.00	TIChE National Chemical Engineer Student Design Project Competition			
16.00	Award announcement/Closing ceremony			

## LIST OF ORAL AND POSTER PRESENTATIONS

PLENARY SPEAKER		
PL-01	<b>CO<sub>2</sub> as a feedstock could be a game changer</b> <i>Ms. Kesinee Kiatpradab</i> <i>Technology Strategy and New Initiative Manager, SCG Chemicals Public Co., Ltd.</i>	1
PL-02	<b>Bioproduction of 1,2-propanediol as a renewable feedstock from glucose using engineered lactic acid bacteria</b> <i>Prof. Dr. Yuji ASO</i> <i>Department of Biobased Materials Science, Kyoto Institute of Technology</i>	2
PL-03	<b>In-melt separation and upcycling of polymer blends</b> <i>Prof. Dr. João Maia</i> <i>Department of Macromolecular Science and Engineering, Case Western Reserve University</i>	
PL-04	<b>Certification System for Marine Biodegradable Plastics: A Review</b> <i>Prof. Dr. In-Joo Chin</i> <i>President Korean Bioplastic Association, Inha University</i>	3

INVITED SPEAKER		
IN-01	<b>Nanofibers in Membrane Microfiltration</b> <i>Assoc. Prof. Dr. Fatma Yalcinkaya</i> <i>Technical University of Liberec</i>	4
IN-02	<b>Phase morphology of non-reactive and reactive PLA/PBAT/PBS blends: how PBS locates and compatibilizes in the blend</b> <i>Assoc. Prof. Dr. Supakij Suttiruengwong</i> <i>Faculty of engineering and industrial technology, Silpakorn University</i>	5
IN-03	<b>Simultaneous production of hydrogen and carbon nanotubes from biogas</b> <i>Asst. Prof. Dr. Sakhon Ratchahat</i> <i>Department of Chemical Engineering, Mahidol University</i>	6
IN-04	<b>Eco-friendly polymers and their smart properties</b> <i>Assoc. Prof. Dr. Pornnapa Kasemsiri</i> <i>Sustainable Infrastructure Research and Development Center and Department of Chemical Engineering, Khon Kaen University</i>	7
IN-05	<b>Mechanical Performance and Biodegradability of Copolymers of L-Lactide and <math>\delta</math>-Valerolactone</b> <i>Prof. Dr. Yong Ku Kwon</i> <i>Department of Polymer Science and Engineering, Inha University</i>	8
IN-06	<b>Lignin valorization via thermochemical reaction approach</b> <i>Assoc. Prof. Dr. Chanatip Samart</i> <i>Department of Chemistry, Thammasat University</i>	9
IN-07	<b>CO<sub>2</sub> Capture Process: Zeolite Catalyst-Aided for Energy-Efficient Regeneration of Amine</b> <i>Dr. Natthawan Prasongthum</i> <i>Expert Centre of Innovative Clean Energy and Environment, Thailand Institute of Scientific and Technological Research (TISTR), Ministry of Higher Education, Science, Research and Innovation</i>	10

## LIST OF ORAL & POSTER PRESENTATIONS

[ BI ] BIOFUEL, BIOENERGY, AND BIOREFINERY		
ORAL PRESENTATIONS		
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## PL-01

### **CO<sub>2</sub> as a Feedstock could be a Game Changer**

**Kesinee Kiatpradab<sup>1</sup>**

<sup>1</sup> Technology Strategy & New Initiative Manager, SCG Chemicals Public Company Limited

#### **Abstract**

Fossil fuel combustion and industrial activities release carbon dioxide (CO<sub>2</sub>), a major contributor to global boiling. Despite the potential of Carbon Capture and Utilization (CCU) to mitigate CO<sub>2</sub> emissions, it has not gained widespread adoption due to economic factors. Conversely, plastic waste and the need for sustainable feedstock for plastic production pose significant environmental challenges. To address these matters, the industrial manufacturing sector is actively seeking sustainable alternatives to conventional synthetic plastics, fossil fuels, and other products. This presentation will show a commercial case of Carbon Capture and Utilization, highlighting the efforts to bridge the gap between academia and industry. By doing so, it aims to provide a smart solution for environmental sustainability and contribute to a better world.

## PL-02

### **Bioproduction of 1,2-propanediol as a renewable feedstock from glucose using engineered lactic acid bacteria**

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#### **Abstract**

Among diols, 1,2-propanediol (1,2-PDO) is one of the most versatile chemicals with two optical isomers, *R*-1,2-PDO and *S*-1,2-PDO. They can be produced from glucose by engineered microbes possessing 1,2-PDO synthetic genes *pct*, *pduP*, and *yahK*, which encode propionate CoA-transferase, aldehyde dehydrogenase, and alcohol dehydrogenase, respectively. 1,2-PDO can be produced via a pathway in which glucose is first converted to D- and L-lactate, followed by the synthesis of *R*- and *S*-1,2-PDO from D- and L-lactate, respectively. The present study demonstrated the production of *R*- and *S*-1,2-PDO using engineered lactic acid bacteria *Lactococcus lactis* NZ9000 and AH1, respectively, through an exogenous 1,2-PDO production pathway. The L- and D-lactic acid-producing *L. lactis* strains NZ9000 and AH1 were transformed with the plasmid harboring *pct*, *pduP*, and *yahK* genes for 1,2-PDO biosynthesis, resulting in *L. lactis* LL1 and LL2, respectively. These engineered *L. lactis* produced *S*- and *R*-1,2-PDO at concentrations of 0.69 g/L and 0.50 g/L with 94.4% *ee* and 78.0% *ee* optical purities, respectively, from 1% glucose after 72 h of cultivation. Both 1% mannitol and 1% gluconate were added instead of glucose to the culture of *L. lactis* LL1 to supply NADH and NADPH to the 1,2-PDO production pathway, resulting in 75% enhancement of *S*-1,2-PDO production. Production of *S*-1,2-PDO from 5% mannitol and 5% gluconate was demonstrated using *L. lactis* LL1 with a pH-stat approach. This resulted in *S*-1,2-PDO production at a concentration of 1.88 g/L after 96 h of cultivation. [Ref. Sato R. *et al.*, *AMB Expr.*, 11, 117 (2021)]

**Keywords:** 1,2-propanediol; *Lactococcus lactis*; fermentation; engineered microbes

## PL-04

# Certification System for Marine Biodegradable Plastics: A Review

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### Abstract

According to the Ellen MacArthur Foundation, the amount of plastic production over the past five decades has surged almost 20 times, and it is expected to double again in the next 20 years. It is reported that each year at least 8 million tonnes of plastics leak into the ocean, and there are over 150 million tonnes of plastics in the ocean today. Also, most of the plastics are produced from fossil feedstocks with a significant carbon impact that becomes even more significant with the projected surge in consumption. Thus, solutions to the environmental pollution problems cause by plastic waste and the global warming due to the increased carbon emissions are urgently needed. Bioplastics are considered to be one of the alternatives; biodegradable and/or biomass-based bioplastics with various properties have been developed and commercially available. In order to fully utilize the characteristics of these bioplastics, it is very important to apply an adequate certification system that accurately reflects the usage environment. In this presentation, we will examine the unique characteristics of poly(hydroxy alkanoate), PHA, a well-known biomass-derived bioplastic that is also biodegradable in the marine environment. The test methods and corresponding certification systems for applying them in marine environments will also be discussed.

**Keywords:** Marine biodegradable plastic; PHA; bioplastics; certification system



## IN-01

### Nanofibers in Membrane Microfiltration

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#### Abstract

Nanofiber materials offer promising filtration capabilities owing to their exceptional attributes, including a highly porous structure, precise pore size control, intricate interconnectivity of pores, and customizable structure. While nanofibers are commonly utilized in air filtration systems, their potential application in water filtration remains underexplored due to inherent mechanical vulnerabilities when submerged and under pressure. In response, this study focuses on developing robust nanofibrous membranes and assessing their performance as microfilters for separating oily wastewater and microplastics. These newly designed membranes demonstrate outstanding permeability, exceeding 2000 L/(m<sup>2</sup>hbar), with maximum rejection rates of over 99.99% for oil and over 90% for microplastics. Additionally, surface modifications have been employed to further enhance membrane permeability and selectivity. In the last phase of this study, nanofibers were utilised to create 3D-printed cartridge filter (3D) specifically tailored to remove particles of micron size. This filter has exceptional water permeability with acceptable particle removal. The overall results suggest that nanofibrous membranes hold significant promise as innovative microfilters, characterized by exceptionally high permeability and exceptional rejection efficiency.

**Keywords:** Nanofiber; Membrane; Microfiltration; Oil rejection; Microplastic removal

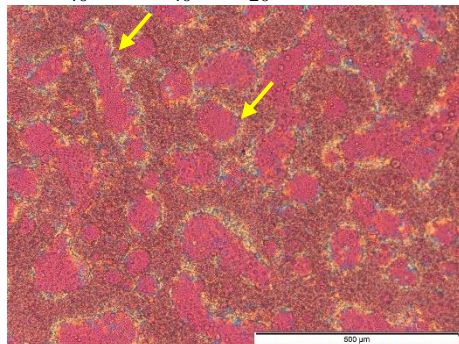
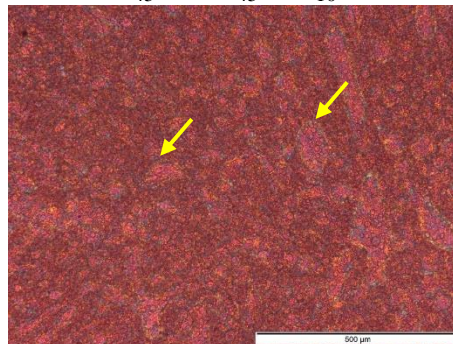
## IN-02

**Phase morphology of non-reactive and reactive PLA/PBAT/PBS blends:  
how PBS locates and compatibilizes in the blend.****S. Suttiruengwong<sup>1,\*</sup>, S. Chuakhao<sup>2</sup>, A. Müller<sup>2</sup>, J. Rodríguez<sup>2</sup>**<sup>1</sup> Sustainable Materials Laboratory, Department of Materials Science and Engineering, Faculty of Engineering and Industrial Technology, Silpakorn University, Nakhon Pathom, Thailand.<sup>2</sup> Department of Polymers and Advanced Materials: Physics, Chemistry and Technology, Faculty of Chemistry, University of the Basque Country UPV/EHU, Paseo Manuel de Lardizabal 3, 20018. Donostia-San Sebastián, Spain.

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**Abstract**

Substituting petroleum-based plastic products with the innovative compostable polymer ones is one of the alternatives toward the circularity of resources and reducing greenhouse emission gases of the products. Compostable plastics such as Poly (lactic acid) (PLA), Poly(butylene succinate) (PBS) and Poly(butylene adipate-co-terephthalate) (PBAT) are among the commercial compostable plastics available in a large scale. Many works have extensively explored the binary blends of those pairs in order to improve the properties and enable the processability. However, PLA/PBS and PLA/PBAT are incompatible. The simplest method to compatibilizing these is the reactive blending technique, where the reactive compounds are used to modify both the required processability and desired product properties. In this work, PLA/PBAT/PBS ternary blends with different ratios of PBS from 0-40% wt at the constant ratio of 1:1 for PLA and PBAT are investigated via melt mixing. The PLOM and DSC are used to elucidate the blend morphology and the thermal properties. Based on the PLOM images, PBS is found around the PLA dispersed phase (interface) while PBAT is a matrix. The increased proportion of PBS in the blend leads to a more homogeneous morphology. DSC revealed that PLA does not crystallize during the cooling stage but cold crystallization during heating can be observed. The crystallinity percentage (%X<sub>c</sub>) of PLA reaches a maximum of approximately 20%. The morphology of reactive PLA/PBS/PBAT blends showed however the finer droplets and evenly distributed throughout the matrix.

PLA<sub>40</sub>PBAT<sub>40</sub>PBS<sub>20</sub>PLA<sub>45</sub>PBAT<sub>45</sub>PBS<sub>10</sub>

## IN-03

### Simultaneous production of hydrogen and carbon nanotubes from biogas

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#### Abstract

Biogas comprising of carbon dioxide (CO<sub>2</sub>) and methane (CH<sub>4</sub>) is considered as the most promising renewable energy sources in Thailand. Recently, utilization of biogas for producing high value-added products is of great attention. In this study, hydrogen (H<sub>2</sub>) and carbon nanotubes (CNTs) are simultaneously produced from biogas via a combined process of methanation (METH) and chemical vapor deposition (CVD). The METH reaction is used for upgrading CO<sub>2</sub> into CH<sub>4</sub> using 10wt%Ni/CeO<sub>2</sub> catalyst at 350°C. Meanwhile, the CVD reaction is used for simultaneous production of CNTs and H<sub>2</sub> over CoMo/MgO catalyst at 900°C. The influences of design process, CoMo loading, and Ce addition were experimentally investigated. The process with steam condenser between METH and CVD shows the best scenario for producing CNTs and H<sub>2</sub>. The removal of steam minimizes gasification of carbon into gaseous products, providing the highest CNTs yield as well as the highest H<sub>2</sub> purity. The 30wt%CoMo on MgO is the optimum loading for production of multi-walled carbon nanotubes (MWCNTs). The diameter of CNTs and its distribution are crucially governed by catalyst diameter which is directly related to the loading content. The property of synthesized MWCNTs is comparable with commercial MWCNTs. The Ce addition to CoMo/MgO catalyst provides CNTs with higher graphitic carbon, due to amorphous carbon reduction, causing the surface area decreased. The optimum Ce addition is at 5wt%, resulting in the highest CNTs yield with relatively high H<sub>2</sub> purity. In conclusion, the study demonstrates the high potential in utilization of biogas for simultaneous production of CNTs and hydrogen.

**Keywords:** Hydrogen; Carbon nanotubes; Biogas; Combined process

## IN-04

### Eco-friendly polymers and their smart properties

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#### Abstract

Both bio-based synthetic polymers and natural polymers have been applied in various applications such as cosmetic, medical, food, and textile industries. Nowadays, these biopolymers have attracted much attention in many daily life applications due their unique properties viz. biodegradability, biocompatibility, renewability and inexpensiveness. Besides these outstanding properties, biopolymers have been developed to achieve new inspiring properties. Smart properties of biopolymers are gaining increasing importance in many fields, for example, self-healing coatings, self-adhesive sensors and shape memory polymers. The smart biopolymers can change their specific properties upon an external stimulus such as temperature, humidity, pH, intensity of light and electrical or magnetic fields. Based on our research, we focused on the development of smart biopolymers by use of agricultural by-products and wastes such as cassava starch waste (CSW), cashew nut shell liquid (CNSL) and extracted plants. The prepared nanocomposite hydrogel from CSW and extracted plants exhibited pH-responsiveness for control drug release. For CNSL, it can be used as a bio-curing agent for epoxy. The epoxy/CNSL composite had self-welding properties and could be used as patch repair for metallic materials. The use of agro-waste products for preparation of smart polymers would be a new alternative which would create value-added to these wastes.

**Keywords:** Biopolymers; Smart properties; Shape memory; Self-healing; Agro-waste products

## IN-05

# Mechanical Performance and Biodegradability of Copolymers of L-Lactide and $\delta$ -Valerolactone

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### Abstract

A series of novel biodegradable homopolymers and copolymers of L-lactide (LA) were polymerized alcohol via various polymerization methods in the presence of catalysts. One of examples were copolymers of LA with  $\delta$ -valerolactone (VL). The chain topology of these copolymers was suggested to be either cyclic or linear depending on the initiator used. The feeding molar ratio of LA : VL was changed to investigate the chain microstructure, thermal properties, as well as degradability of copolymers. <sup>1</sup>H-NMR revealed that incorporating 30, 50, and 70 mol% VL provided blocky, gradient, and random chain copolymers, respectively. Increasing VL content relative to the LA content decreased the  $T_g$ ,  $T_m$ , and crystallinity of the copolymers. All copolymers displayed higher thermal stability than PLA homopolymers due to the presence of the VL comonomer. The cyclic polymers showed higher  $T_g$ , lower  $T_m$ , and lower crystallinity than their linear counterparts. Furthermore, it was found that the degradability of the copolymers can be controlled by adjusting the compositions of VL and LA and their chain architecture.

**Keywords:** L-lactide;  $\delta$ -valerolactone; chain topology; degradability.

## IN-06

### Lignin Valorization via Thermochemical Reaction Approach

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#### Abstract

Lignin generally an underutilized byproduct in industries, is targeted for valorization through thermochemical conversion, aiming to generate valuable phenolic compounds. In this context, the current study focuses on the oxidative conversion of Palm kernel shell biomass which is highly rich in lignin content. A mixture of isopropanol-water (9:1) was used as a solvent, alongside the oxidizing agent was 30% hydrogen peroxide. For catalytic cracking, the metallic and bi-metallic catalysts were synthesized through the wet impregnation method with different loading of Co and Cu metal over zeolite HY support. The experiment was carried out in a high-pressure reactor, with different reaction times (2-4 h) and temperatures (140°C -180°C). Output products were identified by using GCMS and were categorized into phenol, phenol derivatives, phenolic aldehydes, carboxylic acids, and others. Key compound groups include phenol derivatives, phenolic aldehydes, and carboxylic acids. At 180°C for 2h Co/Zeolite HY catalyst yielded 9.81%, Cu/Zeolite HY catalyst yielded 13.53% for phenol derivatives. The optimal lignin-derived compound yield was achieved with 5 wt.% catalyst loading concerning biomass weight, particularly with 10% metal loading of Co and Cu over Zeolite HY support. Both metallic and bi-metallic catalysts yielded carboxylic acids at 5.59% to 11.31%, notably higher than the 1.66% with Zeolite HY alone. For Bi-metallic (Co: Cu=2:1) overall lignin-derived compound yield obtained around 32%. BET, XRD, TEM, NH<sub>3</sub>-TPD, and H<sub>2</sub>-TPR studies were used to further assess the catalyst's functionality. The results of this study show that integrating metals into acidic zeolite support catalysts improves their efficiency in lignin oxidation.

**Keywords:** Lignin, Oxidation, Catalytic, Fractionation, Depolymerization

## IN-07

### CO<sub>2</sub> Capture Process: Zeolite Catalyst-Aided for Energy-Efficient Regeneration of Amine

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#### Abstract

Amine-based CO<sub>2</sub> capture process is a crucial technology for supporting the present net zero policy by capturing CO<sub>2</sub> emissions after combustion process in conventional heat and power generation. Monoethanolamine (MEA) is a common chemical substance used in CO<sub>2</sub> post-combustion capture due to its cheap and high CO<sub>2</sub> absorption rate. However, the interesting challenge of this process is a high energy requirement for CO<sub>2</sub> stripping, for further CO<sub>2</sub> either storage or utilization, typically carried out at elevated temperature (e.g., 120-150 °C). This step constitutes a substantial portion (70-80%) of overall operating cost in CO<sub>2</sub> capture process. Introducing a solid catalyst such as zeolite into amine regeneration step presents a promising approach to address energy requirements [1-3]. Interestingly, it is imperative to develop a cost-effective catalyst to propose its usefulness in large-scale CO<sub>2</sub> capture processes. This work investigated the utilization of an industrial-waste fly ash from power plants for synthesizing zeolite to study its catalytic performance in desorption of CO<sub>2</sub> from amine solution. The experimental results showed that synthesized zeolite exhibited highly effective in amine regeneration promoted desorption performance and reduced relative energy requirement by 54% and 37%, respectively. Catalyst characterization revealed that high performance of produced zeolite resulted from high acidity and large number of Lewis acid sites. The exploration manifested that zeolite derived from waste fly ash was well-suited for deployment in CO<sub>2</sub> stripping offered not only a high potential to improve energy efficiency in CO<sub>2</sub> capture processes but also, a value-added product in term of circular economy aspects.

**Keywords:** CO<sub>2</sub> capture; Amine regeneration; Catalyst; Zeolite; Circular economy

## BI-O-008

### Effect of temperature on the methanol synthesis through alcohol-assisted CO<sub>2</sub> hydrogenation in fixed bed reactor

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#### Abstract

As a fundamental chemical compound, methanol plays a pivotal role in producing various chemicals in numerous industries, including the chemical and synthesis industry, pharmaceuticals, electronics, and coatings. Currently, a significant portion of methanol is derived from natural gas. To address environmental concerns and improve economic efficiency, there is a growing interest in directly synthesizing methanol from carbon dioxide, a process known as CO<sub>2</sub> hydrogenation. CO<sub>2</sub> hydrogenation is an exothermic reaction, which typically operates under high-pressure and high-temperature conditions. The standard synthesis temperature ranges from 250°C to 300°C, resulting in a lower conversion of CO<sub>2</sub> to methanol at equilibrium. High pressures in the 50-100 bar range are also required, making the process energy-intensive. In this study, an alternative approach is explored, known as alcohol-assisted methanol synthesis. This method involves using alcohols as solvents to facilitate the reaction, reducing the required temperature and pressure while improving methanol yield. Methanol synthesis with the assistance of alcohols in a gas phase has been thoroughly investigated in a fixed-bed reactor. The effect of temperature is studied, assessing their impact on both methanol yield and CO<sub>2</sub> conversion. This study has gained valuable insights that can contribute to energy reduction in methanol production via the CO<sub>2</sub> hydrogenation process. This research serves as a guiding pathway for the future development and improvement of this process.

**Keywords:** Methanol; Hydrogenation; Alcohol-assisted;



## BI-O-030

### **Life cycle assessment of bio-hydrogenated diesel from palm fatty acid distillate and refined palm stearin.**

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#### **Abstract**

Energy demand has been growing, especially in the transportation sector, while environmental concerns have also been under focus. Green diesel, a renewable energy, can be an alternative to fossil fuel to tackle both issues. Prior to using green diesel, environmental impact assessment is required to ensure environmental friendliness of its production. This study focuses on the environmental impact of production processes of green diesel alternatively called bio-hydrogenated diesel (BHD) produced from hydro-processing technology by comparing between two feedstocks (palm fatty acid distillate (PFAD) and refined palm stearin (RPS) with those of diesel from fossil fuel. BHD production processes were simulated using ASPEN Plus to analyze material and energy balances with the production rate of 50-ton BHD/day, while reaction information was attained from experiments. The environmental impact analysis was within the Cradle-to-Gate system boundary starting from palm oil plantation, cultivation to the production of BHD. Life cycle assessment (LCA) was carried out using ReCiPe 2016 method with LCSoft where databases were collected from relevant research studies. LCA results in this study focusing on the end point results are typically shown as an impact on human health, ecosystem quality, and resource depletion. In summary, the highest impact among the endpoint indicators of the BHD process comes from the refining and fractionation stages due to the substantial energy requirement in these steps.

**Keywords:** Bio-hydrogenated diesel; Palm oil; Life cycle assessment; Palm fatty acid distillate; Refined palm stearin

## BI-O-031

### Techno-economic Study of Green Diesel Production from Palm Oil By-product using Recycled Solvent

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#### Abstract

Bio-hydrogenated diesel (BHD) or green diesel is a second generation of biofuel, having a straight chain alkane structure with 15 – 18 carbon atoms, which is in the same range as petroleum diesel. However, the production process is still limited because the hydro-processing requires high operating conditions and high energy. This study aims to compare the effects of different starting materials, palm fatty acid distillate (PFAD) and refine palm stearin (RPS), which are the by-products from a palm oil refining process. Impact of using BHD product as recycle stream to lower the operating condition and reduce energy consumption is also focused. The study was divided into four cases: PFAD and RPS as feedstocks with and without recycle stream with the production capacity of 50 tons/day of feed. From lab-scale experimental results, BHD production using solvent can be done under lower operating condition from 50 bar to 17 and 34 bar for PFAD and RPS, respectively. Based on the experimental data, the simulation study was carried out using ASPEN Plus, while BHD product-recycle stream was added as solvent in the continuous processes. The results showed that main products from PFAD was pentadecane (C<sub>15</sub>) and heptadecane (C<sub>17</sub>), whereas that of RPS produced primarily pentadecane. It is worth mentioning that, in the case of using a solvent, the main product for both feedstocks is hexadecane (C<sub>16</sub>) as cracking reaction may occur, and the energy consumption is increasing to 63% for heating duty, and 90-120% for cooling duty as increasing flowrate in process.

**Keywords:** Green diesel; Hydro-processing; Solvent; Palm fatty acid distillate; Refine palm stearin.

## BI-O-043

### Utilization of Industrial Waste Cellulose for Solid Fuel Production in Pilot Plant Scale

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#### Abstract

In this work, the production of solid fuel produced from mixing of industrial waste cellulose and coal is investigated. In the laboratory study, lime can be used as a binder between cellulose and coal, however in the pilot scale, the solid fuel is easily broken. This may be due to that the extruder force used in the laboratory equipment is less than that performed in the pilot machine. Therefore, the tapioca starch is introduced to use as the binder in this study. The optimal ratio between cellulose, lime, coal, and tapioca starch is investigated. The size of cellulose and coal are also shown the effect on the solid fuel casting. The physical and thermal properties of all materials and chemical used in this study are analyzed, for example, moisture content, ash, volatile matter, fixed carbon and heating value. The heating value of mixture materials were then determined. The heating value of coal is the greatest one, the heating value of tapioca starch is less than that of cellulose. There is no heating value of lime evaluated. Solid fuel compositions (cellulose, lime, coal, with and without starch) are mixed in different ratios, and then it is extruded by using the charcoal compressor. The solid fuel briquettes without starch are easily broken, but the briquettes with starch are hard enough to maintain its form. We also vary the size of coal and cellulose to see how they can affect the formation of solid fuel briquettes. When comparing solid briquettes with different compositions in the combustion test, it is found that solid fuels are not easy to ignite and the heating value of the mixture and the original coal are not much different. The smaller size of cellulose and coal can help the shorter briquette formation time.

**Keywords:** Cellulose; Coal; Heating Value; Solid Fuel; Solid Waste

## BI-O-051

# High-Temperature Catalytic Oxidative Cleavage of Oleic Acid to Produce Azelaic and Pelargonic Acids

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### Abstract

Azelaic acid (AA) and pelargonic acid (PA) are medium-chain fatty acids that are used as building blocks in organic synthesis in various industries. Simultaneous production of AA and PA from oleic acid, which is abundantly available in nature, is possible via oxidative cleavage at the carbon-carbon double bond. However, it is still a great challenge to achieve high conversion and yields of AA and PA from this reaction. In this work, oxidative cleavage of oleic acid by hydrogen peroxide was investigated at a temperature higher than that previously reported, in the range of 80-160°C, under autogenous pressure. Tungsten (VI) oxide was used as a catalyst. Tertiary butanol was used as a co-solvent. The results showed that a complete conversion of oleic acid could be achieved. The analysis by gas chromatography with tandem mass spectroscopy (GC-MS) revealed various products, including various medium-chain fatty acids and 9, 10-dihydroxy octadecanoic acid. The yields of both AA and PA were increased as the temperature was increased.

**Keywords:** Oxidative cleavage; Oleic acid; Medium-chain fatty acids; Tungsten (VI) oxide

## BI-O-057

### UV- Enhanced Catalytic Oxidative Cleavage of Oleic Acid.

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#### Abstract

Oleic acid, a prominent fatty acid, serves as a vital precursor in various industrial processes. This study explores its conversion potential into valuable compounds, such as propionic acid, butyric acid, caproic acid, pelargonic acid, and azelaic acid. Traditionally, these acids were synthesized from oleic acid using ozone-based ozonolysis, a method fraught with safety hazards and high energy demands. In contrast, this research investigates an alternative approach employing hydrogen peroxide as an oxidizing agent, coupled with UV radiation and a tungsten oxide catalyst. The study delineates the impact of UV radiation on the oxidative cleavage of oleic acid, demonstrating enhanced conversion under UV radiation. Experimental results indicate that UV-assisted oxidative cleavage achieves maximum conversion efficiency at 80°C, outperforming non-UV conditions. Notably, UV radiation enables efficient conversion even at lower temperatures, significantly reducing energy consumption. Gas chromatography-mass spectrometry analysis (GC-MS) corroborates this analysis, showcasing the effectiveness of UV-enhanced catalytic oxidative cleavage in oleic acid transformation. Overall, this study highlights the efficacy of UV-C radiation in facilitating the oxidative cleavage of oleic acid, offering a promising avenue for environmentally sustainable and energy-efficient industrial processes.

**Keywords:** Oxidative cleavage; Oleic acid; Tungsten-based catalysts; Radical reaction pathway; UV-C.

## BI-O-058

### Enhancement of Oleic Acid Content in Palm Oil via Chemical Interesterification for Application as Bio-Transformer Oil

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#### Abstract

Mineral oil, a product obtained from petroleum refinery, has excellent electrical insulation properties, efficient heat dissipation, and stability at high temperatures. However, it is non-biodegradable and toxic to the environment. Thus, palm oil is expected to replace the use of mineral oil as a liquid translator for transformers to reduce fossil fuel consumption. Although palm oil has several advantages involving environmental issue, the high viscosity and pour point of palm oil due to the equal quantity of saturated and unsaturated fatty acids are required to be improved. Palmitic acid (C16:0) is the most saturated fraction, while oleic acid (C18:1) is the most unsaturated component in palm oil. In the case that triacylglycerol in palm oil totally consisting of palmitic acid, the carbon number of this structure is C52. If all three acyl chains are oleic acid, the carbon number is C54. Since the unsaturated portion promotes the cold flow properties of the oils, the enhancement of the unsaturated part in the palm oil structure via chemical interesterification (CIE) involving a rearrangement or exchange of the fatty acids on the glycerol backbone of the triacylglycerol molecule was the aim of this research. Herein, the refined, bleached, and deodourised palm oil (RBDPO) blended with methyl oleate (MO, C18:1) at a ratio of 50/50 was fed into the reactor and the reaction was conducted in the presence of sodium methoxide (NaOCH<sub>3</sub>, 0.2-0.5 wt% based on the reactant mixture content) at 70-110 °C for 0.5-1.5 h. The results showed that the product obtained from CIE using 0.5 wt% NaOCH<sub>3</sub> content at 110 °C had the higher content of triacylglycerol in carbon number of C54 from 5.2% to 10.9%

**Keywords:** Chemical interesterification; Methyl oleate; RBD palm oil.

## BI-O-062

### **Methanol production via CO<sub>2</sub> hydrogenation with 1-propanol assisted in fixed bed reactor**

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#### **Abstract**

Carbon capture, utilization, and storage (CCUS) is developed to reduce anthropogenic CO<sub>2</sub> emissions from industrial processes that have the capability to capture and efficiently utilize the substantial quantities of CO<sub>2</sub> that are released by industrial processes. As a result, it assumes a critical role in furthering the causes of global climate change and decarbonization. Furthermore, the utilization of carbon dioxide conversion to chemicals or CO<sub>2</sub> conversion to higher-valued products, such as methanol, Hydrogenation is a chemical process that often takes place in the presence of a catalyst and involves molecular hydrogen and an element or molecule. The reaction could potentially include hydrogen merely forming an additional double or triple bond between two atoms within the molecule's structure, or it could lead to the dissociation (fragmentation) of the molecule (called hydrogenolysis, or destructive hydrogenation). In this study, the concept of alcohol-assisted methanol synthesis is investigated as an alternate strategy by using primary alcohols, especially 1-propanol, to avoid the product purification problem and also to achieve an acceptable methanol yield and CO<sub>2</sub> conversion, which typically function in high-temperature and high-pressure environments. To enhance methanol yield while decreasing the necessary temperature and pressure, this approach utilizes alcohols as solvents to aid the process. A fixed-bed reactor has been utilized to explore in depth the synthesis of methanol with the aid of alcohols in the gas phase. The effects of temperature, pressure, and composition ratio are studied. This study provides a pathway for the subsequent advancement and refinement of the scale-up approach.

**Keywords:** Methanol; Hydrogenation; Alcohol-assisted;

## BI-O-066

# Efficient Hydrodeoxygenation of Guaiacol to Produce Biochemicals Using Nickel Phyllosilicate Catalysts

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### Abstract

Cyclohexanol serves as a highly valuable raw material for industrial synthesis of caprolactam, which is an important precursor for manufacturing of Nylon 6 fibre. The Nylon 6 market was worth 5.75 billion dollars in 2022 and is expected to grow yearly 3.7% to 7.68 billion dollars by 2029. Currently, the conventional approach for cyclohexanol production involves oxidization of petroleum-derived cyclohexane. Despite its efficacy, this process faces challenges, including a low conversion rate, necessitating the suppression of by-product generation, and a high cost related to waste treatment. Catalytic hydrodeoxygenation of guaiacol derived from lignin has attracted increasing research attention as an innovative approach to production of renewable cyclohexanol. In this work, nickel phyllosilicate (Ni-PS) catalysts were synthesized by deposition-precipitation method in which fumed silica and diatomite were comparatively used as silica sources. The Ni phases containing in the Ni-PS catalysts underwent partial conversion into NiO nanoparticles through reduction under hydrogen pressure, while the remaining portion served as supports. The siliceous supports exhibited a robust interaction with Ni species, preventing the aggregation of NiO particles and minimizing their size. The catalysts showed an enhanced acidity originated from surface defects at interface between Ni-Si bonding and highly dispersed NiO particles. These catalysts demonstrated remarkable performance, achieving >99% conversion in the hydrodeoxygenation of guaiacol and the product selectivity was controlled by catalyst loading, reaction temperature, and reaction time. The innovative preparation method of these catalysts offers valuable insights for designing high-efficiency catalysts for preparing biochemicals from low-cost lignin through hydrodeoxygenation process.

**Keywords:** hydrodeoxygenation, nickel phyllosilicate, guaiacol, cyclohexanol



## BI-O-079

### Preparation and Synthesis of Carboxymethyl Cellulose from Rice Straw

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#### Abstract

Rice straw (RS) is an abundant agricultural byproduct in Thailand; often being disposed through burning caused the PM<sub>2.5</sub> and environmental problems. Utilizing RS (cellulose-rich material) to produce value-added products, such as carboxymethyl cellulose (CMC), serves to increase the value of agricultural wastes and manage it without harming to the environment. This research aims to find optimal conditions of alkaline peroxide pretreatment of RS for producing CMC. RS was firstly treated with different concentrations of hydrogen peroxide including 2.5, 5, and 7.5% (v/v), the solid:liquid ratio was 1:10 and the pH was adjusted to 11.5 using 5M NaOH. The mixture was then incubated at 45 °C for different durations including 8, 16, and 24 hours. The obtained cellulose-rich samples were used to cellulose-based material for CMC synthesis. The physical and chemical characterizations were conducted including FT-IR, and XRD to examine the functional groups and the crystallinity index. Moreover, the degree of substitution, and the whiteness index were also evaluated in order to find the suitable conditions for CMC production from RS.

**Keywords:** Alkaline peroxide pretreatment; carboxymethyl cellulose; cellulose derivative; rice straw

## BI-O-080

### The Role of Nonionic Surfactants in Lubricity of Green Diesel

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#### Abstract

Fossil fuel emissions in transportation and industry drive the search for alternative fuels. Bio-hydrogenated diesel (BHD) is a promising candidate for the transportation sector because it has a chemical composition similar to petroleum diesel while providing cleaner combustion in diesel engines. However, a critical barrier to the practical implementation of BHD is its poor lubricating properties, which do not meet the standards specified in the specifications for appearance and quality of diesel and biodiesel in the national regulations by the Department of Energy Business, Ministry of Energy, Thailand, 2020, which could result in engine wear and tear. This study aims to overcome this challenge by exploring sorbitan esters (Span) as promising additives to improve the lubrication of BHD. Due to its amphipathic molecular structure, Span can be adsorbed onto engine surfaces, resulting in a protective layer of molecules that reduces friction between contacting parts. This study found that the addition of Span groups like Span20, Span80, and Span120 could significantly improve the lubricity of BHD investigated by High Frequency Reciprocating Rig under ISO 12156-1:2018 standard testing procedure, which can reduce the wear scar diameter (WSD) by more than 60% when adding Span without exceeding 5% by volume. Further analysis of disc specimens employing a scanning electron microscope (SEM), Fourier transform infrared (FTIR) microscope, and OLS5100 3D laser microscope confirmed the positive impact on the wear surface both physically and chemically. This study demonstrates the potential of Span as a BHD additive to enhance lubrication and reduce engine wear.

**Keywords:** Bio-Hydrogenated Diesel, Tribology, Surfactant, Lubrication

## BI-O-101

### Rice Bran Wax as a Renewable Resource for Biolubricant Formulation

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#### Abstract

Rice bran wax (RBW) is the major byproduct of rice bran oil production, which can be directly used in several applications such as cosmetics, personal care products, and pharmaceuticals. The wax esters in RBW, containing long-chain fatty acids and fatty alcohols, could be used in biolubricant preparation. In this study, a saponification reaction was initially performed by treating RBW with 30% potassium hydroxide in isopropanol to obtain fatty acid potassium salt. Subsequently, this salt was treated with 30% HCl to obtain fatty acids via a substitution reaction, while fatty alcohols from the initial reaction were discarded. Following this, the obtained crude fatty acids were treated with 5% methanol in the presence of sulfuric acid as a catalyst to produce crude fatty acid methyl esters (FAME). Fourier-transform infrared spectroscopy (FTIR) confirms the presence of fatty acids in the RBW and the crude fatty acids obtained after the saponification and substitution reactions. FTIR was also used to characterize the crude FAMEs. In the future, a transesterification process could be then performed using the crude FAME and trimethylolpropane (TMP) to obtain TMP-esters, which can be utilized as a biolubricant precursor.

**Keywords:** Biolubricant, Fatty acid methyl ester, Rice bran wax, Trimethylolpropane ester, Transesterification

## BI-O-104

### Catalytic Hydrothermolysis of Palm Oil with *in situ* Generated Hydrogen to Produce Jet Fuel-Range Hydrocarbons

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#### Abstract

Fats, oils and greases have gained significant attention as viable feedstock for producing sustainable hydrocarbons within aviation fuel spectrum. Hydrodeoxygenation (HDO) is a thermochemical process used for production of bio-jet fuel derived from triglycerides. There are few drawbacks in the HDO route, such as a high temperature and high hydrogen (H<sub>2</sub>) consumption. Catalytic hydrothermolysis (HTS) is an emerging way for conversion of triglycerides into bio-jet fuel range hydrocarbons. This process has many advantages over HDO, especially the presence of H<sub>2</sub> generated *in situ* from glycerol reforming. In this study, a series of activated carbon-supported nickel (10 wt.%) catalyst (10Ni/AC), prepared via incipient impregnation and physically mixed with alumina (Al<sub>2</sub>O<sub>3</sub>), was used for hydrocarbon production from palm oil via HTS. A mass ratio of 10Ni/AC:Al<sub>2</sub>O<sub>3</sub> was varied at mass ratios of 1:1 to 1.9:0.1. The temperature-programmed desorption of ammonia indicated that the acid properties of physically mixed catalysts were determined by Al<sub>2</sub>O<sub>3</sub> content. Above 300 °C, the triglycerides conversion was driven to nearly completion, giving fatty acids as primary products, while the selectivity to hydrocarbons increased with the reaction temperature. Under the optimized conditions, for palm oil into the bio-jet fuel range alkanes are 15 wt.% of 10Ni/AC@Al<sub>2</sub>O<sub>3</sub> (19), 400 °C of reaction temperature and 4 hours of reaction time give higher than 71.86% of selectivity of the bio-jet fuel range (C<sub>8</sub>-C<sub>14</sub>) alkanes and 35.5% liquid product yield. This approach is considered more environmentally friendly and yields a broader range of sustainable aviation fuel, containing alkanes, aromatic compounds, and oxygenated chemicals.

**Keywords:** Bio-jet fuel; catalytic hydrothermolysis; heterogeneous catalyst; in-situ hydrogen

## BI-P-075

### Iron-modified ZSM-5 zeolites as solid acid catalysts for glucose conversion into 5-hydroxymethylfurfural (HMF) in biphasic system

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#### Abstract

5-Hydroxymethylfurfural (5-HMF), a versatile compound that can be produced from lignocellulosic biomass via acid-catalyzed processes, has received attention due to its ability to be transformed into various value-added chemicals. Among several types of catalysts, ZSM-5 is one of potential zeolite-based catalysts due to its suitable acidity properties, good thermal stability and high surface area. In the present work, a commercial ZSM-5 ( $\text{SiO}_2/\text{Al}_2\text{O}_3 = 24$ ) was modified through mild dealumination, followed by iron (Fe) impregnation. The obtained zeolites (Fe-DeHZSM5) were used as bifunctional catalysts with Brønsted (B) and Lewis (L) acidity in glucose conversion into HMF. The dealumination using diluted nitric acid resulted in a partial hydrolysis of framework aluminum and alumina debris, improved the amount of Lewis acid sites in the catalysts. The incorporation of Fe species into the dealuminated zeolite induced the formation of isolated  $\text{Fe}^{3+}$  and  $\text{Fe}_2\text{O}_3$ , which improved the Lewis acidity required for catalyzing isomerization of glucose to fructose. In addition, L/B ratio also increase with increasing of iron loading. A high L/B molar ratio of catalyst led to further polymerization to produce humins, which resulted in a decreased HMF yield and selectivity. Thus, an optimal L/B ratio is very important to achieve a high yield of HMF. Under optimal reaction conditions, Fe-DeHZSM5 with 0.5 wt.% Fe loading afforded the HMF yield of 67.5% at 85% glucose conversion at 170 °C for 120 min. The overall results suggest a promising performance of the synthesized Fe-DeHZSM5 for direct conversion of glucose to HMF.

**Keywords:** glucose, 5-hydroxymethylfurfural, ZSM-5, iron-based catalyst, humins

**BI-P-087**

## **Synergistic Effects of Plastic Wastes and Sludge for Producing Fuel via Co-pyrolysis in a Batch Reactor**

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### **Abstract**

Municipal Solid Waste (MSW) management, particularly disposal as open dumps are nationwide crisis resulting into the global warming and climate change issues. Plastic wastes are certainly crucial problem, on contrary, considered as sustainable sources of energy. Plastics co-mingled with other wastes, i.e., biomass and sludge, is an interesting research trended in enhancing the yield and property of oil products toward taking advantage of flexible resources and sustainable fuel development. This study aims to investigate the influences of dried sludge acquired from wastewater treatment plant co-pyrolyzed with mixed plastics (polypropylene; PE, mixed with polypropylene; PP) using a fixed-bed reactor. The products yields and compositions were determined via the individual pyrolysis process of plastics and sludge at temperature of 500 °C, and their synergistic effects (25, 50 and 75 %wt of sludge in plastic wastes) were also explored under the inert atmosphere, 100 ml/min of nitrogen, with 60 min of reaction time. The experimental results revealed that decomposition of plastic pyrolysis was significantly improved when the mixing ratio of sludge was increased. However, the oil yield of plastic co-pyrolyzed with 25 %wt of sludge was reportedly achieved about 51 %wt which rose up to about 20% from the pure plastics used as feed. Moreover, the higher mixing ratios, the lower oil yields were obtained.

**Keywords:** Plastic wastes; Sludge; Synergistic effects; Pyrolysis, Fuel

## BI-P-095

# Optimizing Bioethanol Production from Napier Grass: A Simulation and Economic Analysis Using Aspen Plus V.11

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## Abstract

This study explores the production of bioethanol from Napier grass through process simulation using Aspen Plus V.11 software. The research delves into the simulation of bioethanol production, examining the evolution of bioethanol production from the prototype process. Additionally, it conducts a comparative economic analysis of two processes: the pure ethanol production process utilizing the absorption method and the distillation process employing azeotropic distillation. The optimization of the azeotropic distillation simulation encompasses key variables such as the mass ratio of ethanol to hexane fed into the distillation column, the product flow rate entering the column's bottom, the number of trays, and the positions for introducing ethanol and hexane. Employing Aspen Plus V.11, optimal conditions were identified, including a mass ratio of ethanol to hexane at 1.5:1, a product flow rate at 102 kg/h entering the bottom of the distillation column, 12 trays, and specific feed positions for ethanol and hexane. Comparative analyses revealed that the original process achieved ethanol separation with a concentration of 99.9%, while the modified process achieved a separation of 99.5%. The economic assessment favored the absorption process, deeming it the most suitable, with a total production cost estimated at \$6,694,964. This research provides insights into process optimization and economic considerations for bioethanol production, offering valuable implications for sustainable biofuel development.

**Keywords:** Bioethanol Production; Process Simulation; Azeotropic Distillation; Economic Analysis

## BI-P-125

### atalytic conversion of palm refined oil to bio-hydrogenated diesel over monometallic and bimetallic supported on ZSM-5

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#### Abstract

The deoxygenation of Refined Palm oil to bio-hydrogenated diesel (BHD) via hydrotreating process over the ZSM-5 zeolite supported catalysts prepared monometallic and bimetallic catalyst by the wet-impregnation method was conducted into autoclave reactor (fixed bed reactor system) under a hydrogen pressure of 30 bar, the reaction time of 3 hours and operating temperature is 360 °C. These studies were divided into 2 parts. Firstly, the effect of monometallic and bimetallic catalysts (Ni, NiCu, NiMo). Secondly, the comparison of SiO<sub>2</sub>/Al<sub>2</sub>O<sub>3</sub> molar ratios in ZSM-5 Zeolite (molar ratio of 23 and 40), respectively. The catalyst was investigated by N<sub>2</sub> physisorption, X-ray diffraction (XRD), Temperature – programmed desorption of ammonia (NH<sub>3</sub>-TPD) and product analysis from converting of palm fatty acid distillate which by-product from refining palm oil occurred mainly via decarboxylation/decarbonylation pathways accompanying with cracking reaction to lighter hydrocarbon. Overall, this work showcases a promising route to produce added value bio-fuels from bio-compounds using metallic-doped ZSM-5 catalysts.

**Keywords:** Monometallic; Bimetallic; ZSM-5; Hydro process; Bio-hydrogenated diesel.



## BA-O-003

### Polymeric Adsorbent from Silicone Rubber for Carbon Dioxide Capture

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#### Abstract

One of the major greenhouse gases contributing to the global warming comes from carbon dioxide (CO<sub>2</sub>) which is commonly produced through fossil fuel combustion, industrial processes, transportation, volcanic eruption and forest fire. It is very crucial to solve the problem by reducing CO<sub>2</sub> before emission to atmosphere which can be done by adsorption of silica, zeolite, metal-organic frameworks or polymeric material. In this work, the polymeric adsorbent material of rubber scrap from silicone manufacture was chosen to study as the CO<sub>2</sub> adsorbent. The characterization of silicone rubber was examined by using thermogravimetric analysis, durometer and tensile testing machine. The effect of hardness (50-70 shore A) on the CO<sub>2</sub> adsorption capacity was investigated and the regeneration of adsorbent material was established by 5 adsorption-desorption cycles. The result showed that the CO<sub>2</sub> adsorption capacity increased with the increase of hardness of silicone rubber. Moreover, CO<sub>2</sub> adsorption capacity of silicone rubber was higher than that of natural rubber under the same condition. This result referred that silicone rubber can be used as an alternative adsorbent material for CO<sub>2</sub> capture.

**Keywords:** Silicone rubber; CO<sub>2</sub> capture; CO<sub>2</sub> adsorption; Polymeric adsorbent

## BA-O-026

### Synthesis and Characterization of Core-Shell Zeolitic Imidazolate Frameworks by Seed-Mediated Growth Method

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#### Abstract

This study focuses on the synthesis of bimetallic Metal–organic frameworks (MOFs), specifically beginning with Core ZIF-8 and ZIF-67. The physical and chemical properties of these cores were characterized using X-Ray diffraction analysis (XRD) and fourier-transform infrared spectroscopy (FTIR) techniques, while their thermal stability was evaluated through thermogravimetric analysis (TGA) to elucidate the effects of heat. Subsequent analysis of the Core materials led to the development of Core-shell structures, namely ZIF-8@ZIF-67 and ZIF-67@ZIF-8. These structures were thoroughly examined using scanning Electron Microscopy (SEM) and transmission Electron Microscopy (TEM) to investigate their morphology. Surface area and porosity analyzer (BET) analysis was conducted to determine the surface area and pore volume, revealing that ZIF-8@ZIF-67 had a surface area of 1997.2 m<sup>2</sup>/g and a pore volume of 0.751 cm<sup>3</sup>/g, whereas ZIF-67@ZIF-8 had 1758.9 m<sup>2</sup>/g and 1.59 cm<sup>3</sup>/g. The seed-mediated growth synthesis effectively preserved the dodecahedral structure of ZIF-8 and ZIF-67. These materials were observed to form a Core-shell structure, with a uniform distribution of Co and Zn particles on the surface. The integrity of the dodecahedral structure was maintained, boasting an excellent surface area and pore volume. Further enhancement of the physical and chemical properties was achieved by adding Cu particles to ZIF-67@ZIF-8 through co-precipitation.

**Keywords:** ZIF-8; ZIF-67; Composite materials; Metal–organic frameworks

## BA-O-067

### Tuning magnetic properties and particle size of iron oxide by changing Fe<sup>2+</sup>/Fe<sup>3+</sup> precursor ratios and rotation speed

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#### Abstract

Iron oxide is widely used in a variety of applications such as catalysts, contrast agents, medicine delivery, and crack detecting spray because it come in several forms. For application in crack detecting spray, iron oxide having a high saturation magnetization ( $M_s$ ) and a low magnetic retentivity ( $M_r$ ) is required. There are two common phases of iron oxide: magnetite ( $Fe_3O_4$ ) and maghemite ( $Fe_2O_3$ ), each of which has specific characteristics. Moreover, the magnetic properties and particle size of iron oxide can be modified by using different iron precursors and synthesis conditions. Thus, the influences of  $Fe^{2+}/Fe^{3+}$  precursor ratio, and rotating speed on the phase, particle size, and magnetic characteristics of iron oxide were investigated in this work. Mixtures of  $Fe^{2+}/Fe^{3+}$  in the ratios of 1:1, 1:2, and 2:1 were used as a precursor. The precursor solution was precipitated in  $NH_4OH$  at 80 °C and rotating speeds of 300 and 3,000 rpm. When the amount of  $Fe^{2+}$  precursor was increased, the iron oxide particle size reduced while the  $M_s$  and  $M_r$  increased. At a rotating speed of 300 rpm, the  $Fe^{2+}/Fe^{3+}$  precursor ratio of 2:1 produced the iron oxide with the highest  $M_s$  and  $M_r$  of 80.90 emu/g and 6.40 emu/g, respectively. Using a high shear reactor to increase the rotating speed to 3,000 rpm can reduce particle size and increase the  $M_s$  to 91.85 emu/g, which is closer to the  $M_s$  of iron oxide particles in commercial grade crack detecting spray.

**Keywords:** Iron oxide; magnetic particle; magnetization; particle size.

## BA-O-082

### Removal of iodine compounds for periodate oxidation of water-soluble carbohydrates

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#### Abstract

Periodate oxidation is extensively used to functionalize carbohydrates because of its high efficiency. Free vicinal hydroxyl groups are specifically cleaved and formed aldehyde groups by periodate. However, a crucial issue arises due to the residual periodate and iodine compounds in treated carbohydrates, especially for water-soluble carbohydrates (i.e., glucose and starch). To address this issue, two popular techniques have been developed for removing iodine compounds: ethylene glycol addition, and dialysis. This research aims to compare the efficiency of these techniques in removing iodine compounds from tamarind kernel powder (TKP), which is representative of water-soluble carbohydrate polymers. Treated TKP (T-TKP) was analyzed using X-ray Diffraction (XRD) and colorimeter. Moreover, the residual of iodine compounds in T-TKP was measured.

**Keywords:** Periodate oxidation; Sodium periodate; Ethylene glycol; Dialysis

## BA-O-086

### **A Pouch-Type Liquid-to-Gas Phase Transition Actuator: Performance Tests and Cost Analysis** **Julamane Wachiradecha<sup>1</sup>, Sira Srinives<sup>2</sup>, and Yodchanan Wongsawat<sup>1, \*</sup>**

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#### **Abstract**

The electric-driven liquid-to-gas phase transition actuators offer advantages in design and functionalities, such as high power density, high adaptability to environments, ease of processing, and high precision in device operation. The advantages make the actuators well-suited for applications that benefit from good dynamic responses and high energy efficiency with compact design. In this work, we developed 20 x 20 mm pouch-type actuators using laminated aluminum films as the structural material and dichloromethane as the phase transition fluid. The actuators utilize the conductive carbon coat on the surface of the aluminum pouch as a heat source for phase transition. The transition drives volumetric increase inside the pouch and causes mechanical deformation in the actuator. The actuators were tested and analyzed for thermal and mechanical responses. The fabrication cost, durability, and thermodynamic correlations between deformation, force, temperature, and operating time were analyzed. Our best device realized a maximum vertical displacement of 10.82 mm (7.98 times the initial value), yielding 90% displacement within 30 seconds. The fabrication cost was determined to be 0.53 USD/device at a total weight of 0.35 to 0.42 g/device. The actuator was tested to be cost-effective and high-performance.

**Keywords:** Liquid-to-gas phase transition actuator; phase transition actuators; pouch motor

## BA-O-089

# Formation and Stability of Oil-in-Water Pickering Emulsions stabilized by Chitosan nanoparticles

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### Abstract

Oil-in-Water pickering emulsions are surfactant-free emulsions stabilized by food-grade solid particles have attracted growing attention in recent year owing to their excellent stability and non-toxicity. In this study, we prepared chitosan nanoparticles via deprotonation method. The effect of chitosan concentration and oil fraction on the synthesis of pickering emulsion stabilization were investigated. The particle size and zeta potential of chitosan particles was measured using dynamic light scattering (DLS). Using canola oil as oil phase at different volume fraction (10-30% v/v), oil-in-water pickering emulsions were formed using 0.1-0.4 % w/v of as-prepared chitosan nanoparticles as stabilizers through homogenization followed by sonication. The morphology and droplet size of the resultant emulsions were then characterized using optical microscope and DLS technique. The results showed that the oil-in-water Pickering emulsions prepared at canola oil 10% v/v possessed smallest droplet size ~ 1  $\mu\text{m}$  with greatest stability. It was found that the chitosan nanoparticles at high concentration were able to form emulsions with smaller droplet size and better physical stability compared to that of emulsions stabilized by low concentration of chitosan particle. Moreover, the chitosan particles stabilized emulsions were of spherical shape and uniform droplet distribution, as evidenced by our optical microscopic images. To gain a more thorough understanding of the controlling factors influencing the formation and stability of emulsions, more research is necessary.

**Keywords:** Pickering emulsions; Canola oil; Chitosan; Deprotonation.

## BA-O-093

### **Toughness-Modified Polylactic Acid filled with Ultrafine Fully Vulcanized Natural Rubber Powder Grafted with Methyl Methacrylate Monomer**

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#### **Abstract**

The purpose of this study is to enhance the toughness properties of Polylactic acid (PLA) by incorporating a bio-based filler as toughening modifier. The bio-based filler was prepared by grafting methyl methacrylate monomer onto deproteinized natural rubber (DPNR-g-PMMA), followed by vulcanization through electron beam irradiation and subsequent powder production via a spray drying process. The resulting ultrafine fully vulcanized powdered natural rubbers (UFPNR) were utilized in the fabrication of PLA composites to study their impact on toughness. The efficiency of the DPNR-g-PMMA was evaluated in terms of monomer conversion (Conv%) and grafting efficiency (GE%) using evaporation and soxhlet extraction methods, respectively. The melt blending process was employed in an internal mixer at 50 rpm with 180 °C for 5 min, followed by hot press molding at 180 °C for 5 min and cold press molding for 3 min at room temperature to produce PLA composites with varying filler contents (5, 10, 15, 20 wt%). The properties of composite were investigated, including the degradation temperature at 5% weight loss ( $T_d_5$ ) using thermal gravimetric analysis (TGA) and mechanical properties such as flexural strength, flexural modulus, and flexural toughness were investigated using universal testing machine (UTM).

**Keywords:** Toughening Filler; UFPNR; Natural Rubber; Polylactic Acid; Composite (maximum 5 keywords).

## BA-O-099

### UV-vulcanized Natural Rubber Grafted with Methyl Methacrylate for Production of Ultrafine Powder as Toughening Fillers in Polylactic Acid.

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#### Abstract

This research focuses on the development of UV-vulcanized natural rubber grafted with methyl methacrylate (MMA) as a toughening filler in polylactic acid (PLA). To enhance compatibility with PLA, deproteinized natural rubbers (DPNRs) were endowed with hydrophilic functions through grafting copolymerization with MMA monomer. The UV vulcanization process was employed to enhance the crosslinking in the resulting grafted DPNR. Additionally, a spray drying technique was utilized to produce MMA-grafted ultrafine fully vulcanized powdered natural rubbers (UFPNR-g-(PMMA)). The study integrates an assessment of the efficacy of grafting process of the DPNR-g-PMMA in terms of monomer conversion and grafting efficiency via evaporation and Soxhlet extraction techniques, respectively. Fourier-transform infrared spectroscopy (FTIR) technique was conducted to confirm alterations in functionality. Compatibility between the obtained DPNR-g-PMMA and PLA film was assessed based on water contact angle (WCA). Additionally, swell testing was incorporated to evaluate the swelling ratio and crosslink density of the UFPNR-g-(PMMA). This study highlights the potential of UV-vulcanized natural rubber grafted with MMA as an effective toughening filler, offering a sustainable solution for enhancing the mechanical performance of environmentally friendly PLA-based materials in various applications.

**Keywords:** UV vulcanization; UFPNR; Toughening filler; etc.



## BA-O-106

### The Optimization of Carbon Dots in Various Precursor by Central Composite Design approach

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#### Abstract

This work aims to select the preferable precursor for carbon dots production for photodynamic application. Cellulose, xylose, fructose, glucose and sucrose, as abundant simple carbon source precursors, were used to produced carbon dots in batch reactor at 220 and 240 °C for 6 and 12 h. The preferable precursor was then optimized by Central Composite Design (CCD) according to 2 factors (time and temperature). The batch experiments showed that xylose generates the highest Quantum Yield (QY) in all conditions compared with the other precursors. Fluorescent measurements reveal that all CDs emit blue emission, and morphological analysis informs that all CDs have average size below 10 nm. Zeta potential analysis informs that all precursors produce CDs with negative charges (-38.5–84.6 eV) in all synthesis conditions. The optimization of xylose by CDD confirms that time and temperature significantly impact QY, band gap energy,  $I_b$  and  $I_g$  ratio, and zeta potential, but not particle size. CCD predict: 303,5 % of QY can be produced at 224 °C for 6 h, 7.64 of  $I_b/I_g$  might be produced at 238 °C at 6.5 h, 4.48 eV band gap energy will be produced at 243.5 for 15 h and hydrothermal at 244 for 5,5 will produce CDs with -80.1 mV of zeta potential.

**Keywords:** Carbon Dots, Xylose, Quantum Yield, and Central Composite Design.

## BA-O-107

### The Development of Metal/Carbon Quantum Dots/Cellulose Nanocomposites for Glucose Sensing by Fluorimetric and Colorimetric Detection

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#### Abstract

Diabetes is concerned as one of the principal chronic diseases which is indicated by the high glucose level in human blood stream. In clinical diagnosis, high glucose concentration in blood can cause fast coagulation, while intensive biomolecule components lead to analytical problems. Therefore, noninvasive and accurate glucose detection is preferred. In this work, synthesis of carbon quantum dots using lignin as a carbon source (LCDs) via a simple and eco-friendly hydrothermal method in an aqueous solution was developed. The influence of mono- and bi-metallic dopants (Pt and Ru) onto LCDs structure on enhanced catalytic activity for low glucose concentration detection was investigated. The results exhibited that PtRu/LCDs-water was the best nanozyme that showed best performance on catalyzing H<sub>2</sub>O<sub>2</sub> dissociation and thus promisingly facilitated both colorimetric and fluorimetric glucose detection with high accuracy. Successful colorimetric glucose detection using PtRu/LCDs nanozyme at the range of glucose between 0.01 mM and 1 mM at limit of detection of 0.01 mM covered the glucose blood level range of both healthy persons and ones with diabetes. The color changes of PtRu/LCDs-water/cellulose nanocomposites were virtually observed at the different concentrations of H<sub>2</sub>O<sub>2</sub>. PtRu/LCDs-water/cellulose nanocomposites have potential to utilize as paper-based H<sub>2</sub>O<sub>2</sub> and glucose sensing application.

**Keywords:** carbon dots; metal/cellulose nanocomposite; fluorescence assay; colorimetric assay; glucose detection.

## BA-O-136

### **Fine-tuning Heat Resistance and Impact Toughness of Natural Rubber-toughened PLA at Various Degrees of PLA/PDLA Stereocomplexation**

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#### **Abstract**

This study represents a new investigation into the influence of stereocomplex crystal content within the blend system of natural rubber (NR) and polylactic acid (PLA), aiming to concomitantly enhance both the impact strength and thermal properties of PLA. The NR content was fixed at 15 wt%, while the amount of stereocomplex crystals was increased by adjusting the PLA:PDLA ratio from 100:0 to 50:50 corresponding to the PDLA content ranging from 0 – 42.5 wt%. Regarding the effect of NR alone, the incorporation of well-dispersed NR into PLA resulted in a significant improvement in the impact strength with a slight increase in heat resistance of PLA as NR acted not only as a toughening agent but also as a mild nucleating agent for PLA. The addition of PDLA, especially at higher contents, provided higher % crystallinity and crystallization rate of stereocomplex crystals, consequently enhancing the heat resistance of the blends. At the optimal PDLA content of 30 wt%, the molded specimens could successfully withstand a temperature of 100 °C throughout the 24-hour test with a 3-fold higher impact strength than that of neat PLA.

**Keywords:** Polylactic acid, Natural rubber, Poly D-lactic acid, Stereocomplex, Heat resistance , Impact strength

**BA-P-048**

## **The Effect of Glycerol Concentration as Bio-Coating on Lotus Leaf Fracture Improvement**

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### **Abstract**

This research studied about the fracture improvement of dried lotus leaf by using glycerol, beeswax and chitosan as coating agent. The aim of this research is focus on the effect of glycerol on lotus leaf fracture improvement. The optimum ratio of glycerol in bio-coating was investigated from the percentage of recovery of lotus leaf after coating, which can indicate to elastic properties of lotus leaf. The 27% recovery was increased after using 5 g chitosan 24% v/v glycerol and 76% v/v acetic solution for 1 day immersion. The moisture content and thickness of coated lotus leaf were increased 38% and 7.1%, respectively. Meanwhile the contact angle was 24% decreased, since the increasing of moisture content. Moreover, the mechanical properties were show that the young's modulus was 76% decreased, although the elongation was 78% increased after coating, because of the fracture improvement of dried lotus leaf. In addition, the thermal stability was increased when compare with the dried lotus leaf by using thermal analysis study.

**Keywords:** Lotus leaf; Bio-coating; Glycerol; Fracture improvement

**BA-P-078**

## **Comparative Study of The Properties of Lignin Isolated from Bagasse Using Different Solid-to-Liquid Ratios of Dilute Sulfuric Acid Pretreatment**

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### **Abstract**

Sugarcane bagasse is a valuable byproduct of the sugar production industry. It contains a significant amount of lignin, which possesses beneficial properties, including antioxidant ability, antimicrobial activity, and UV protection. However, the pretreatment technique and operational conditions used for extracting lignin can critically impact its properties. This research aims to investigate lignin extraction from sugarcane bagasse using a dilute acid pretreatment (1% sulfuric acid). The effect of the solid-to-liquid ratios (1:2.5, 1:5, and 1:10) on lignin characteristics was investigated. The chemical structure of the extracted lignin was analyzed using the Fourier Transform Infrared Spectrometer (FT-IR) technique. Total phenolic compound (TPC) and antioxidant activity were also examined.

**Keywords:** Dilute sulfuric acid; Lignin; Sugarcane bagasse; Total phenolic compound

## BA-P-090

### Enhancement of Porous Carbon from Oil Palm Empty Fruit Bunch and CO<sub>2</sub> Capture Application

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#### Abstract

Two hydrochars were produced from palm oil empty fruit bunch (EFBs) using hydrothermal carbonization (HTC) at a temperature of 240 °C for 2 hour. These hydrochars, namely conventional hydrochar (CH) and H<sub>2</sub>SO<sub>4</sub>-assisted hydrochar (A-CH). They also were developed to enhance higher porosity by KOH chemical activation using appropriate conditions, including a weight ratio of 1:1 between hydrochar and KOH, an activation temperature of 800 °C, and a duration of 1 hour, namely CH-K and A-CH-K. The results showed H<sub>2</sub>SO<sub>4</sub>-assisted HTC plus KOH activation (A-CH-K) produced the excellent properties porous carbon that contained surface area 1,348 m<sup>2</sup>/g, pore volume 0.83 cm<sup>3</sup>/g and proper pore size in mesoporous range 2.47 nm. CH and A-CH provided the same chemical functional groups such as C-H, C-O and C=O, but all disappeared after the KOH activation. A-CH-K showed the highest amount CO<sub>2</sub> capture as 1.002 mmol CO<sub>2</sub>/g.

**Keywords:** Palm oil; Empty fruit bunch; Porous carbon; Chemical activation; CO<sub>2</sub> capture.

## BA-P-097

# Purification and Functionalization of MWCNTs Synthesized from BTX through One-Pot Acid Treatment and Application as Fluorescent Probe for Metal Ion Detection

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### Abstract

The properties of multi-walled carbon nanotubes (MWCNTs) include unique tensile strength, light weight, and high thermal conductivity, but they may exhibit low purity and low dispersibility in polar solvents. Purification and functionalization through acid treatment are, therefore, necessary to remove catalyst residues (metal and support) and add functional groups, such as carboxyl, into the structure of MWCNTs. MWCNTs can be synthesized from BTX with the ratio of benzene (B): toluene (T): xylene (X) of 51.25: 38.91: 9.84 vol% via catalytic chemical vapor deposition (CCVD) using Fe supported on basic alumina as a catalyst. The purification and functionalization processes were performed through a one-pot acid treatment in a mixture of various acids at different ratios under sonication for 3 h at room temperature. The FTIR spectrum revealed absorption bands related to the formation of carboxyl groups (-COOH) on the surface of carbon nanotubes. The results of titration experiment indicated that MWCNTs treated in the mixture of H<sub>2</sub>SO<sub>4</sub> with HNO<sub>3</sub> at a ratio of 3:1 (v/v) had the highest amount of carboxyl content at 3.29 mmol/gCNT, with a purity of 81.01%, up approximately 8 % of their pristine form. The functionalized MWCNTs (f-MWCNTs) exhibited photoluminescence with emission in the visible light region. Moreover, addition of different metal ions to f-MWCNTs resulted in varying degrees of fluorescence intensities (quenching or enhancement), which might confirm the self-photoluminescence of the f-MWCNTs. These self-photoluminescence characteristics suggest its potential application as a fluorescent-probe sensor to detect heavy metal ions in wastewater applications.

**Keywords:** Multi-walled carbon nanotubes; Functionalization; Purification; Acid treatment; Fluorescent-probe

## BA-P-098

# Development of Alginate-based Hydrogels Hybridized with Modified Multi-Walled Carbon Nanotubes for Colorimetric Gas Sensing Application

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### Abstract

Alginate hydrogels hybridized with functionalized multi-walled carbon nanotube (f-MWCNTs) were developed as colorimetric indicator for gas sensing application. f-MWCNTs was performed through oxidation process in a mixture of sulfuric/nitric acid in ratio of 3:1 (v/v) under sonication for 3 h at room temperature. The FTIR spectrum revealed the absorption bands regarding to the formation of carboxyl group (-COOH) on the surface of CNTs. The hybridized alginate-based hydrogels were prepared by adding f-MWCNTs and glutaraldehyde (GA), as the crosslinking agent to alginate-based hydrogels. The result revealed that addition of GA would increase the homogeneity and dispersibility of f-MWCNTs in the hydrogel matrix. FTIR demonstrated the peaks shift regarding to the H-bonding between crosslinking of GA, f-MWCNTs and alginate matrix. The mixture of pH-sensitive dye methyl red and bromothymol blue was incorporated into the hydrogel to act as the colorimetric indicator. The gas sensing evaluation was performed by varying carbon dioxide (CO<sub>2</sub>) concentration and relative humidity (RH) in close glass tube. The hybrid hydrogels demonstrated a color change from green to orange red up on detecting to CO<sub>2</sub> in the system. Hydrogel incorporated f-MWCNTs and GA exhibited faster rate of colorimetric sensitivity than alginate-based hydrogel. The concentration of CO<sub>2</sub> and relative humidity (RH) of the system influenced the color change of hydrogels. Increasing of CO<sub>2</sub> concentration reduced the time required to change the color of the hydrogels. The color change of hybrid hydrogel at high RH (85% RH) was relatively slow compared with that at low RH (50% RH).

**Keywords:** Alginate-based hydrogel; Multi-walled carbon nanotubes; Functionalization; Colorimetric gas sensing



## BA-P-102

### **Influence of chitosan content on antibacterial property of chitosan/polyvinyl alcohol composites**

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#### **Abstract**

The effect of chitosan particle size on the antibacterial properties of chitosan/polyvinyl alcohol composites was investigated. The objectives were to determine the effects of chitosan concentration and the method of chitosan incorporation into PVA film on composite material properties. Preparation of chitosan/polyvinyl alcohol composite films at various concentrations, analysis of composite material properties and antibacterial testing of chitosan solution. The results obtained from studying the effect of chitosan particle size on the antibacterial properties of chitosan/polyvinyl alcohol composite materials revealed that these composite materials could be fabricated using chitosan powder and chitosan solutions with varying chitosan amounts of 0.008, 0.28, and 0.42 g. However, increasing the chitosan content reduced the visibility of the composite materials. The chitosan solutions were tested against two different species of bacteria: *Escherichia coli* (*E. coli*) and *Staphylococcus aureus* (*S. aureus*). Each concentration of chitosan solution efficiently prevented bacterial growth. Moreover, increasing the chitosan concentration resulted in enhanced antibacterial efficacy. When the antibacterial capabilities of the composite materials were evaluated, it was clear that all composite material samples were ineffective in preventing bacteria growth. It can be concluded that chitosan has antibacterial characteristics in solution at amounts of 0.008, 0.28, and 0.42 g, but has negative antibacterial resistance when incorporated into composite materials.

**Keywords:** Chitosan; polyvinyl alcohol; composite materials; antibacterial.

## BE-O-059

### L-lysine Production by *Corynebacterium Glutamicum* TISTR 461 Using Cassava Pulp Hydrolysate as a Carbon Source

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#### Abstract

L-lysine is one of the essential amino acids for humans and animals. In general, a fermentation process is used to produce L-lysine. Glucose is utilized as a carbon source for fermentation. Various starch feedstocks are converted to glucose. However, cassava pulp is an interesting feedstock for L-lysine production because it is waste in the starch industry. The cassava pulp was converted to glucose by enzymatic hydrolysis. After that, the cassava pulp hydrolysate was filtered, centrifuged, and concentrated. The condensed hydrolysate (glucose) was utilized as the carbon source for L-lysine production. *Corynebacterium glutamicum* TISTR 461 was cultured on a nutrient agar, inoculum medium, and main medium in an Erlenmeyer flask, respectively. The conditions were maintained in a shaker at 200 rpm and 30 °C for 72 h. This fermentation investigated the effects of glucose, initial glucose concentration, and incubated pH for L-lysine production. The glucose from the AR grade gave a higher L-lysine concentration (11.52 g/L) than hydrolysate (7.65 g/L). The optimum condition for L-lysine production was 100 g/L of initial glucose concentration at incubated pH of 7.2 and provided L-lysine concentration of 8.17 g/L.

**Keywords:** Cassava pulp; L-lysine; *Corynebacterium glutamicum*.

## BE-O-071

### Production of L-lysine by Fermentation Using Glucose as a Carbon Source

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#### Abstract

L-lysine is an essential amino acid. Humans and animals cannot make lysine, so it must be eaten in the diet and drug. Generally, it can be produced by a fermentation process. Glucose is the most carbon source for this fermentation. In this research, D(+)-Glucose anhydrous was used as the carbon source for the fermentation of L-lysine. *Corynebacterium glutamicum* TISTR 461 was cultured on a nutrient agar, inoculum medium, and main medium in an Erlenmeyer flask, respectively. The fermentation times and sizes of fermenter were studied. Fermentation was operated as an aeration process. Three sizes of Erlenmeyer flask were studied including 125, 250 and 500 mL. The maximum concentration of lysine was found at the fermentation time of 120 hrs. At the same volume of initial medium and cell, the highest concentration of L-lysine was produced in 500 mL fermenter size.

**Keywords:** Glucose; L-lysine; *Corynebacterium Glutamicum*.

## BE-O-108

### Separation of Iron and Copper Metals from Industrial Wastewater Using Functionalized Cellulose Membranes

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#### Abstract

High-performance biopolymer membranes are gaining popularity as potential replacements for non-biodegradable and petroleum-based polymer membranes. However, most natural biopolymer membranes have low mechanical strength and poor flux, limiting their applications. In this study, functionalized hybrid cellulose membranes with defined functionality have been developed using a simple vacuum filtration procedure. Pristine cellulose nanofibers and 2,2,6,6-tetramethylpiperidine-1-oxyl (TEMPO) cellulose nanofibers of empty palm bunches with varying cellulose concentrations were used to fabricate cellulose membranes with good mechanical strength and flux. The cellulose isolated from empty palm sludge served as a support layer, while the pristine and modified cellulose nanofibers served as a functional layer. The properties of cellulose membranes, such as membrane thickness, density, pore size and distribution, mechanical strength, and flux, were evaluated with advanced analytical techniques. Our findings indicate that the hybrid cellulose membranes exhibit superior mechanical strength and flux. The membranes were evaluated for the separation of metal ions, iron, and copper from industrial wastewater. This high-performance cellulose nanocomposite can be employed as a renewable material in a variety of applications.

**Keywords:** Cellulose nanofibers; Cellulose membranes; TEMPO oxidation; Metal ion separation

## BE-O-124

### Inhibitory Effects of *Schinus terebinthifolia* Leave Extract on Polyphenol Oxidase Activity and Enzymatic Browning

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#### Abstract

In response to the significant challenge posed by polyphenol oxidase (PPO)-induced enzymatic browning in food products, this study aimed to assess the effectiveness of natural anti-browning agents in preserving the quality and visual appeal of *Musa acuminata* banana peels. Specifically, the study focused on the high-antioxidant extract derived from *Schinus terebinthifolia* leave. The antioxidant properties of the extract were evaluated through DPPH and FRAP assays, revealing an impressive 99% inhibition of PPO activity, comparable to sodium metabisulphite. Further analysis identified phenolic and flavonoid compounds in the extract as crucial contributors to its PPO inhibitory activity. Additionally, the study explored the practical application of the *Schinus terebinthifolia* leave extract in combination with a coating agent (Chitosan/Polyvinyl Alcohol) to reduce the browning index of banana peels. Results demonstrated a substantial reduction in the browning index, highlighting the extract's efficacy in minimizing enzymatic browning. The findings not only offer a natural and sustainable alternative to synthetic inhibitors but also underscore the potential of *Schinus terebinthifolia* leave extract in enhancing the shelf life and visual appeal of fruits. This research contributes to the advancement of eco-friendly approaches in the food industry, providing valuable insights into the application of natural anti-browning agents for improved food preservation.

**Keywords:** Enzymatic browning; Polyphenol Oxidase Inhibitor; Banana peel; Browning index

## BE-O-127

### Enhancing Polycaprolactone (PCL) Incorporating Ethanol Organosolv Lignin (EOL) for Improved Properties

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#### Abstract

This study investigates the development of polycaprolactone (PCL) properties, focusing on UV protection and antibacterial activity, through the incorporation of lignin extracted from biomass. Lignin, a natural biological polymer renowned for its exceptional UV and antibacterial properties, holds promise as a suitable additive for PCL, particularly in biomedical applications. The lignin used in this study was extracted into ethanol organosolv lignin (EOL). Different ratios of PCL and lignin were 10:0, 9:1, 8:2, 7:3, and 6:4 were introduced and processed through electrospinning under optimal conditions. The fiber size in PCL/lignin films decreased proportionally with an increasing lignin ratio, ranging from 170 to 250 nm, indicating a finer fiber structure. Concurrently, enhanced fiber distribution was observed with escalating lignin ratios. Despite the absence of antibacterial efficacy against Gram-negative bacteria, further evaluation for resistance to Gram-positive bacteria is recommended. UV and visible light transmittance tests revealed a reduction as the lignin ratio increased, particularly in the UVB and visible light wavelength ranges. Mechanical properties demonstrated favorable compatibility between PCL and lignin when the lignin ratio remained below 20%. This research contributes valuable insights into the potential applications of lignin as an effective additive for enhancing PCL properties, specifically in the realms of UV protection and antibacterial activity.

**Keywords:** Lignin, Composite, Functional additive, Organosolv lignin, Polycaprolactone, Electrospinning

## BE-P-074

### Evaluation of HEK293.2sus Growth in 5 Commercial Media

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#### Abstract

Human embryonic kidney 293 (HEK 293) cells are widely used as cell factories for production of recombinant therapeutic proteins because of their stable growth and high protein production on large scale. At present, various commercial culture media are available for HEX 293, yet there is no report on comparative cell growth performance among these media. In this work, we compared the growth of HEK293.2sus cells cultured in BalanCD HEK293, CDM4HEK293, CD293, FreeStyle 293, and 293 SFM II in shake flasks. First,  $3 \times 10^5$  cells/mL of HEK 293.2sus cells were seeded into 20 mL of each culture medium supplemented with 4mM L-glutamine and 0.01 %v/v anti-clumping in a 125-mL Erlenmeyer flask, and cultured at 37 °C, 5% CO<sub>2</sub>, 100 rpm for 9 days. The cultures were sampled every day over the culture period for analysis of viable cell density, specific growth rate and %viability. The results revealed that CDM4HEK293 was the best media for HEK293.2sus growth, providing the max cell density, the %viability at max cell density, and the specific growth rate around  $5.62 \times 10^6$  cells/mL, 88.73%, and 0.44 day<sup>-1</sup>, respectively.

**Keywords:** cell culture, HEK293.2sus, biopharmaceuticals

## BE-P-113

### Transdermal Drug Delivery System of Hesperidin-Loaded Cubosomes for Anti-Aging

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#### Abstract

Skin is the largest external organ of the human, making it constantly exposed to the external environment. Therefore, the skin is easily susceptible to damage from external factors. These damages affect the skin at the molecular level, causing signs of aging and leading to diseases and premature skin aging. To counteract this phenomenon, researchers have explored the potential of hesperidin as an antioxidant agent. Hesperidin stands out due to its high capacity to scavenge the reactive oxygen species effectively, its safety for the skin, and its affordability. However, hesperidin still faces certain drawbacks. Those challenges can be overcome with the use of an efficient carrier system like Cubosomes. It is self-assembled inverted bicontinuous cubic nanoparticles ranging from 100 to 500 nm in size, offer an ideal solution. In this study, it was aimed to determine the optimal formulation ratio of GMO and Poloxamer 407 to load maximum amount of hesperidin, thereby maximizing its anti-aging effect on the skin. The study revealed that a compromise ratio of 4.5% GMO to 0.5% Poloxamer 407 achieved the highest encapsulation of hesperidin, with an impressive entrapment efficiency rate of 94.03% and a particle size of 207.4 nm. The highest drug release of 88.98% with 27 µg/ml contained hesperidin cubosome, and 30% antioxidant activity.

**Keywords:** Anti-aging/ Antioxidant/ Cubosomes/ Hesperidin/ Nanoparticles/ Transdermal Drug Delivery



## BE-P-120

### Bioethanol Production from Rice Straw Using Simultaneous Saccharification and Fermentation Process

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#### Abstract

Rice straw is one of the biomaterials with potential to reduce the dependency of Thailand on fossil fuel. In this paper, rice straw is converted to bioethanol using the simultaneous saccharification and fermentation (SSF) process. Different types of microorganisms are used in the experiments including *Zymomonas mobilis*, *Saccharomyces cerevisiae* and *Pichia stipites*. The results show that the SSF process can give the highest amount of bioethanol using *Zymomonas mobilis* in combination with *Pichia stipites* via the pre-hydrolysis step at 50°C for 1 hour followed by the SSF process at 30°C for 48 hours. The yield of bioethanol is 0.23 g/g reduced sugar. The highest amount of bioethanol that can be produced is 1.34 g/L. In addition, the developed SSF process gives higher yield in bioethanol production than the current separate hydrolysis and fermentation (SHF) process.

**Keywords:** rice straw; bioethanol; microorganisms; simultaneous saccharification and fermentation; separate hydrolysis and fermentation

## CE-P-094

# Coaching for Research and Development in Chemical Engineering Senior Projects

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### Abstract

This research investigates the application of coaching methodologies to enhance the research and development (R&D) aspects of chemical engineering senior projects. The objective is to assess how coaching can effectively guide students in formulating, executing, and presenting research within the senior design project context. The study develops a personalized coaching framework tailored to individual project requirements, emphasizing skill development, problem-solving, and fostering continuous improvement. Employing a GROW model approach, the research evaluates the impact of coaching on student performance in R&D activities, with a focus on indicators such as research design quality, data interpretation effectiveness, and project innovation. The findings of the research demonstrate how well students enhance their problem-solving and skill-building abilities when they receive coaching for project-based learning. In order to better prepare students for the dynamic and innovative world of chemical engineering research and development, the report's suggestions propose for the curriculum to incorporate coaching techniques.

**Keywords:** Coaching; Chemical Engineering; Senior Project; Problem-solving; Continuous improvement

CC-O-012

## Esterification of Oleic Acid with Glycerol using Solid Acid Catalysts

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### Abstract

Esterification of oleic acid (OA) with glycerol to produce monoacylglycerols (MAG) for the food, cosmetic, and pharmaceutical industries was investigated using different solid acid catalysts. The catalysts were characterized by XRD, BET, and SEM-EDX. The effects of operating parameters including catalyst type ( $\gamma$ -Al<sub>2</sub>O<sub>3</sub>, ZSM5, ZnO/ $\gamma$ -Al<sub>2</sub>O<sub>3</sub>, and ZnO/ZSM5), reaction temperature, and reaction time were investigated. Reactions were conducted at glycerol-to-oleic acid molar ratio (GL/OA) of 4:1 and catalyst loading of 0.5 wt.% of the total reaction mixture in the range of 150–200 °C using a batch reactor. Samples were collected during the reaction period, and MAG, diacylglycerol (DAG), triacylglycerol (TAG), and OA concentrations were analyzed using HPLC. The results indicated that impregnation of ZnO on the supports ( $\gamma$ -Al<sub>2</sub>O<sub>3</sub> and ZSM5) providing higher oleic acid conversion. Among the catalysts tested, zinc oxide-supported ZSM5-zeolite (ZnO/ZSM5) gave the highest catalytic activity. 94.1% oleic acid conversion was obtained at the reaction temperature of 180 °C, catalyst loading of 0.5 wt.%, and reaction time of 2 h. In addition, increasing the reaction temperature significantly increased the DAG and TAG selectivity due the nature of consecutive reaction.

**Keywords:** Esterification; Oleic acid; Glycerol; Monoacylglycerols (MAG); Zinc oxide supported ZSM5.

CC-O-013

## A Green Sulfonated Activated Carbon Catalyst for Esterification of Oleic Acid with Glycerol

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### Abstract

A green sulfonated activated catalyst was successfully synthesized through sulfonation of activated carbon (SAC). The sulfonation temperature (140-200 °C) was investigated and the catalytic activity was tested via esterification of oleic acid and glycerol to produce mono-olein (MO). The carbon-based catalysts were characterized by X-ray diffraction (XRD) and scanning electron microscope energy-dispersive X-ray spectroscopy (SEM-EDS). The catalyst's total acid density was determined using a modified Boehm titration approach. The effects of operating parameters including reaction temperature, catalyst loading and reaction time were investigated. The sulfonation temperature varied from 140 to 200 °C as named SAC-140, SAC-160, SAC-180, and SAC-200 catalysts. It was found that SAC-180 catalyst exhibited the highest initial rate due to the highest total acid site density. As-prepared SAC-180 catalyst showed the excellent catalytic performance to obtain 70.75 % of oleic acid conversion at reaction temperature of 170 °C, catalyst loading of 2 % wt. and reaction time of 180 min.

**Keywords:** Esterification; Oleic acid; Glycerol; Mono-olein (MO); Sulfonated activated carbon catalyst.

## CC-O-014

### Effect of Surface Functional Group on Siliceous Zirconia for Glycerol Acetylation with Acetic Acid

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#### Abstract

Glycerol acetylation with acetic acid produces a mixture of mono-, di-, and tri-acetins, which have significant commercial value and are used in various industries such as cosmetics, plastic, and food. In the present study, siliceous zirconia (SZ) was functionalized with sulfuric acid and 12-tungstophosphoric acid to generate sulfonated SZ catalysts. The catalysts were characterized using X-ray diffraction (XRD), thermogravimetric analysis (TGA), and scanning electron microscope energy-dispersive X-ray spectroscopy (SEM-EDS). The effects of operating parameters including surface groups on the SZ catalyst, reaction temperature, and reaction time were investigated at a glycerol-to-acetic acid molar ratio of 1:9. The sulfuric acid-loaded SZ catalyst showed excellent catalytic performance to obtain 97.8% of glycerol conversion, and 51.8% of di-acetin yield at a reaction temperature of 110°C and reaction time 60 min. In addition, increasing the reaction temperature showed a significant increase in di-acetin selectivity.

**Keywords:** Acetylation; Glycerol; Acetic acid; Acetins; Heterogeneous catalyst.

## CC-O-015

### Valorization of Glycerol via Esterification with Acetic Acid Using 12-Tungstophosphoric Acid Catalyst

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#### Abstract

A renewable fuel, biodiesel, is an environmentally friendly and alternative resource for local availability which has potential to replace diesel. However, 10 kg of biodiesel production via transesterification produces 1 kg of glycerol as a byproduct. Crude glycerol from this process requires the distillation unit to increase purity of glycerol which is an extensive energy requirement. The glycerol esterification is one of potential process to produce bio-additive fuel as diacetin (DA) and triacetin (TA). The solid acid catalysts, namely, graphene oxide (GO), reduced graphene oxide (rGO) and 12 – tungstophosphoric acid (TPA) were selected to catalyze the glycerol esterification using acetic acid to glycerol molar ratio of 6:1, catalyst loading of 1 wt.% and reaction temperature of 110 °C for 2 h. It was found that TPA and rGO offered high glycerol conversion as well as high selectivity of DA and TA. The characterization results of catalyst supported their catalytic activities in term of active function groups including sulfonated group for rGO and heteropoly acid group for TPA.

**Keywords:** Glycerol; Esterification; 12-Tungstophosphoric acid (TPA); Graphene oxide (GO); Reduced graphene oxide (rGO); Acetin

CC-O-027

## Effect of Cerium Promoter in the Silica Supported Copper Catalyst on the Selective Hydrogenation of Furfural to Furfuryl Alcohol

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### Abstract

The selective hydrogenation of furfural to furfuryl alcohol on the Cu-Ce/SiO<sub>2</sub> catalyst was studied in this work. The cerium with 0.1 – 10 wt% loadings was added in the 20 wt% Cu/SiO<sub>2</sub> catalyst. The catalysts were characterized by the X-ray diffraction (XRD), N<sub>2</sub> physisorption, temperature programmed reduction (TPR) and N<sub>2</sub>O decomposition. The catalytic reaction was tested under 20 bar of hydrogen at 160 °C for 2 h. Addition of the Ce hardly affected the crystalline structure and the pore characteristics of the catalysts, except the 0.1 wt% Ce loading. The presence of Ce can lower the reduction temperature of the Cu/SiO<sub>2</sub> catalyst. An undetectable copper metal active sites by N<sub>2</sub>O decomposition indicated a weak interaction between copper metal and silica support resulting in the aggregation of copper metal to form the particles with larger size. The 0.5 wt% Ce was suitable content to maintain high reaction rate and high selectivity to furfuryl alcohol. An overload of the Ce content produced the other byproducts and therefore decreased significantly the selectivity of furfuryl alcohol. The impregnation of Ce after Cu showed the promising catalytic activity and selectivity compared to both the impregnation of Ce before Cu and the co-impregnation of Ce and Cu.

**Keywords:** Furfural hydrogenation; Furfuryl alcohol; Cu-Ce/SiO<sub>2</sub> catalyst.

CC-O-040

## Methane Reforming with CO<sub>2</sub> in Gliding Arc Plasma Minireactor Integrated with NiO and CoO Catalysts on Al<sub>2</sub>O<sub>3</sub> Ball Support

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### Abstract

An integrated effect of non-thermal plasma and catalyst on methane reforming with CO<sub>2</sub> was investigated in gliding arc plasma minireactor with supported catalysts. This research work focused the effects of metal oxide types (NiO and CoO) and metal oxide loading (1, 2 and 3 M concentration of metal salt solution) on the plasma-catalytic performance. NiO and CoO catalysts on Al<sub>2</sub>O<sub>3</sub> ball support were prepared by a wet impregnation method, and were characterized by SEM-EDS and BET surface area & pore analyzer. The results showed that the catalytic activity of NiO/Al<sub>2</sub>O<sub>3</sub> catalyst was comparatively greater than CoO/Al<sub>2</sub>O<sub>3</sub> catalyst. At the same metal oxide loading, NiO/Al<sub>2</sub>O<sub>3</sub> catalyst provided higher CH<sub>4</sub> and CO<sub>2</sub> conversions than CoO/Al<sub>2</sub>O<sub>3</sub> ones. The higher amount of NiO and CoO loaded on Al<sub>2</sub>O<sub>3</sub> ball support synergistically resulted in the higher H<sub>2</sub> and CO selectivities. The catalyst of 1M NiO/Al<sub>2</sub>O<sub>3</sub> exhibited the highest CH<sub>4</sub> and CO<sub>2</sub> conversions of 22.87% and 8.82% with the H<sub>2</sub> and CO selectivities of 53.41% and 24.38% while the 3M NiO/Al<sub>2</sub>O<sub>3</sub> catalyst exhibited the highest H<sub>2</sub> and CO selectivities of 58.07% and 26.83% with the CH<sub>4</sub> and CO<sub>2</sub> conversions of 20.66% and 3.26%, respectively.

**Keywords:** non-thermal plasma; gliding arc plasma; methane reforming; supported catalysts



## CC-O-041

### **Alkali Treatment Time and SiO<sub>2</sub>/Al<sub>2</sub>O<sub>3</sub> Ratio Effects on The Structural Modification to Produce Micro-mesoporous Commercial and Synthesized ZSM-5 Zeolite Catalysts**

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#### **Abstract**

This research investigated the structural modification by a facile alkali treatment of the commercial and synthesized ZSM-5 zeolites. The introduction of mesopores to ZSM-5 structure could potentially improve its catalytic performance in cracking and reforming process. ZSM-5 zeolite samples at SiO<sub>2</sub>/Al<sub>2</sub>O<sub>3</sub> ratios (60, 100 and 140) were hydrothermally synthesized in a fabricated autoclave reactor. The commercial and synthesized ZSM-5 zeolites were alkali-treated in 0.20 M NaOH aqueous solution at varying times (0.5-3 hr). All ZSM-5 zeolite samples were examined by analytical instruments, e.g. XRD, SEM-EDS, BET surface area & pore analyzer and particle size analyzer. The results demonstrated the pore properties of commercial and synthesized ZSM-5 zeolite samples depended on alkali treatment time. The increment of alkali treatment time brought about an increased mesopore surface area and volume for both kinds of ZSM-5 zeolite samples, accompanied by a more pronounced type IV isotherm with a hysteresis loop. However, the more increasing time for alkali treatment (3 hr) resulted in the decrease of mesoporosity in the synthesized ZSM-5 zeolite samples. Moreover, the observed changes in alkali-treated synthesized ZSM-5 zeolite structure were significantly affected by the effect of SiO<sub>2</sub>/Al<sub>2</sub>O<sub>3</sub> ratio. The mesopore formation is a result of preferential dissolution of Si from the synthesized ZSM-5 zeolites structure, particularly at higher SiO<sub>2</sub>/Al<sub>2</sub>O<sub>3</sub> ratios. The alkali-treated synthesized ZSM-5 zeolite at a SiO<sub>2</sub>/Al<sub>2</sub>O<sub>3</sub> ratio of 140 in 0.20 M NaOH aqueous solution for 1 hr was considered to be the optimal condition due to its high produced mesopore surface area and pore volume plus the preserved MFI structure.

**Keywords:** modified ZSM-5 zeolite; alkali treatment; micro-mesopore structure; catalyst

CC-O-044

## Continuous Conversion of Fatty Acid Methyl Esters to Bio-Jet Fuel via Hydroisomerization /Hydrocracking over NiGa/Modified Beta zeolite catalysts

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### Abstract

Currently, the consumption of fossil fuels used for internal combustion engines in the transportation sector tends to be declined according to the replacement of electric vehicles. This consequently cause an excess supply of biodiesel in the future. To maintain the balance in the palm oil market, the biodiesel derived from palm oil has a potential to be supplied as the feedstock for producing the bio-jet fuel in accordance with the policy of International Civil Aviation Organization (ICAO) to support the use of sustainable aviation fuels (SAF). In this regard, this research focuses on the continuous hydroconversion of biodiesel derived from palm oil to bio-jet fuel in a fixed bed reactor. Due to the drawbacks of nickel (Ni)-based catalysts, such as agglomeration, extensive hydrogenolysis and coke formation during the hydroprocess, the effect of incorporation of gallium (Ga) as a second metal in bimetallic Ni-based catalysts supported on the modified beta zeolite obtained from hydrofluoric acid/ammonium fluoride (HF/NH<sub>4</sub>F) solution on the catalytic properties and reactivity was investigated. At 360 °C, 2.45 h<sup>-1</sup> weight hourly space velocity (WHSV), and 30 bar pressure with H<sub>2</sub> at flow rate of 60 mL/min. The results showed that the liquid yield obtained from the system using Ni/modified beta zeolite was improved from 42.7 for Ni/unmodified beta zeolite to 68.3 wt%. Furthermore, the addition of Ga effectively suppressed the hydrogenolysis of the Ni-based catalyst, leading an increase in the selectivity to jet fuel range from 23.0 to 29.9%.

**Keywords:** Hydroisomerization; Bio-jet; Nickel; Gallium; Fatty acid methyl esters.

CC-O-049

## Elimination of Polycyclic Aromatic Hydrocarbons in Light Cycle Oil via Hydrogenation over NiMo-Based Catalysts

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### Abstract

Light cycle oil (LCO) is a by-product obtained from the catalytic cracking (FCC) unit in the petroleum refinery. Since LCO has high contents of organosulfurous compounds and polycyclic aromatic hydrocarbons (PAHs), which adversely affect environment and animal, LCO cannot be directly applied to the combustion engines. To utilize LCO as the higher value-added chemicals, this work aimed to transform PAHs in LCO as aromatics with lower toxicity such as BTX (benzene, toluene, and xylene), tetralins and decalins via hydrogenation over nickel (Ni) – molybdenum (Mo)-based catalysts. The effect of catalyst's supports such as -alumina (-Al<sub>2</sub>O<sub>3</sub>), KIT-6 and -zeolites on the hydrogenation efficiency was investigated. The results showed that the NiMo/KIT-6 catalyst exhibited the highest ability for hydrogenation of PAHs (77.4% removal of PAHs) and produced alkylbenzenes, decalins, and tetralins at 9.82, 5.22, and 63.7% selectivity, respectively when the reaction was conducted under 40 bar H<sub>2</sub> pressure and 350 °C at a stirring rate of 300 rpm for 3 h. This study proposed an alternative way to produce value-added chemicals from a by-product stream from petroleum refinery process, thereby expanding the options for sustainable development.

**Keywords:** hydrogenation; light cycle oil; polycyclic aromatic hydrocarbons; catalysts.

CC-O-050

## Characterization and properties of K-ZrO<sub>2</sub> Catalyst Derived from UiO-66 for Glycerolysis of Methyl Palmitate

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### Abstract

The glycerolysis process is mainly applied glycerol to produce monoglycerides (MG) and diglycerides (DG) that are in the food industry and pharmaceutical industries. This reaction required a high temperature to react. So, the catalyst plays an important role in improving process economics by increasing productivity and reducing energy consumption. However, homogeneous catalysts are not economically viable for recovery and reuse. Therefore, the use of heterogeneous catalysts has been explored to address these issues. Nevertheless, the catalytic activity of heterogeneous catalysts is limited by factors such as active site dispersion, stability, and the quantity of active sites. K-ZrO<sub>2</sub> is metal-organic frameworks (MOFs) have emerged as a technology to overcome the challenges associated with both heterogeneous and homogeneous catalysts. K-ZrO<sub>2</sub> is a mesoporous catalyst substance synthesized through a direct heat-treatment process that involves loading KNO<sub>3</sub> on the UiO-66 metal-organic framework. This process results in K-ZrO<sub>2</sub> catalysts exhibiting high surface area and basicity properties. Therefore, the objective of this research is to investigate the optimal conditions for synthesizing K-ZrO<sub>2</sub> catalysts in term of calcined temperature and among of loading KNO<sub>3</sub>, Characterize K-ZrO<sub>2</sub> catalysts properties.

**Keywords:** Glycerolysis; Catalyst; UiO-66 derived K-ZrO<sub>2</sub>.

## CC-O-084

### Modified resin as Catalyst for synthesis selectively triacetin by equilibrium shift via distillation reaction

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#### Abstract

This study focuses on optimizing the glycerol-esterification process with acetic acid to produce bio-additive fuel compounds monoacetin (MA), diacetin (DA), and triacetin (TA). Employing a modified Indion 225-H resin catalyst. The acetylation reaction using acetic acid to glycerol molar ratio of 6:1, catalyst loading below 7 wt.% and the reaction exceeds 70% conversion within 4 hours. For shifting equilibrium toward a distillation reaction for remove water was used in reaction via modified stark apparatus with an entrainer method based on Le Chatelier's principle for enhanced selectivity, surpassing over 50% for DA and TA under glycerol conversion. For catalyst properties characterization properties with FT-infrared spectroscopy, X-ray diffraction, SEM, and TEM elucidate structural changes. For reaction parameters establish optimized conditions over catalyst loading, temperature and entrainer condition.

**Keywords:** Glycerol-esterification; Modified resin; Monoacetin (MA); Diacetin (DA); Triacetin (TA)

## CC-P-042

### Investigation of the polymerization of ethylene and ethylene/1-hexene over zirconocene/MMAO catalyst supported on Ga-modified silica

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#### Abstract

Silica is commonly used as a support material in metallocene catalytic systems (MTC). However, silica has many different kinds of surface functional groups. The presence of various functional groups on silica may result in the deactivation of active sites due to their inherent undesirable properties. Considerable effort has been dedicated to the development of active supported metallocene species, which exhibit enhanced stability and activity. In this study, methylaluminumoxane (MAO) cocatalysts supported on two distinct types of structured mesoporous silica supports, namely MCF-Si and CAB-O-SIL, which were modified with Ga. First, the modification of calcined CAB-O-SIL and MCF-Si was conducted with 1 wt% of Ga impregnated on the support, and then the support was sequentially impregnated with MAO cocatalyst using the proper immobilization technique. Each of the modified support and supported cocatalyst possessed the following techniques including scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (EDX), X-ray diffraction (XRD) to determine the physicochemical properties. Under slurry polymerization conditions, ethylene and ethylene/1-hexene were polymerized over cocatalyst and the zirconocene supported catalysts using toluene as solvent with  $[Al]_{MAO}/[Zr]_{cat}$  molar ratio = 2,000 at 70°C and 3.5 bar of ethylene pressure. Various methods were applied to the polymer samples in order to investigate their properties.

**Keywords:** mesocellular foam; Ga-modified; ethylene polymerization; metallocene catalyst; methylaluminumoxane

CC-P-069

## Fe-doped in LaNiO<sub>3</sub> Perovskite Catalysts for Dry Reforming of Methane

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### Abstract

Emissions of greenhouse gases consisting of methane (CH<sub>4</sub>) and carbon dioxide (CO<sub>2</sub>), impact our food sources and living conditions. The dry reforming of CH<sub>4</sub> reaction can transform CH<sub>4</sub> and CO<sub>2</sub> into hydrogen (H<sub>2</sub>) and carbon monoxide (CO), aiming to reduce greenhouse gas emissions in chemical industries and others. The mixture of H<sub>2</sub> and CO, called synthesis gas, is known to be used in methanol production and Fischer-Tropsch process to generate hydrocarbon fuels. The challenges in dry reforming of CH<sub>4</sub> include coke formation on the catalyst surface and low H<sub>2</sub> selectivity. It was previously reported that doping a small amount of Fe in LaNiO<sub>3</sub> perovskites and a core-shell structure can enhance a metal-support interaction that aids in the dispersion of active sites, inhibiting sintering, and improving catalytic stability, activity, and carbon resistance in the dry reforming of CH<sub>4</sub>. The present study aims to investigate the catalytic performance of doped Fe in LaNiO<sub>3</sub> perovskite covered with CeO<sub>2</sub> shell for the dry reforming of CH<sub>4</sub> at high temperatures. LaNi<sub>0.8</sub>Fe<sub>0.2</sub>O<sub>3</sub> perovskite was synthesized using the hydrothermal method and then covered with a CeO<sub>2</sub> shell using the sol-gel method. The prepared catalyst was performed in dry reforming at 600 °C under atmospheric pressure, with a methane-to-carbon dioxide ratio of 1:1. Both fresh and spent catalysts will be characterized using transmission electron microscopy (TEM) and scanning electron microscopy (SEM) to examine morphology, as well as x-ray diffraction (XRD) to analyze crystal structure and phase information.

**Keywords:** Coke formation; CeO<sub>2</sub> shell; Dry reforming of methane; LaNiFeO<sub>3</sub>; Perovskite Catalysts

CC-P-085

## Preparation of sulfonated activated carbon from polymer waste for conversion of fructose to 5-hydroxymethylfurfural

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### Abstract

Conversion of polymer waste from industry to valuable products such as activated carbon (AC) is an interesting and sustainable pathway. This research aims to investigate the preparation of sulfonated AC from polymer waste, focusing the effect of one-step and two-step KOH activation on characteristics of AC, and the use of the resulted material as a catalyst in fructose dehydration to 5-hydroxymethylfurfural (5-HMF). In this study, activated waste (A) and activated pyrolyzed waste (P/A) through potassium hydroxide (KOH) activation at 800 °C in N<sub>2</sub> were synthesized. Sulfonation of the A and P/A carbons was carried out by heating them in H<sub>2</sub>SO<sub>4</sub> at 180 °C resulting in A-SO<sub>3</sub>H and P/A-SO<sub>3</sub>H. The characterization of the prepared ACs and sulfonated AC catalysts was performed by element analysis, XRD, FTIR, TGA and N<sub>2</sub> adsorption-desorption. The analysis of fructose dehydration products was performed using an HPLC. The carbon yields were found to be 37.18% and 51.17%, and the specific surface areas were 2860 and 1406 m<sup>2</sup>/g, for A and P/A, respectively. Other results will be presented and discussed further.

**Keywords:** Activated carbon; pyrolysis; activation; sulfonation; 5-hydroxymethylfurfural



## CC-P-092

# Chemical Recycling of Waste PET into Terephthalic Acid by Alkaline Hydrolysis

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### Abstract

The intensifying issue of plastic waste and widespread use of petrochemical resources for single-use plastics has become a global concern that requires urgent attention. Polyethylene terephthalate (PET) is one of the most widely produced single-use polymers globally. Although mechanical recycling is widely used for recycling PET, this process presents challenges due to the loss of mechanical and chemical properties during reprocessing. Chemical recycling such as hydrothermal depolymerization is a potential alternative pathway to recover terephthalic acid (TPA) monomers from PET waste. In this work, waste PET bottles were completely depolymerized using alkaline hydrolysis. Effects of experimental parameters, such as NaOH concentration, hydrolysis time and ethanol concentration on TPA yield, were investigated. The results revealed that adding ethanol in alkaline hydrolysis not only accelerated depolymerization of PET but also aided in separation of TPA product, enhancing overall efficiency of the process. In the presence of ethanol as a co-solvent, the highest TPA yield of 96% was achieved at reaction of 3 h with ethanol of 75 vol%. In contrast, when using an aqueous system without ethanol, it required a reaction time of 6 h to achieve 100% conversion of PET, with a resulting TPA yield of 90%. In addition, the structure of the obtained TPA was confirmed by FTIR and NMR spectroscopy. This study unveils an environmentally friendly and efficient approach to managing PET plastic waste. The obtained TPA from recycling PET can serve as a crucial precursor for repolymerization of PET or for synthesis of biodegradable plastics and metal–organic frameworks.

**Keywords:** Polyethylene terephthalate; Terephthalic acid; Hydrolysis; Depolymerization

## CC-P-103

### Conversion of furfuryl alcohol to butyl levulinate using alumina-supported tungsten catalysts

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#### Abstract

Butyl levulinate (BL) is an attractive alternative as a biofuel additive. This research was studied conversion of furfuryl alcohol to butyl levulinate using an alumina-supported tungsten catalyst. The effect of different tungsten precursors, including ammonium metatungstate (ANW), phosphotungstic acid (PWA), silicotungstic acid (SWA), amount of tungsten and reaction time on furfuryl alcohol conversion and product yield were investigated. The catalysts were prepared by an incipient wetness impregnation, and they were tested in the reaction between furfuryl alcohol and butyl alcohol. The results from the reaction test showed that the catalyst with the best results was the SWA/Al<sub>2</sub>O<sub>3</sub> catalyst. It presented the highest furfuryl alcohol and BL yield. An increasing the amount of tungsten on the SWA/Al<sub>2</sub>O<sub>3</sub> catalyst from 10 to 30 wt% resulted in improving BL yield due to the large amount active site making it highly reactive. By changing the reaction time, it was found that the increase of reaction time from 3 to 6 hours can enhance BL yield. The appropriate conditions for converting furfuryl alcohol to butyl levulinate using the alumina-supported tungsten catalyst in this study were using 30 wt% of SWA on Al<sub>2</sub>O<sub>3</sub> catalyst, furfuryl alcohol to butyl alcohol ratio of 1:20 at 120°C for 6 hr.

**Keywords:** Furfuryl alcohol, butyl levulinate, tungsten, alumina

## CC-P-131

### Intensification of monoolein production from oleic acid and glycerol using high speed homogenizer

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#### Abstract

Monoolein (MO) is the most commonly used surfactant in diverse industries, including pharmaceuticals, cosmetics, and food. This study focuses on the synthesis of MO via the glycerolysis of oleic acid, employing a homogeneous acid catalyst. The synthesis occurs within a high-speed homogenizer (HSM), with comparative studies using the mechanical stirred reactor (MS). Operating parameters, such as catalyst type, catalyst loading, and reaction time, were investigated. Reactions are conducted in a batch reactor at 120 °C, utilizing a glycerol-to-oleic acid molar ratio (Gly/OA) of 3:1. Samples were collected during the reaction period, and MO, diolein (DO), triolein (TO), and OA concentrations were analyzed using HPLC. Among the catalysts tested, H<sub>2</sub>SO<sub>4</sub> exhibits the highest catalytic activity. The results indicate a maximum OA conversion of 69%, achieved with a 1wt% catalyst loading and a glycerol-to-oleic acid molar ratio of 3:1 at 120°C, with a rotation speed of 5,000 rpm in 120 min. Notably, employing a high-speed homogenizer leads to an increase in MO production rate compared to conventional stirring methods.

**Keywords:** Glycerolysis; Oleic acid; Glycerol; Monoolein (MO); High speed homogenizer (HSM).

**DE-O-006**

## **Numerical Analysis of Vapor Distribution in Industrial-Scale Waste Heat Boilers**

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### **Abstract**

Waste Heat Boilers (WHBs) are essential in recovering waste heat from processes such as the Sulfur Recovery Unit (SRU). Modern WHBs are designed for high-temperature and pressure operating conditions. The increased load on WHBs results in more frequent failures due to issues such as the accumulation of superheated steam within the shell-side tube bundle, especially for kettle-type WHBs. As such, to design WHBs that are less susceptible to failures, it is important to understand the complex relationship between heat transfer, phase change, and mass transfer on the shell-side. Detailed experimental observations of existing WHBs are infeasible due to the operating conditions of modern WHBs. In the presented study, multiphase computational fluid dynamics simulations are used to capture the hydro-thermal behavior of an industrial-scale WHB with different tube bundle designs. The effect of tube pattern and pitch on vapor distribution on the shell-side is studied. Simulation results indicate that for the range of heat fluxes studied, steam hold-up increases with increasing heat flux and decreasing tube pitch. Additionally, the hydrodynamical behavior inside the tube bundle with the three commonly used tube patterns (square, rotated square, and rotated triangle) is presented.

**Keywords:** waste heat boilers; two-fluid model; multiphase flow; computational fluid dynamics

**DE-O-052**

## **Simulation-Assisted Transfer Learning for Steam Consumption Prediction in Industrial Steam Monitoring with Limited Data Scenario**

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### **Abstract**

Steam consumption is a primary factor in industrial operations, serving as a crucial heat source that necessitates an accurate monitoring system. However, one of challenges in implementing effective steam monitoring arises from the limited availability of data. In a practical industrial setting, only the measurement of total steam usage is accessible, lacking specific information regarding the steam utilization by each individual equipment unit. To address this challenge, this study proposes a novel approach for predicting steam consumption across multiple equipment units using simulation-assisted transfer learning allocator. The proposed method leverages pre-trained knowledge acquired from a simulated domain, which outnumbered the target domain to constrain and initialize the fine-tuning process. Simultaneously, the target domain is supervised by total steam consumption to adjust the learnable parameters towards the true function. By combining these strategies, the study aims to enhance adaptation and improve the accuracy of estimating steam consumption among different equipment units within industrial processes, even limited information. Furthermore, the proposed model verifies the practicability and reliability through a case study of a large-scale crude glycerol purification process.

**Keywords:** Limited data; Simulation-assisted allocator; Transfer learning; Steam consumption prediction

**DE-O-054**

## **Enhancing Small Dataset Prediction of Silver Nanoparticle Size with Deep Learning and Latin Hypercube Sampling Framework**

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### **Abstract**

The inherent characteristics of experiments, difficulty in data gathering, high costs in experimental analysis, and time-consuming are generally found in laboratory experiments. These constraints usually lead to a limited number of experimental data and cause problems to calculation analysis such as overfitting and underfitting. To prevent the scenarios as mentioned above, in this study, an integrated framework of deep learning with Latin hypercube sampling is applied to enhance the prediction model based on small dataset. The case study of size prediction in silver nanoparticle synthesis is used to illustrate the performance of the developed framework. The Latin hypercube sampling (LHS) technique extends the amount of raw data for model development. Therefore, the original raw data and generated data from LHS has been integrated as training data for development of deep learning prediction model. As a result, the integrated model improves prediction performance, which is validate and test dataset values are 0.924 and 0.918, respectively. In addition, the unseen data test results in higher accuracy when compared with a small data-trained model. The unseen test results in a value rising from 0.442 to 0.893, which is increasing significantly. With the utilization of the proposed framework, it can be used to predict the size of silver nanoparticles with small experimental data and other conditions within the boundary with high accuracy.

**Keywords:** Latin hypercube sampling; Limited data; Deep learning; Artificial intelligence

## DE-O-112

# Machine Learning for Predictive Modelling of Hydrogen Production from Biomass Gasification

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### Abstract

Biomass gasification has been studied widely as one of the most suitable approaches to recover energy from biomass feedstocks. However, since the process relies on a complex mix of interacting variables, traditional models such as thermodynamic equilibrium and kinetics often struggle to achieve an accurate prediction. This research, therefore, focuses on a more powerful alternative that can handle complex input-output relationships, i.e., machine learning techniques, to develop predictive models of syngas from biomass gasification, including hydrogen. The inputs of machine learning models include different key variables affecting product yield which cover different feedstocks and operating conditions, while the effect of cross-validation was also explored. The results showed that the most accurate model for hydrogen prediction was the Gradient Boosting Regressor, having  $R^2$  of 0.9771 without cross-validation. It can be observed that the model with cross-validation exhibited a lower performance than the model without cross-validation. This could be attributed to the step of hyperparameter tuning with cross-validation which gives a more generalized set of hyperparameters that leads to a slightly less accurate model but could be more reliable to handle unseen data. SHAP analysis was implemented to the highest performance model to determine the important factors influencing the gasification process. It was found that gasifying agents are the most influential factor for hydrogen production. This information can be used as a valuable guideline for further process optimization.

**Keywords:** Biomass gasification; Hydrogen; Machine learning; K-fold cross-validation; SHAP analysis

**DE-O-129**

## **Data Augmentation Enhanced Predictive Model for Catalytic CO<sub>2</sub> Methanation**

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### **Abstract**

CO<sub>2</sub> methanation is beneficial not only for green-house gas abatement but also energy demand support. Various catalysts and reaction conditions have been studied and its experimental data were accumulated for decades. Machine learning is received wide attention due to the ability to reveal insight from literature data. However, the size of experimental data is limited and considerably small even accumulated for decades, affecting the robustness of the model. In this work, we used data augmentation technique to create more dataset for training the models using support vector machine, random forest, and XGBoost algorithms. Catalyst properties and reaction conditions were features and CO<sub>2</sub> conversion was target for the model. The effects of original train size, augmented data size, and model parameters were elucidated. The results could be summarized that the RMSE and R<sup>2</sup> of the model could be enhanced by training with augmented data. This work demonstrated the advantage of using digital technology for specific field of chemical engineering such as catalyst.

**Keywords:** Machine learning; data augmentation; CO<sub>2</sub> methanation.



## ET-O-010

### Density, Viscosity, and CO<sub>2</sub> Absorption capacity of Tri-amine blends 2-amino-2-methyl-1-propanol (AMP), Piperazine (PZ), and Monoethanolamine (MEA)

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#### Abstract

Amine based carbon dioxide (CO<sub>2</sub>) absorption technology has been commercially proved over a decade in several locations around the world. Its key is to use a highly effective solvent, which can capture larger amount of CO<sub>2</sub> than the conventional aqueous solution of 30% wt. monoethanolamine (MEA). This study focuses on a formulation of tri-amine blend, which consists of 2-amino-2-methyl-1-propanol (AMP), piperazine (PZ), and monoethanolamine (MEA). A mixture design based on the Design-Expert software was applied to design the blends with various weight ratios of each amine. With total amine concentrations of 20% wt., 30% wt., and 40% wt., twenty-one aqueous solutions of AMP-PZ-MEA were proposed. Density and viscosity of the blends were measured by Stabinger viscometer SVM 3001 (Anton Paar, Austria) at 293–363 K. It was found that density of AMP-PZ-MEA was in a same range with that of benchmark 30% wt. MEA. At 303 K, 5% wt. AMP:17.5% wt. PZ:17.5% wt. MEA had the highest density of 1.0166 g/cm<sup>3</sup>, which is slightly greater than that of 30% wt. MEA (1.0085 g/cm<sup>3</sup>). On the other hand, viscosity of AMP-PZ-MEA was much larger than that of 30% wt. MEA. At 303 K, 5% wt. AMP:30% wt. PZ:5% wt. MEA showed the largest value of 6.9078 mPa.s, which is approximately four-time higher than viscosity of 30% wt. MEA (1.7186 mPa.s). At CO<sub>2</sub> concentration of 12% v/v. and 313 K, a promising 5% wt. AMP:30% wt. PZ:5% wt. MEA had absorption capacity of 0.841 molCO<sub>2</sub>/mol amine, which is 67.5% greater than that of 30% wt. MEA.

**Keywords:** CO<sub>2</sub> capture; capacity; amine; density; viscosity

## ET-O-056

### Life Cycle Assessment of Carbon Capture and Methanol Production

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#### Abstract

In recent times, approximately 44.6 GtCO<sub>2</sub> of carbon dioxide (CO<sub>2</sub>), a significant contributor to global warming, has been emitted into the atmosphere. To achieve the goal of keeping Earth's temperature below 1.5°C, the conversion of CO<sub>2</sub> to methanol presents itself as a promising solution due to the high market demand for methanol. This research aims to evaluate the Life Cycle Assessment (LCA) of methanol production using Alcohol-assisted CO<sub>2</sub> Hydrogenation with a catalyst, comparing it to conventional methanol production methods. The study utilizes the Aspen Plus V12 simulation process to analyze the material and energy input, as well as the output inventory of the process. Additionally, the life cycle impact assessment employs the ReCiPe Method, covering both midpoint and endpoint environmental impact assessments. The results show that methanol production using the alcohol-assisted process generally results in lower impact across most categories compared to conventional methanol production. However, certain impact categories, namely Water consumption, Land use, and Freshwater ecotoxicity, exhibit higher impacts. Notably, both processes significantly contribute to the Human carcinogenic toxicity category. Moreover, concerning global warming, a key point of consideration, the alcohol-assisted process shows a reduction of 9.03% compared to the conventional method. The study concludes that alcohol-assisted processes have the potential to reduce environmental impact when compared to conventional methods. Furthermore, this research could support the potential for advancements in carbon utilization in the future, with the goal of minimizing environmental impacts and promoting the sustainable use of resources.

**Keywords:** Alcohol-Assisted CO<sub>2</sub> Hydrogenation; Global warming; Life Cycle Assessment; Methanol production

## ET-O-065

### The Assessment of The Relationship Between Fine Particulate Matter and Related Meteorological Conditions

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#### Abstract

The issue of PM<sub>2.5</sub> in Thailand stands as a pressing national concern, demanding urgent solutions. Particularly in the Bangkok metropolitan region, PM<sub>2.5</sub> values consistently surpass established standards, directly impacting the daily lives of residents. These levels tend to escalate during the winter season, spanning from October to March each year. Meteorological factors significantly influence the occurrence and accumulation of PM<sub>2.5</sub>, prompting this research to investigate the correlation between these factors and PM<sub>2.5</sub> levels in Bangkok.

This research aims to explore the correlation between meteorological factors and PM<sub>2.5</sub> levels specifically in the Bangkok area. It involves employing a Deep Neural Network (DNN) model to predict PM<sub>2.5</sub> values. Additionally, the study includes testing the accuracy of these predictions and analyzing the mass concentration of PM<sub>2.5</sub> in ambient air using the Cascade Virtual Impactor (CAVI). The results demonstrate the predictive efficiency of the DNN model for PM<sub>2.5</sub>, showcasing an R-Squared ( $R^2$ ) value of 0.6637 and a Root Mean Squared Error (RMSE) value of 12.8610. The value predicted using the DNN MODEL has an average value of 24.6557. When comparing the results from the Environment Agency and BKK measurements within the same area, they exhibit 59.06% discrepancy. Additionally, the values obtained from the measurement of CAVI show a difference of 35.33% when compared to the predicted average value. The results show that the predicted values still exhibited low accuracy. Therefore, further efforts should concentrate on refining the model and structuring the dataset systematically for data training purposes. Experimentation with adjusting the model to accommodate time series data, such as using an LSTM model, should also be considered.

**Keywords:** Air Pollution; Particulate Matter; PM<sub>2.5</sub>; Weather; Meteorological Factors

## ET-O-081

# Hydrodynamics simulation of sorbent riser and regenerator for carbon dioxide capture process using $K_2CO_3/Al_2O_3$ in circulating fluidized bed reactor

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### Abstract

Currently, the world is facing the problem of global warming. The main cause is the release of carbon dioxide from industrial plants and electricity production. Carbon dioxide capture technology is used to reduce the release of carbon dioxide into the atmosphere after fuel combustion. In this study, a circulating fluidized bed reactor is used for carbon dioxide capture processes since it has many advantages. Potassium carbonate support on alumina is used as a sorbent to capture carbon dioxide gas. The sorbent is loaded into the circulating fluidized bed reactor that consists of a riser and a downer. A control valve is installed to regulate the flow rate of the sorbent from the downer to the riser. However, the hydrodynamics of the downer have not yet been thoroughly studied. In the previous study, it was found that some solids in the downer were buoyant due to the pressure distribution in the downer might not fit with the actual condition. To make the model more realistic, this research has developed hydrodynamic models for the riser and downer by using computational fluid dynamics and studying the effect of drag models on the hydrodynamics of sorbent inside the riser and downer of the carbon dioxide capture process in the circulating fluidized bed reactor. The carbon dioxide capture process was divided into two sections or reactors: a riser (sorption) section and a downer (desorption) section. Several drag models were employed to investigate the proper hydrodynamics in the reactors which are Wen and Yu, Syamlal O'brien, and Gidaspow drag models. It was found that the Gidaspow drag model provided proper hydrodynamics in the riser. The distribution of the sorbent in the riser is similar to the experiment result. Then Wen and Yu, Syamlal O'brien, and Gidaspow drag models were used to investigate the hydrodynamics in the downer. The Wen & Yu, and Syamlal O'brien drag models show gaps in the downer. However, the Gidaspow drag model reduces the flotation of the sorbent in the downer which is coherent with the observation. Thus, it was concluded that the Gidaspow drag model could be used for both the riser and downer.

**Keywords:** Carbon dioxide capture, Regeneration, Circulating fluidized bed, Hydrodynamics

**ET-O-096**

## **Adsorption of Uremic Toxins in Hemodialysis using Bio-based Hybrid Granular Activated Carbon for Dialysate Regeneration**

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### **Abstract**

In kidney hemodialysis system, adsorption has been investigated as a beneficial physical treatment to reuse spent dialysate containing uremic toxins such as creatinine and uric acid. This could minimize the required quantity of new dialysate. In this study, sugarcane bagasse (SCB) and sugarcane bagasse ash (SCBA) were utilized as main raw materials to produce granular activated carbon (GAC) hybridized with alginate as a bio-based polymer matrix via gelation method. SCB activated carbon (SCB AC) was firstly prepared from raw SCB by carbonization at 500 °C for 1 h and steam activation at 900 °C for 1 h. The strength and stability of the hybrid GAC could be improved by adding SCBA-derived mesoporous silica (SCB MPS) at different mixing ratios. Swelling degree was primarily investigated by comparing commercial GAC and SCB GAC at different ratios of SCB AC and SCB MPS. It was observed that SCB GAC mostly exhibited better swelling degrees than those of commercial GAC. The higher swelling degree was possibly anticipated to enhance adsorption efficiency of uric acid and creatinine in dialysate solution. The weight ratio of SCB AC to SCB MPS at 1:2 and 1:1 in the GAC seems to be the optimum ratio to achieve relatively high swelling degree and adsorption efficiency due to their less structural deformation.

**Keywords:** Sugarcane bagasse; Granular activated carbon; Adsorption; Dialysate; Uremic toxins

## ET-O-111

### Assessing Sustainability Performance of Thailand Provinces via Super-efficiency Data Envelopment Analysis

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#### Abstract

Sustainable development at the provincial level involves striving for economic and social growth while minimizing adverse impacts on the environment. Assessing the sustainability performance of provinces not only provides a measure of their sustainability but also highlights areas that require immediate attention. This assessment can lead to suggestions for improvement methods to move towards sustainable development. In this research project, the aim is to evaluate the sustainability performance of provinces in Thailand. Data Envelopment Analysis (DEA) model was employed to assess the performance of 77 provinces in 2022, using sustainability indicators that cover all three key elements: social, economic, and environmental. The chosen social indicator is the unemployed rate, the economic indicator is provincial gross product, and environmental indicators include electricity consumption, water consumption, the amount of waste generated, and the amount of waste that can be recycled. The results of the DEA analysis, particularly utilizing the Super-efficiency model, indicate that approximately 28.6 percent of the provinces are efficient, while the remaining 71.4 percent are considered inefficient. The inefficient provinces have the potential to improve their efficiency by learning from the efficient ones. Notably, Sisaket is frequently referred to as a model for improvements, with the most significant area for enhancement being the recycling of waste, followed by water consumption. Additionally, the analysis reveals that Yasothon as the most efficient province, obtains an impressive score of 4.95. This suggests that Yasothon excels in waste resource management while efficiently utilizing other resources.

**Keywords:** Sustainability Assessment; Thailand Provinces; Data Envelopment Analysis; Super-efficiency; Sustainability Indicators

## ET-O-114

# Travelling Salesman Problem Considering Traffic Data and IoTs for Smart Waste Collection System: Case Study of a University

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### Abstract

The crucial way to protect the environment from bad smells and unsightly views from waste bins is collecting full waste bins in time as an efficient waste collection system. The aim of this study is to collect the waste bins based on real time information using Internet of things (IoT) and suggest the optimal shortest route for waste collection vehicles at a university. Traffic data for campus closing and opening period, and for special annual events such as Graduation ceremony were collected from Google Traffic Maps. Geographic Information System – GIS and Travelling Salesman Problem were used to find the optimum shortest path and route sequence for different scenarios considering possible combination of locations to be collected. The result indicates that the time with the traffic value higher than 1.79, 1.84 and 2.1 for closing and opening periods, and Graduation ceremony, respectively, was defined as a rush hour where the launch of collecting vehicles should be avoided. The results of optimal route for collecting scenarios were grouped as they shared the same route pattern; however, the collecting sequences were different.

**Keywords:** Smart Bins; Waste Collection System; Vehicle Routing Problem; QGIS; Travelling Salesman Problem

## ET-O-116

### Zinc-organic framework and titanium dioxide nanocomposite for use as photocatalyst for dye degradation

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#### Abstract

The influence of this research is to create novel composite photocatalyst materials that combine a new zinc-organic framework (MOF) and Titanium dioxide nanoparticles. The first step, a new zinc-organic framework was synthesized by using microwave technique. The new  $[\text{Zn}(4,4\text{'-bipy})_2(\text{Suc})]_n$ , contains a central zinc ion which was coordinated by two molecules of 4,4'-bipyridine ligands and two molecules of succinic acid ligands. The second step, the surface of  $[\text{Zn}(4,4\text{'-bipy})_2(\text{Suc})]_n$  micro crystals were coated with TiO<sub>2</sub> nanorods (P25 and anatase TiO<sub>2</sub>) by co-precipitation method. The chemical structure of a MOF crystal was studied using the Single-crystalline X-ray diffraction technique. Both bulk samples of  $[\text{Zn}(4,4\text{'-bipy})_2(\text{Suc})]_n$  and composited materials were confirmed the crystal structure by powder XRD diffraction technique. The powder XRD peaks indicated that the composite materials comprised a small amount of TiO<sub>2</sub> anatase and TiO<sub>2</sub> rutile and the majority phase of MOF. In addition, we used SEM images to confirm that P25 nanoparticles and TiO<sub>2</sub> nanorods were well deposited on the entire MOF surface. Finally, the as-synthesized materials were test the photocatalytic performance for methyl orange degradation using 2.5 mg/L of catalysts. The best results showed that the degradation efficiency reached 48.76% within 300 min under UV-C irradiation which higher than solely MOF (24.56%).

**Keywords:** Metal-Organic framework; Composite material; Titanium dioxide; Photocatalyst; Dye degradation



## ET-O-118

### **An Insight into Seawater Hydrate-Based Technology: Effects of Difference Kinetic Promoters on Methane Hydrate Formation**

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#### **Abstract**

Solidified natural gas via clathrate hydrate (SNG) has emerged as a new technology for gas storage candidate. SNG has lots of advantages including high storage capacity, extremely safe, and environmentally benign. In order to artificial the technology, operating condition and cost need to be concerned. Therefore, this work shed light on roles of difference kinetic promoters on methane hydrate formation in simulated seawater. The addition of salt presented an inhibitory effect on methane hydrate formation kinetics. Sodium dodecyl sulfate (SDS) was used, revealing two steps of hydrate formation alongside low hydrate formation kinetics. This suggested a competition between enhancing and inhibiting effects. Four types of amino acids, including valine, leucine, methionine, and tryptophan, were also investigated. All amino acids significantly improved hydrate formation kinetics by enhancing the rate of hydrate formation, increasing the final gas uptake, and improving the induction time compared to SDS. Notably, kinetics improved with an increase in the amino acid concentration. However, the concentration of amino acids must be sufficiently high to overcome the inhibitory effect of NaCl, especially in the case of valine and methionine. Tryptophan demonstrated the best performance in enhancing the kinetics under the given conditions. Morphological investigations of hydrate formation using SDS with NaCl indicated a less dense structure than the system without NaCl. Furthermore, the presence of amino acid displayed a similar pattern of hydrate formation morphology. This comprehensive investigation suggested a prospective approach that could potentially enhance methane hydrate formation, offering a promising option for SNG technology.

**Keywords:** Solidified Natural Gas (SNG), Clathrate Hydrate, Kinetic Promoter, Sodium Dodecyl Sulfate (SDS), Amino Acids

## ET-O-119

### Enhancing CO<sub>2</sub> Hydrate Formation via Cyclopentane-Amino Acid Synergy: Implications for Hydrate-Based Carbon Capture

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#### Abstract

In the quest to reduce carbon dioxide (CO<sub>2</sub>) emissions without abandoning fossil fuels, hydrate-based technology emerges as a cutting-edge approach, holding significant promise for achieving carbon neutrality. However, one major challenge related to this technology is the lack of understanding of how to improve the formation kinetics of CO<sub>2</sub> hydrate effectively. In this study, we reveal the synergistic enhancement of CO<sub>2</sub> hydrate formation by combining a low dose thermodynamic promoter as Cyclopentane (CP), with an environmentally friendly kinetic promoter, an amino acid such as L-Methionine (Met). The experimental results indicate that CP efficiently promotes the formation of CO<sub>2</sub> hydrates. In the case of a single CP system, as the concentration of CP increases from 0.1 to 1 mol%, its promoting effect increases in relation to the concentration of CP, resulting in a significant decrease in induction time compared to the DI-water system. The combination of CP and Met in CO<sub>2</sub> hydrate formation shows a synergistic effect, with the optimal outcomes coming from 1 mol % CP and 0.05 wt % Met. Both kinetic experiments and morphological observations confirm this optimal combination for CO<sub>2</sub> uptake. The findings highlight the crucial role of Met in enhancing the efficiency of CO<sub>2</sub> hydrate formation, contributing valuable insights to our understanding of the process.

**Keywords:** CO<sub>2</sub> hydrate; Cyclopentane; L-Methionine; Hydrate formation kinetics.

## ET-O-121

### Effects of Mono- and Di-valent Salts on Methane Hydrate Formation with Methionine

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#### Abstract

The storage of natural gas through clathrate hydrate, commonly referred to as Solidified Natural Gas (SNG) technology, presents a promising technology for future applications. While SNG technology has numerous advantages, the use of deionized water in the hydrate formation process may pose cost challenges in large-scale operations. To overcome this, seawater can be used as an alternative water source for hydrate formation. In this context, understanding the behaviors of various salt ions becomes crucial. The study focused on major seawater salt ions, such as potassium chloride, sodium chloride, calcium chloride, and magnesium chloride. Experiments were conducted at 4 °C and 8.0 MPa with the addition of 1.0 wt% methionine and continuous stirring at 550 rpm. Results indicated that the presence of salt ions inhibited the methane uptake and the hydrate formation kinetics compared to formations without any salts (deionized water). Moreover, increased salt ion concentrations increased the inhibition effects. While all salt ions exhibited similar methane uptake at fixed concentrations, their impact on hydrate formation kinetics varied. Monovalent salt ions demonstrated milder inhibition effects than divalent ones. Interestingly, when ion charges were the same, smaller ions exhibited milder inhibition effects. The morphology of methane hydrate formations was also studied, revealing that high concentrations of salt ions led to clustered formations. These discoveries signified a substantial step toward making SNG technology a practical and promising solution for natural gas storage and transportation.

**Keywords:** Methane hydrates; Hydrate formation kinetics; Amino acid; Salt ions.

## ET-O-132

# A STUDY OF PIG FARM WASTE TO PROMOTE THE CIRCULAR ECONOMY CONCEPT

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### Abstract

Wastewater pollution from pig farms is the main source that polluted the lower Tha Chin River Basin, especially NakornPathom province. The basin faces challenges with excessive levels of Ammonia nitrogen and Phosphorus, major components of pig farm wastewater. Despite relying predominantly on Biogas production systems, current wastewater management practices remain inadequate. This study aims to estimate pollution loads from pig farms in Nakhon Pathom Province into the Tha Chin River Basin and implement circular economy principles for waste management. Using Material Flow Diagram analysis, the improving scenario indicated that improving the wastewater treatment system could play the main role of reducing pollution 0.03 kg BOD/day per pig. Therefore, enhancing wastewater treatment efficiency and the reuse in farm is imperative in order to meet the standards of Thailand.

**Keywords:** Pollution load; Waste management model; Pig farm; Circular economy concept.

## ET-O-133

### **Examining the connection between nutrients and water hyacinth invasion in the Lower Tha Chin River**

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#### **Abstract**

Water hyacinth (*Eichhornia crassipes* (Mart) Solms) is a rapidly developing aquatic plant that can double its coverage area every 62 days or increase its population from 10,000 to 600,000 plants in just eight months. Water hyacinths are biennial freshwater plants that can reproduce both sexually and asexually. The Tha Chin River has an estimated volume of 322,852 tons, or 20 tons/m<sup>2</sup>, between October 2020 and May 2021. From February to June, water hyacinths grow at a rapid rate. Ammonia, nitrite, and total phosphorus from the environment and life, with a focus on people, industry, agriculture, fisheries, transportation, and consumption. The water hyacinth uses phosphorus as a nutrient when it grows quickly, which affects aquatic life and gives the water a bad taste and odor. Ammonium is harmful to aquatic life, and nitrogen, in the form of nitrite and nitrate, causes eutrophication, which accelerates the growth of aquatic weeds and water hyacinth. Surveys using satellite imagery from remote sensing, based on past data from Landsat 8 satellite images in this study investigated the relationship between nutrient elements and water hyacinth invasion in the lower Tha Chin River. The results demonstrated that the area between TC07 and TC04 and between TC04 and TC01 has a level of plant coverage in the moderately density range related to the concentration of ammonia and phosphorus in Tha Chin River.

**Keywords:** Water hyacinth; Ammonia; Nitrite; Nitrate; Total phosphorus

## ET-P-021

### On the Sustainable Production of PVDF-OH Ag/TiO<sub>x</sub> Nanocomposites for Efficient Cleaning of Oily Wastewater

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#### Abstract

The formidable challenge of freshwater scarcity, widely deliberated within the clean water reclamation community, is a grave threat to humanity, primarily stemming from inadequate disposal of oil and its associated organic pollutants into water bodies. Despite ongoing efforts to address this pressing concern, the development of a material capable of efficiently cleansing oily wastewater while sustainably and scalably removing dissolved organic pollutants remains elusive. This contribution reviews a sustainable solution to this critical problem. Herein, a unique connection established between two highly-evolving nanotechnologies that have already reached the technology transfer stage - electrospinning and reactive laser ablation in liquids (RLAL) is considered. Their union permits the incorporation of precisely engineered multielement NPs into robust nanofibrous membranes. The junction between the NPs and membranes unlocks a simultaneous separation of water from oily polluted sources (>80 % of an n-hexane extremely tight emulsion in water) while purifying it by catalytically reducing organic pollutants in an ultra-fast process (beyond 58 % of 4-nitrophenol in about 0.3 s). Beyond its exceptional performance, a sustainability assessment, encompassing electrospinning and any laser-mediated synthesis of nanomaterials in colloids strategy, underscores that the nanocomposite's manufacturing aligns with the environmental, social, ecological, and technical pillars of sustainable development—a critical consideration for real-life applications. Collectively, these aspects emphasize the significance of such type of nanocomposites, suggesting that their utilization and production have the potential to alleviate the shortage of clean water without posing adverse effects on the environment throughout their operational lifespan.

**Keywords:** oil-water separation; nanocomposites; membranes; reactive laser ablation in liquids; nanoalloys

## ET-P-022

### Specific Regeneration Energy of the High Concentration Tri-amine AMP-PZ-MEA Solvent for Carbon Capture

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#### Abstract

In this study, specific regeneration energy ( $Q_{reg}$ ; kJ/mol CO<sub>2</sub>) of the high concentration tri-amine blend, which includes 2-amino-2-methyl-1-propanol (AMP), piperazine (PZ), and monoethanolamine (MEA), was investigated at total amine concentrations of 6 M and 7 M. Typically,  $Q_{reg}$  composes of three heat components including heat of desorption ( $Q_{des}$ ), heat of vaporization ( $Q_{vap}$ ), and sensible heat ( $Q_{sen}$ ). A major contributor on  $Q_{reg}$  was  $Q_{sen}$ , while  $Q_{des}$  and  $Q_{vap}$  were rarely change.  $Q_{sen}$  can be calculated from mole of desorbed CO<sub>2</sub>, which is a difference between initial CO<sub>2</sub> loading and CO<sub>2</sub> loading after regeneration, and a specific heat capacity ( $C_p$ ). The regeneration experiment was conducted in a desorption reactor at 363 K for 100 minutes. The studied AMP-PZ-MEA blends were (i) 2.5:0.5:3, 2:1:3, 1.5:1.5:3, 2:2.5:1.5, 1.3:3.2:1.5, and 0.95:3.55:1.5 (6 M) and (ii) 2:2.5:2.5, 1.3:3.2:2.5, and 0.95:3.55:2.5 (7 M). To calculate  $Q_{reg}$ ,  $C_p$  of studied blend (which can be analyzed by differential scanning calorimeter) was measured. The results showed that AMP-PZ-MEA had a lower  $C_p$  than the benchmark MEA at the same amine concentration. Among them, 0.95:3.55:2.5 possessed the lowest  $C_p$  value. Unfortunately, 0.95:3.55:2.5 did not show the lowest  $Q_{reg}$ . It is because  $C_p$  does not the only parameter affect  $Q_{reg}$  but mole of desorbed CO<sub>2</sub>. It was also found that the minimum  $Q_{reg}$  was observed at 2.5:0.5:3, which is the one with the largest mole of desorbed CO<sub>2</sub>. To reduced  $Q_{reg}$ ,  $C_p$  of the blend should be decreased while mole of desorbed CO<sub>2</sub> should be increased.

**Keywords:** Absorption; Amine; Carbon capture; Specific heat capacity; Regeneration

## ET-P-100

### The Assessment of Greenhouse Gases for Lerdsin Hospital

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#### Abstract

This research aims to study an evaluation of greenhouse gases (GHG) emissions from activities of Lerdsin Hospital. The emissions were evaluated by calculating the carbon footprint as kilogram carbon dioxide equivalent (kgCO<sub>2e</sub>). The GHG emissions were divided into 3 categories based on activities of the hospital as follows: Scope 1 comprises direct GHG emissions from sources that are owned or controlled by hospital such as stationary combustion, mobile combustion, refrigerants, CH<sub>4</sub> emission from septic tank & wastewater and LPG consumption. Scope 2 comprises indirect GHG emissions from purchased electricity by hospital. Scope 3 comprises all other indirect emissions due to activities of the hospital not included in Scope 2 e.g., water supply, amount of paper used and municipal solid waste. The results of GHG emissions of hospital evaluated using Thailand Greenhouse Gas Management Organization (TGO) from January to December 2023 reveal that the total GHG emission was 7,060,841 kgCO<sub>2e</sub>. Scope 1 had GHG emissions of 288,956 kgCO<sub>2e</sub> (contribute to 4.09%). The use of electricity (Emission Scope 2) contributed most greenhouse gas emission which emitted 5,691,900 kgCO<sub>2e</sub> (accounting of 80.61%). Finally, the GHG emissions from Scope 3 was the second rank with the value of 1,079,984 kgCO<sub>2e</sub> which share 15.3% of the total emission. The present result is in agreement with GHG emissions and share (%) in 2021 and 2022.

**Keywords:** Greenhouse Gases; Carbon Footprint for Organization; Global Warming; Climate Change



## ET-P-105

### **Investigating the relationship between Air Quality Index (AQI) and Meteorological Conditions and Health Risk Assessment: a Case Study of Bowin Subdistrict, Chonburi Province, Thailand**

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#### **Abstract**

Air pollution is a significant global issue that affects public health. Sources of air pollution include industrial, open burning, agriculture, and transportation. Understanding the relationship between meteorological factors and air pollution problems is crucial. This comprehension enables the development of effective measures, plans, policies to manage and reduce air pollution, promoting the overall health and well-being of the population. Therefore, the purposes of the study are to investigate the relationship between Air Quality Index and meteorological factors, and health risk assessment. The area selected is Bowin Subdistrict, Chonburi Province, as an industrial zone. Data on air pollution and meteorological factors from the past 10 years (2012-2021) were collected from the Pollution Control Department and Chonburi Meteorological Station, respectively. Air pollution consists of SO<sub>2</sub>, NO<sub>2</sub>, O<sub>3</sub>, PM<sub>10</sub> and PM<sub>2.5</sub>, while meteorological factors include atmospheric pressure, rainfall, windspeed, temperature, and relative humidity. Pearson's correlation, simple linear regression, and multiple linear regression were used to analyze the relationship between air quality index and meteorological factors. In addition, a health risk assessment based on the United States Environmental Protection Agency (U.S. EPA) was applied to assess and quantify potential health risks corresponding with air pollution concentration. The result revealed that atmospheric pressure has a direct relationship with AQI, while rainfall, relative humidity, and wind speed are inversely proportional to AQI. For health risk assessment, HQ values were highest in cold season, followed by the rainy and hot seasons. Children aged 6 and 12 exhibited higher HQ value than other age groups.

**Keywords:** Air Quality Index; Health Risk Assessment; Meteorological factor;

## IT-O-061

### Adsorption of Moisture by Rice Husk Silica and Commercial Silica

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#### Abstract

Adsorption of moisture by rice husk silica and commercial silica was investigated in this study. Rice husk silica was extracted from rice husk using a strong base solution and neutralized by a strong acid solution. After drying process, the silica was characterized by XRF and BET. Subsequently, the adsorption experiments were carried out in a batch to determine adsorption equilibrium time and adsorption isotherm. It was found that the purity and the surface area of rice husk silica were 80% and 210 m<sup>2</sup>/g, respectively. The adsorption process of both silicas reached equilibrium within 36 hr. Furthermore, the adsorption isotherms were found to be linear in the range of moisture content studied and the adsorption capacity of rice husk silica was around 63% of that of commercial silica.

**Keywords:** Adsorption; rice husk silica; air moisture content.

## IT-O-130

### Development of Convolutional Neural Network for Leaked Gas Detection and Classification in Chemical Processes

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#### Abstract

In recent years, the development of machine learning is considered as one of the best achievement in technology advancement. Numerous types of machine learning algorithms are available to help human being to tackle real-life advance problems in various domains, e.g., bioinformatics, medical information processing, cybersecurity, gas classification, and many others. Detecting gas become crucial for health and safety aspect in chemical industry. Classifying the type of gases in chemical industry is important to know the best treatment if there are small leakages in pipelines for instance. Furthermore, classifying the type of gas can be done by using machine learning. One of the most popular machine learning algorithms is convolutional neural network (CNN). CNN has been chosen due to the capability to automatically detect significant features without any human supervision. In addition, CNN has better generalization compared to any other machine learning algorithms. In this research, a developed CNN architecture will be trained and validated by using different types of data set. There are five types of gases that will be used, which are pure Methane, pure Ethylene, pure CO, mixture CO-Ethylene, and mixture Methane-Ethylene. The highest accuracy given by the CNN architecture will be considered as the best model in this research.

**Keywords:** Deep Learning; Convolutional Neural Network; Gas Classification; Gas Prediction.

## IT-O-134

### **Predictive model for the Fatigue life of a low-cost leaf cup mold**

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#### **Abstract**

Natural, environmental and health conservation have recently been a driving trend in using natural materials for foodware, such as teak and banana leaves, instead of plastic and foams. But cup forming machine is generally expensive primarily because of mold price. This research therefore proposes a design for cup forming machine made of natural leaves, and on that basis, predicts useful lifetime of the associated low-cost molds. The design of the machine that has the capacity to form foodware by using natural leaves with diameter of 200 mm, will have the depth of 450 mm. From the experiment, it is found that the optimal factor conditions for the forming process can be achieved by using heat at 120°C for 150 seconds. In this setting, the average cost of each banana-leaf cup is estimated at 0.35 Baht, starch water weighing 10 grams, where estimate of cost recovery is 52 days. If applying static finite element analysis (FEA) by using mold made of stainless steels (SUS 304) weighing 360 grams, fatigue damage based on thermodynamic calculation (by using software ANSYS in the prediction of fatigue life cycles) shows that it requires forces of 10 kN in order to form cups at 120°C. On this premise, there will be residual stress at the maximum level of 284 MPa on each side of the holes at the bottom of the cup, but also residual heat in the process at the maximum temperature of 84.58°C. Fatigue life prediction of the mold is estimated at 36 million cycles.

**Keywords:** Cup-formation machine; Natural-leaf cups; Fatigue life; Thermal fatigue

## IT-O-135

### Study on Coefficient of Performance Model for Industrial Refrigeration System

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#### Abstract

The aim of this research was to study the composition of mixed refrigerants, specifically R32/R290, R32/1270, R134a/R290, and R134a/R1270, their impact on the coefficient of performance (COP) and global warming potential (GWP) of refrigerants. The objective was to improve the efficiency of refrigerants for industrial applications by achieving high COP and appropriate GWP. To achieve this goal, we used Aspen Plus to predict the properties of blending refrigerants. We then used the obtained data in the NIST refrigeration system simulation program (Cycle\_D-HX), which showed that the type of mixed refrigerant, composition, and behavior of the refrigerant in an azeotropic mixture affected the COP significantly. The wide phase difference reduced the COP significantly. Moreover, the composition affected the GWP. The composition of hydrocarbon in blending refrigerants that met the Montreal Protocol Standard were 0.8, 0.8, 0.9 and 0.9 for R32/R290, R32/1270, R134a/R290, and R134a/R1270, respectively.

**Keywords:** Binary refrigerant mixtures, Azeotropic, Coefficient of performance (COP)

PE-O-007

## Design of An Internally Heat-Integrated Distillation Column via Economic Based Column Energy Profile Approach

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### Abstract

The internally heat-integrated distillation column (HIDiC) is considered one of several approaches for process intensification in chemical processes. Research on the design of the HIDiC has become of great interest during the past few decades. The design of an HIDiC could be carried out via various design approaches such as rigorous process simulation, mathematical programming, genetic algorithm, or H-xy and T-xy diagrams. In this study, an alternative approach based on the economic-based column energy profile was applied to the design of an HIDiC. The economic criterion for generating column energy profiles is the maximum energy saving per additional investment (MESAI). Each data point on the MESAI profile is generated by optimizing the heat load and the additional investment required when adding a side exchanger at any stage. Aspen Plus simulation software was used in the profile generation and the HIDiC simulation. The resulting column profiles could help provide insights into the economic viability of the heat-integrated distillation column, aiding decision-making and reducing optimization efforts. The economic analysis conducted in this study reveals that the designs obtained from the MESAI profiles demonstrate lower costs compared to the design based on the H-xy and T-xy diagrams. Among the configurations studied, the best design from the MESAI profiles is the HIDiC with three side exchangers.

**Keywords:** Internally heat-integrated distillation column, Economic criterion, Maximum energy saving per additional investment (MESAI)

## PE-O-028

### Life Cycle Assessment on Alternative Hydrogen Production for Greener Technology

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#### Abstract

Hydrogen is identified as an alternative energy carrier and one of the future fuels in global clean energy transition journey. Net-zero carbon emissions hydrogen productions have been developed since steam methane reforming is a conventional hydrogen production and involves carbon dioxide emissions. This study aims to perform life cycle impact assessment of conventional hydrogen production and compare the outcomes to two other zero carbon emission technologies: proton exchange membrane electrolysis and methane pyrolysis. Main inventory data collection is based on process simulation with Aspen plus V12.0 and Simapro 9.1 is used for impacts assessment. The system boundary involves gate-to-gate consideration with electricity supply from Thailand's grid mix and the functional unit is 1000 kg h<sup>-1</sup> of hydrogen production. Recipe 2016 Midpoint impact assessment method is used to evaluate global warming potential and four other impact categories. In terms of global warming potential comparison, proton exchange membrane electrolysis shows 1.7 times higher than steam methane reforming and 2.3 times larger than methane pyrolysis since its entire energy is based on fossil-based electricity. Although methane pyrolysis is relied on hydrocarbon feedstock like steam methane reforming, methane pyrolysis proves to have the lowest environmental impact in all five impact categories conducted.

**Keywords:** Hydrogen production; steam methane reforming; proton exchange membrane electrolysis; methane pyrolysis; Aspen Plus; life cycle assessment.

## PE-O-035

### **Economic Evaluation of Intensified Furfural Production Process with Reactive-azeotropic Dividing Wall Column Using Aspen Plus Program**

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#### **Abstract**

The conventional process to produce the furfural from bagasse was modified in this work. The sections of reaction and separation were combined to reduce the fixed capital cost and the energy consumption. The separation process with three simple distillation columns to purify the furfural proposed by Silva et al. was referred for the synthesis of the prototype process. Some process parameters such as number of stages, reflux ratio, and steam flow rate were varied by sensitivity analysis of Aspen Plus program. The furfural product with 99 wt% purity was obtained by the prototype process. The process intensification via reactive distillation (RD) and reactive- azeotropic dividing wall column (RDWC) was investigated. After tuning the suitable parameters, both modified processes can maintain a 99 wt% purity of the furfural with high product recovery and decrease about 86% of the usage of cold utility. Economic indicators including total capital cost (TCC), total operating cost (TOC), net present value (NPV), internal rate of return (IRR), and discounted payback period (DPP) were evaluated. The TCC savings of the RD and RDWC processes were 37.4 and 68.6%, respectively. However, both modified processes showed about 26% increase of the TOC. The NPV, IRR and DPP showed positive results after modification and therefore an investment to modify the furfural production process was promising.

**Keywords:** Furfural production process; Reactive-azeotropic dividing wall column; Economic evaluation; Aspen Plus program.



## PE-P-016

### Performance Improvement of Wet Scrubbing Unit for Resin Production

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#### Abstract

The resin manufacturing plant is a facility where resin is produced on a larger scale. Plant resins are valued to produce varnishes, adhesives, polyester, and electro-deposit painting. In the process, there are waste gases such as toluene, xylene, butyl cellosolve, and methyl isobutyl ketone. Wet scrubbers are used resin process for purification of gas and pollution control. Poor performance of wet scrubber cause odor impact and unpleasant odor. The media in scrubber normally use water or 5% of sodium hydroxide solution but waste gas difference for solubility with the media in scrubber. The selection and removal of media is challenging, so other parameters need improvement. In this research, ASPEN PLUS was applied to simulate the waste gas from resin processing to wet scrubber system for improve the performance of wet scrubber. In the resin process, there is a waste gas flow rate of 64 kg/hr. The knockout drum is a crucial unit in the wet scrubber system used to reduce the load of waste gas to the wet scrubber. In the knockout drum multiple temperatures from 30 °C to 50 °C were simulate along with three nitrogen flowrates :5, 10, 20 kg/hr. The optimal conditions identified through simulation can enhance the capture of waste gases in the knockout drum, consequently reducing the impact of waste gases on the wet scrubber.

**Keywords:** Resin process; Knockout drum; Wet scrubber.

## PE-P-019

### Simulation of Hydrocracking Process: Impact of Process Parameters on Product Yields and Properties

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#### Abstract

Residue hydrocracking (RHC) is a crucial refinery process that converts heavy oil residues into valuable distillate products such as diesel and gasoline. This process significantly enhances the value of heavy crude oil by upgrading low-value residues into more marketable products. RHC is a complex process involving high temperatures, pressures, and catalysts to break down the large hydrocarbon molecules found in heavy residues. This study aims to simulate the hydrocracking process to maximize diesel production, considering various process parameters using Aspen HYSYS. The investigated process parameters include feed quality (such as light vacuum gas oil (LVGO), heavy vacuum gas oil (HVGO), and short residue (SR)), feed rate, gas-to-oil ratio, recycle gas H<sub>2</sub> purity, and combined feed ratio (CFR). A simulation model was developed using the factorial design approach to examine the impact of these process parameters on diesel production. The simulation results indicated that feed quality exerts the most significant influence on diesel production, followed by feed rate, gas-to-oil ratio, recycled gas H<sub>2</sub> purity, and CFR. Implementing these conditions is predicted to yield diesel production of 36.62%, 49.94%, and 54.03% using feed quality as SR, HVGO, and LVGO, respectively. The simulation results also demonstrated that optimizing process parameters can enhance diesel production. These simulation outcomes are valuable as they provide a practical tool for optimizing hydrocracking process operations to maximize diesel production. Additionally, the study emphasizes the crucial role of feed quality in determining diesel production.

**Keywords:** Hydrocracking process; Aspen HYSYS; Factorial design; Diesel production; Process optimization.

## PE-P-023

# Simulation and Techno-Economic Comparison of Subcritical Dimethyl Ether, Supercritical Carbon Dioxide and Organic Solvent Extraction of Rice Bran Oil Manufacture

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### Abstract

This study aims to evaluate the economic feasibility using subcritical dimethyl ether (SUBDME) and supercritical carbon dioxide (SC-CO<sub>2</sub>) as alternative solvents to replace the conventional toxic solvent hexane of extraction rice bran oil (RBO). Large-scale RBO extraction processes were simulated in Aspen Plus through semi-batch operations, with extraction conditions obtained from published literature. The simulation results, including mass balances, energy consumptions, and equipment costs, were further analyzed to assess economic feasibility. Techno-economic analysis revealed that SUBDME and hexane extraction processes were the most economical compared to SC-CO<sub>2</sub>. Raw material and utility prices were identified as the most impactful variables on the cost of manufacturing (COM), making SC-CO<sub>2</sub> extraction less profitable overall. Profitability analysis indicated that SUBDME could compete favorably with commercial RBO extraction by hexane with the NPV of  $182.2 \times 10^6$  US\$ and the payback period of 3.49 years.

**Keywords:** Rice bran oil; Subcritical DME extraction; Simulation; Techno-economic analysis

## PE-P-024

### **Process simulation and techno-economic evaluation of free lutein production from marigold flowers by dimethyl ether extraction and de-esterification**

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#### **Abstract**

Marigold flower extract is known to be the richest source of lutein, which has numerous applications in the food, pharmaceutical, cosmetic, and health sectors. Lutein in marigold flowers is generally found in mono- or di-esterified forms of fatty acids, the majority of which are lutein palmitate. In these forms, lutein is not readily absorbed by human body. After extraction, the extract of lutein in esters form or marigold oleoresin, therefore, needs to be converted to free lutein by reacting with an alkali solution (e.g., KOH). Extractions with organic solvent and supercritical (e.g., CO<sub>2</sub>) have been successfully employed for large-scale extraction of marigold flowers. Due to its economic and environmental benefits, liquefied dimethyl ether (DME). The possibility for simultaneous DME extraction and de-esterification has also been demonstrated, requiring fewer process steps, and thus improve the process efficiency. In this work, Aspen Plus V.11 software was used to model a free lutein manufacturing process from marigold flowers (1000 tonnes/year). Techno-economic and economic sensitivity analyses will be carried out for the two-step extraction and simultaneous extraction/de-esterification processes, and the estimation of energy and utility consumption, the estimation of capital expenditure (CAPEX), and operating expenditure (OPEX), will be compared.

**Keywords:** Marigold flowers; Lutein; Liquefied dimethyl ether; Techno-economic analysis

## PE-P-033

# DETECTION AND REPLACEMENT OF STATES WITH SPIKES AND NOISE BY LONG SHORT-TERM MEMORY MODELS OR NEURAL NETWORKS

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### Abstract

Spike signals are often discussed in the context of neuroscience, but it's found that they are also encountered in control systems. Both fields share a similarity in that spike signals have a common characteristic of immediate and temporary changes in signal amplitude. The difference lies in the source of the spike signals and the purpose of detection. In control systems, the sources of spike signals can be varied, such as signal interference, environmental factors like temperature changes or vibrations, sensor defects or damage like sensor degradation or calibration issues, etc. The purpose of detecting spike signals in control systems is to find and eliminate them, as spike signals can have several detrimental effects on the control system. For example, they can introduce incorrect data into control circuits, result in inaccurate measurements and feedback, leading to inappropriate control outcomes or overreactions that cause the system to become unbalanced and less efficient. This work presents a new method using LSTM or NN models for detecting spikes and noise signals, and for replacing these signals in second-order systems.

**Keywords:** Long Short-Term Memory (LSTM), second-order systems, spike signals

PE-P-034

## Two-stage Stochastic Optimization of Sustainable Bioethanol Supply Chain under Demand Uncertainty and Multi-Season Biomass

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### Abstract

Bioethanol-blended gasoline fuel is one of the alternatives to reduce CO<sub>2</sub> emissions from the transportation sector. Since its production still depends on demand fluctuation and feedstock availability, an optimal supply chain design needs to be evaluated. A two-stage stochastic optimization model with mixed-integer linear programming (MILP) is developed for the bioethanol supply chain under multi-feedstock second-generation biomass, biomass multi-season, and demand uncertainty. The model maximizes the expected profits by optimizing biomass type, plant location, and biomass-bioethanol pathways. An extension model by considering environmental performance is also studied to observe the impact of net emission reduction. The validation process was then performed by comparing the stochastic and deterministic models in terms of plant location and operating decisions. The obtained model was applied to a real data of case study in Thailand involving 26 existing plants and agricultural residue availability. The optimization result illustrates that the stochastic model is 16% more profitable than the deterministic model for all random data sets. Furthermore, an extension model shows that carbon credit can involve around 5% of the total profit earned. Thus, the proposed model can address demand uncertainty situations in supply chain design and can be implemented by policymakers to achieve sustainable bioethanol production.

**Keywords:** Biomass to Bioethanol; Sustainable Supply Chain; Stochastic MILP; Second Generation Biomass

**PE-P-045**

## **Sustainable Heat Exchanger Network Synthesis Using Linearization Method**

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### **Abstract**

The Paris Agreement aims to reduce global warming by 45% by 2030 and reach a net-zero target by 2050, CO<sub>2</sub> emissions have also become the trend right now to reduce global warming and gain credit from it. Heat Exchanger Network Synthesis (HENS) is a method to reduce energy use, affecting environmental, social, and economic impact. Stage-wise superstructure (SWS) is a mathematical programming model using Mixed Integer Nonlinear Programming (MINLP) to synthesize HENS. The area term in SWS becomes an obstacle for the computational process because of nonlinearity. This research will be focused on the sustainable aspect by adding a CO<sub>2</sub> emission variable into the SWS model and reducing nonlinear terms. The credit gained from CO<sub>2</sub> emission reduction by exchanger-heat recovery will be subtracted from overall cost in the objective function. The linearization method will be applied to reduce nonlinear terms in the model by converting the continuous model to a discrete model. Linearization terms will significantly reduce the processing time problems and make more robust HENS models to generate the most cost-effective design.

**Keywords:** CO<sub>2</sub> Emission; Linearization; Sustainability; Heat Exchanger Network Synthesis.

## PE-P-083

# Performance Analysis and Optimization of Sorption-Enhanced Chemical Looping Oxidative Steam Reforming of Methanol for High-Temperature Proton Exchange Membrane Fuel Cell

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### Abstract

Hydrogen is widely regarded as a promising energy carrier for sustainable energy systems, particularly in achieving high efficiency through fuel cell applications. However, the storage of hydrogen poses significant challenges in the development of a hydrogen-based economy. Alternatively, due to its distinctive properties, methanol emerges as an attractive hydrogen carrier. This study explores an integrated system that combines sorption-enhanced chemical-looping oxidative steam methanol-reforming (SECL-OSRM), utilizing CuO-MgO as a bi-functional material, with a high-temperature proton exchange membrane fuel cell (HT-PEMFC). The integrated process simulation employs a thermodynamic model in Aspen Plus. A comprehensive parametric analysis of the proposed system is conducted to gain insights into the impact of the mole ratio of CuO/CH<sub>3</sub>OH, MgO/CH<sub>3</sub>OH on SECL-OSRM performance parameters including methanol conversion, hydrogen production concentration, carbon monoxide concentration, and hydrogen production rate. Additionally, the effects of operating temperature and current density are considered to assess the performance of the HT-PEMFC. The findings indicate that the SECL-OSRM system enhances the production of high-purity hydrogen, achieves low CO concentrations at lower than 0.3 vol.%, and high production flowrate at 0.5, 0.5 mole ratio of the CuO/CH<sub>3</sub>OH, MgO/CH<sub>3</sub>OH, which is suitable for HT-PEMFC operation. Furthermore, SECL-OSRM has the capability to achieve auto-thermal operation and can be enhanced by harnessing waste heat from the fuel cell. The increment of fuel cell temperature and current density are favorable for improving net power output. The proposed system presents a maximum system total efficiency at 41.5%.

**Keywords:** Sorption-enhanced chemical looping reforming; Methanol; High-temperature proton exchange membrane fuel cell; Performance optimization; Exergy analysis



## SP-O-011

### Potential of Advanced Tri-amine blends of 2-amino-2-methyl-1-propanol (AMP), methyl diethanolamine (MDEA), and piperazine (PZ) for Post-Combustion Carbon Capture

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#### Abstract

Post-combustion carbon capture technology, which uses an absorption process by amine solvent, has widely been implemented to capture CO<sub>2</sub> for decades. This study measured the physical properties and absorption capacity of carbon dioxide in mixed amine solution of 2-amino-2-methyl-1-propanol (AMP), piperazine (PZ), and methyldiethanolamine (MDEA). Since AMP and PZ precipitate at high amine concentration, the mixed solvents were screened based on a visualized solid sediment formation. The possible total amine concentration range of 20-40% wt., which can maintain a clear solution, was obtained. A mixture design then applied to systematically formulate the mixed amine solution. As a result, 21 aqueous solutions at different weight ratios of AMP, PZ, and MDEA were suggested. Physical properties (i.e., density and viscosity) of the mixtures are measured by an Anton Paar SVM3001 at temperatures of 293- 363 K. The results showed that density and viscosity of the AMP- PZ-MDEA solvent increased with concentration of PZ increased but decreased as concentration of MDEA increased. Additionally, both measured densities and viscosities dropped as temperature increased. Absorption capacity of the mixed solvent at CO<sub>2</sub> partial pressure of 12.1 kPa and 313 K was also experimentally determined. It was observed that CO<sub>2</sub> absorption capacity of AMP-PZ-MDEA can be improved by increasing PZ concentration. Interestingly, 5% wt. AMP : 30% wt. PZ : 5% wt. MDEA (40% wt. total amine concentration) showed the highest CO<sub>2</sub> absorption capacity (0.728 mol CO<sub>2</sub>/mol amine), which is much higher than that of 5 M MEA (0.502 mol CO<sub>2</sub>/mol amine).

**Keywords:** Carbon capture; amine; absorption; advanced solvent

**SP-O-017**

## **Exploring Competitive CO<sub>2</sub> and H<sub>2</sub>S absorption by Polyethylene Glycol PEG200**

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### **Abstract**

The exploration of thermophysical and structural attributes regarding competitive gas absorption in Polyethylene Glycol (PEG)200, composed of a blend of ethylene glycol oligomers with an average molar weight of 200 g·mol<sup>-1</sup>, at 298.15 K and 1 bar in the presence of CO<sub>2</sub> and H<sub>2</sub>S, was executed through Molecular Dynamic (MD) simulation. Density, radial distribution function (RDF), mean square displacement (MSD), concentration profile, free volume, and fractional free volume were the subjects of investigation. The descending order of gas solubility in PEG200 at 298.15 K is as follows: H<sub>2</sub>S > CO<sub>2</sub>, reflecting the respective interaction orders between the gas and PEG200. On the contrary, gas diffusivity in PEG200 exhibits an inverse pattern. The alignment of H<sub>2</sub>S gas molecules within the glycol oligomers present in PEG200 solvent, along with calculations involving hydrogen bond interactions and coordination numbers, revealed a pronounced affinity between the solute and solvent. This interaction was particularly notable in its association with the O–H functional groups of glycol monomers. The structural analyses indicated that gas molecules position themselves within the solvent particles by compressing certain sections of PEG200 to occupy free spaces, as confirmed by atomic Z-density and trajectory. The results support the assertion that PEG200 demonstrates higher hydrophilicity owing to its stronger interaction with H<sub>2</sub>S and a reduced number of branched –CH<sub>3</sub> groups, consequently resulting in fewer hydrophobic pockets. RDF analysis elucidates the interaction and stronger intermolecular connections between Pentaethylene Glycol monomers and H<sub>2</sub>S gas, highlighting the distinctive nature of this particular interaction amidst the various oligomers investigated.

**Keywords:** PEG200, CO<sub>2</sub> capturing, Molecular dynamics simulation, RDF analysis

## SP-O-020

### Process simulation of the reactive distillation using various ethanol-to-lactic acid ratios for the purification of lactic acid produced by fermentation

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#### Abstract

The objective of this study was to know the effects of the molar ratios between ethanol to lactic acid on the process that used reactive distillation columns to purify lactic acid obtained from the fermentation. Aspen Plus V.10 was used to simulate the process to produce 88 wt % lactic acid. The molar ratios of ethanol to lactic acid were 3:1, 4:1, and 5:1. The simulation results showed that if the reboiler duty was the same for all ratios, the purity of lactic acid decreased with the increase of the molar ratio. This was because the temperature profiles in the column decreased, leading to the lesser extent of the reactions. When the reboiler duty was adjusted to generate similar temperature profiles, the purity of lactic acid increased to the specified value. When the conversion %, the lactic acid production rate, and the energy utilization were considered, the molar ratio of 3:1 provided the highest conversion % and the production rate. The reboiler duty of the columns was also the least.

**Keywords:** Lactic acid; Process simulation; Reactive distillation; Purification

## SP-O-039

### Extraction of *Thunbergia laurifolia* Lindl. with Subcritical Fluid Technique Nichapa Areepong<sup>1</sup>, and Veronica Winoto<sup>1,\*</sup>

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#### Abstract

*Thunbergia laurifolia* Lindl. or Rang Jued is a local Thai plant that belongs to Acanthaceae family. It was widely used as herbal Thai tea or for medical treatments. Moreover, this plant has been reported that the leaf extracts consist of antioxidants which are phenolic compounds. In this work, the antioxidant activity of *T. laurifolia* (TL) leaves was investigated under subcritical conditions. The extraction was prepared by varied amounts of *T. laurifolia* powder ranging from 0.1 to 0.5 grams, with extraction temperature at 160 to 240°C, and extraction time between 1 to 9 minutes. A 99.9% ethanol was selected as a solvent for this subcritical extraction. The total phenolic content (TPC) was examined by using the Folin Ciocalteu method with UV-visible spectrophotometer at 750 nm. The results indicate that the effect of temperature and time significantly affect the TPC amount. The optimum condition with the highest TPC of 45.42 mg GAE per g was at 0.1 g of *T. laurifolia* powder, at 240°C extraction temperature, and 1 min of extraction time.

**Keywords:** *Thunbergia laurifolia* Lindl.; Subcritical Fluid; Extraction; Antioxidant; Total Phenolic Content.

## SP-O-055

### **Fabrication of Thin Film Composite Nanofibrous Membrane using Electrospinning and Dip Coating Technique for Selective Protein Purification**

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#### **Abstract**

Membrane technology is highly effective in isolating proteins from other molecules through size exclusion or diffusion. However, many protein separation membranes are made from relatively hydrophobic polymers like polysulfone, a widely used material in the traditional membrane production method known as phase inversion. These membranes are prone to fouling caused by various impurities that are exacerbated by their non-uniform pore sizes and inherent hydrophobic properties. This research aimed to fabricate a thin film composite nanofibrous (TFCN) membrane with highly selective and improved anti-fouling properties by using a versatile electrospinning and dip coating method. Polyacrylonitrile-co-methyl acrylate (PAN-co-MA) electrospun nanofiber support was dip-coated with various concentrations (1.5, 3, and 5 wt%) of Pebax®. The results showed that the PAN nanofibrous was successfully coated with Pebax. The highest solute rejection of  $56.63 \pm 4.99\%$  with a permeance flux of  $2.21 \pm 5.26 \text{ L.m}^{-2}.\text{h}^{-1}.\text{bar}^{-1}$  was achieved by the thin film with 5% Pebax®. This membrane exhibited good potential as an ultrafiltration or nanofiltration membrane for the purification of protein. Further studies on the hydrophilicity, specific molecular weight cut-off, and anti-fouling properties of the TFCN are recommended to explore its capacity as a new, lightweight, and highly efficient membrane.

**Keywords:** Electrospinning; nanofibrous membrane; protein purification; thin film.

## SP-O-064

### Antisolvent Crystallization and Nucleation Rate of Polymorphs of DL-Methionine

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#### Abstract

DL-methionine is crucial in the case of health maintenance and produced as an active pharmaceutical ingredient, a dietary supplement, in animal feed, and as a precursor for other chemicals. DL-methionine could be crystallized into three forms:  $\alpha$ —metastable,  $\beta$ —stable, and  $\gamma$ —most stable.  $\alpha$  and  $\beta$  forms normally nucleate concomitantly in the crystallization, then transform into  $\gamma$ , the most stable form. However,  $\beta$  form is difficult to transform, nevertheless, the crystallization of pure form is concerned. Ethanol was selected as antisolvent, an antisolvent crystallization was carried out to nucleated the crystals and a pure form. Raman spectroscopy and Microscopy were used for identifying the crystal polymorphism.  $\alpha$  form was obtained at high fraction of antisolvent used. A mixture of  $\alpha$  and  $\beta$  form were obtained at lower fraction of antisolvent. The nucleation rate of  $\alpha$  form was further estimated by Focus Beam Reflectance Measurement (FBRM). Therefore, this work studied the DL-methionine crystals nucleation and polymorphism, the nucleation rate of a pure  $\alpha$  form was also included.

**Keywords:** Crystal polymorphs; nucleation; antisolvent; crystallization.

## SP-O-068

### **Effect of Methanol on the Solubility and Nucleation Point of Papain** **Chonut Xaiyathoumma<sup>1</sup>, Penchit Chitnumsub<sup>2</sup>, and Lek Wantha<sup>1,\*</sup>**

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#### **Abstract**

The solubility is important information for enhancing the industrial crystallization design and the enzyme crystallization as well. The solubility of crystalline papain was measured by the gravimetric method in this work. An excess amount of papain powder was dissolved in the buffer solution (pH5) and buffer solution with methanol ratio (10:0, 10:1, 10:2 and 10mL:3mL) with controlling the temperatures (20, 10, 0, -4 and -8°C) to observe the saturated point. The saturated solution was filtrated and monitored by refractometer (Reflective Index). The concentrations of the saturated solution were measured by evaporation to dryness. Study of the supersaturated points of papain were performed the experiment by step cooling (°C/h) the saturated solution to the temperature of 3, 0, -3, -4, -6 and -8°C until crystal nucleation. This papain powder was found out that the solubility was raised with increasing temperature and a bit decreased with increasing the ratio of methanol. Even though there was not a large difference. And supersaturation of papain was reached (nucleation) at about -3°C while it had prepared from saturation solution of 20°C with methanol and without methanol.

**Keywords:** papain; saturation; supersaturation; crystallization

## SP-O-091

### Reusability of Functionalized Cellulose Nanofiber for Heavy Metal Adsorption Membrane

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#### Abstract

Currently, heavy metal contamination in water is one of the critical environmental issues. Adsorption membranes was potentially used to solve that problem. Electrospun cellulose nanofiber was fabricated and functionalized by oxidation reaction to provide negative charges of carboxyl groups to interact with positive charges of heavy metal ions in wastewater. Functionalized cellulose nanofiber membrane was characterized using FTIR and SEM, and tested the heavy adsorption ability. Furthermore, different regeneration agents including ethylenediaminetetraacetic acid (EDTA), sodium chloride, and acids were studied the reusability of the functionalized cellulose nanofiber membrane.

**Keywords:** Nanofiber; membrane; heavy metal; regeneration; cellulose



**SP-P-005**

## **Equilibrium Molecular Interactions of Phosphonium-Based Ionic Liquids with CO<sub>2</sub> and H<sub>2</sub>S for Gas Separation**

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### **Abstract**

Molecular dynamics (MD) simulation was conducted to investigate the equilibrium behavior of tetrabutylphosphonium acetate ([P<sub>4444</sub>][AcO]) and tetrabutylphosphonium diethylphosphate ([P<sub>4444</sub>][DEP]) with CO<sub>2</sub>/H<sub>2</sub>S at 333.15 K and 1.01 bar. The GAFF (General Amber Force Field) was selected from the available forcefields to explore potential modifications that could enhance the consistency between simulated properties and experimental data. Analysis of the radial distribution function confirmed a physical interaction between the ionic liquids and the gases. The two ionic liquids have a large free volume that decreases after the absorption of CO<sub>2</sub> but increases with H<sub>2</sub>S which could be attributed to the angular geometry and polarity of H<sub>2</sub>S. This is supported by the significant negative Coulombic Energy observed in the two ionic liquid systems after absorption of H<sub>2</sub>S and its subsequent lower diffusivity. The molar diffusivity of the gases is higher in [P<sub>4444</sub>][DEP] and the self-diffusivity coefficient of CO<sub>2</sub> is 97.2% greater than that of H<sub>2</sub>S in the same ionic liquid. This work revealed that [P<sub>4444</sub>][DEP] can be considered and further studied for devising low-cost phosphonium-based ionic liquid for CO<sub>2</sub> capture.

**Keywords:** MD simulation; phosphonium-based ionic liquids; CO<sub>2</sub> capture

## SP-P-038

# Hollow Fiber Membrane Modeling and Simulation in the Application of Gas Separation Process

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### Abstract

A new hollow fiber membrane consisting of a porous support layer and a dense selective layer was developed for CO<sub>2</sub> separation process. Before industrial application, new membranes must undergo rigorous testing in an enhanced laboratory or a pilot scale, which requires well-equipped facilities and can be costly as well as time-consuming. Modeling and simulation provide a more practical and less costly way to initially test these membranes, avoiding the physical and financial limitations of traditional experimental approaches. This research introduced a mathematical model to describe the separation behavior of hollow fiber membranes operated in a shell-side feed and counter-flow configuration. The succession-of-state method together with the bisection algorithm were applied to investigate membrane performance and product quality. The models were coded via MATLAB and validated with pre-published experimental studies that involve CO<sub>2</sub> separation applications data available in literature and the experimental studies of CO<sub>2</sub>/CH<sub>4</sub> separation using our developed hollow fiber membrane. The result revealed that the mathematical model was unable to adequately describe the gas separation behavior in the novel hollow fiber membrane. The discrepancy is attributed to the assumptions of the modeling. Moreover, mathematical modeling by the shortcut method was insufficient in achieving the acceptable results. The recommendation for further study is to apply the full method in order to improve accuracy and ensure the reliability of the model.

**Keywords:** membrane gas separation; hollow fiber membrane; membrane modeling; succession of state

**SP-P-047**

## **Effect of Dip Coating Conditions on Film Thickness and CO<sub>2</sub>/CH<sub>4</sub> Separation Performance of Pebax/PEI Composite Hollow Fiber Membrane**

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### **Abstract**

A composite hollow fiber (HF) membrane was created, combining a porous polyether imide (PEI) support layer with a dense, selective Pebax layer. The key to its separation efficiency lies in the thickness and structure of this selective layer. The layer was applied to the support using a dip coating method, a straightforward technique offering easy control over film thickness. This study explored how different dip coating conditions, like polymer concentration and number of coating cycles, impact the membrane. The PEI support layer of the HF membrane is dipped in a dip coating solution, and the resulting Pebax-coated HF membranes were further crosslinked using a solution of toluene diisocyanate (TDI) in n-hexane to improve both their mechanical resilience and CO<sub>2</sub>/CH<sub>4</sub> separation ability. Various attributes of the final membrane were thoroughly examined, including the selective layer thickness, the mechanical strength of the membrane, as well as membrane performance (e.g., selectivity and permeance). The result revealed that the thickness of the selective film was easily controlled by adjusting coating concentrations and coating cycles. A membrane with a thicker layer exhibited a better mechanical strength, and improved selectivity but at a cost of gas permeance. Detailed and systematic investigation to obtain the optimal film thickness is highly recommended.

**Keywords:** dip coating; film thickness; hollow fiber membrane; Pebax; membrane gas separation

## SP-P-122

### Effect of Enantiomeric Configuration of Chiral Coformer in Chiral Resolution by Cocrystallization

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#### Abstract

Chiral separation is crucial in the pharmaceutical industry due to the increasing demand in obtaining enantiopure products. Enantiomers of a species have different biological activities. Therefore, the enantiomer with the higher activity or lower toxicity is desired. However, due to the identical physical properties between enantiomers, advanced techniques have to be employed. One of the techniques, cocrystallization with a chiral coformer, was selected to study. The separation process is started by combining a racemic mixture of an active pharmaceutical ingredient (API) with a chiral coformer to form cocrystal(s). In the case of an enantiopure coformer, the product can be either an enantiospecific or a diastereomeric system if the coformer forms cocrystal with one enantiomer of the API or both, respectively. If a racemic coformer is used, it is hoped that a conglomerate cocrystal will form which leads to simultaneously resolution of both enantiomers of the API. Regarding the different outcomes from cocrystallization, we studied the effect of changing the configuration of formerly known chiral-chiral cocrystal systems. We found that the system that can be resolved by forming enantiospecific or diastereomeric cocrystals when combining an API with an enantiopure coformer (*RS*-API + enantiopure coformer) was not always able to separate the enantiomers of the coformer; *i.e.* *RS*-coformer + enantiopure API did not result in separation of the enantiomers of the coformer. Also, the system that forms cocrystals when combining enantiopure API and enantiopure coformer was not always able to form cocrystals when trying to find an enantiospecific, diastereomeric, or conglomerate system.

**Keywords:** chiral resolution; cocrystallization; chiral coformer

## SP-P-138

### Adsorption Behavior of Industrial Dye by Activated Carbon derived from Bagasse Ash

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#### Abstract

Activated carbon derived from bagasse ash (BC) was investigated for the adsorption efficiency and behaviour of two industrial dyes compared with commercial activated carbon (AC). Methylene blue (MB) and Congo red (CR) were varied in concentration in the range of 25 to 100 ppm and adsorption time from 0 to 80 min. Their adsorption mechanisms were analysed using four adsorption isotherms: Langmuir, Freundlich, Dubinin, and Temkin. The results showed that the adsorption behaviour fit with the Langmuir model, which proved that the BC surface had a monolayer adsorbate adduct. The calculated parameters, maximum adsorption ( $q_m$ ) of MB and CR, were 526.32 mg/g and 82.64 mg/g, respectively, due to the smaller molecule of MB influencing the mass transfer rate into the porous structure higher than CR. The results of thermodynamic adsorption revealed chemical adsorption behaviour for two reasons: the standard enthalpy ( $\Delta H^\circ$ ) calculated from the Van't Hoff equation was positive and higher than 50 kJ/mol. The differential Gibb's energy ( $\Delta G^\circ$ ) and standard entropy ( $\Delta S^\circ$ ) confirmed that both industrial dyes adsorption by BC are spontaneous processes or forward reaction.

**Keywords:** Bagasse ash; Activated Carbon; Adsorption; Methylene blue; Congo red.

