

中原70・全球百大 次世代永續材料國際論壇

CYCU 70 x Top 100 Global Partners:
Forum on Next-Gen Sustainable Materials



2025.10.03 FRI
13:30-17:30
聯榮工學講堂



東京大学
THE UNIVERSITY OF TOKYO



TEXAS A&M
UNIVERSITY

主辦單位:



中原大學工學院
College of Engineering, Chung Yuan Christian University

指導單位:

中原大學
Chung Yuan Christian University

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In-Ming Lee

President of Chung Yuan Christian University

Message

On this distinguished occasion marking the 70th anniversary of Chung Yuan Christian University (CYCU), I am honored to extend a warm welcome to all our esteemed guests. On behalf of CYCU, I sincerely thank you for joining us in this celebration, and I offer my heartfelt congratulations.

We are proud to have established strong and enduring partnerships with three world-renowned institutions: Nanyang Technological University (2018), the University of Tokyo (2019), and Texas A&M University (2025). Each of these universities ranks among the top 100 globally, and their collaboration with CYCU reflects our standing as one of Taiwan's most outstanding private comprehensive universities.

These partnerships have flourished over the years, fostering close and friendly ties through a wide range of initiatives—including student exchange programs, annual mutual visits by faculty and students, degree-seeking opportunities, summer camps, internships, and collaborative research. These efforts have laid a solid foundation for rich and meaningful academic bonds.

Over the past seven decades, CYCU has remained steadfast in its commitment to academic excellence, international engagement, and holistic education to our students. The convening of this International Forum on Next-Generation Sustainable Materials exemplifies our forward-looking vision and leadership in addressing global sustainability challenges through interdisciplinary research and dialogue.

We are confident that this forum will serve as a valuable platform for scholarly exchange, the strengthening of global partnerships, and the advancement of innovative solutions toward a more sustainable and circular economy. Please accept my best wishes for the continued success and global impact of CYCU and our sister universities in the years to come.

In-Ming Lee

Oct. 03, 2025



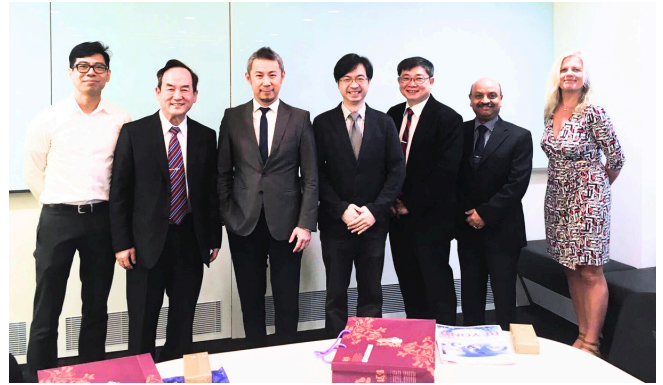
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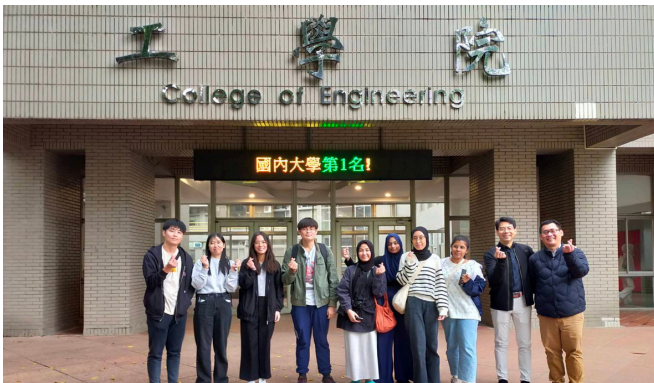
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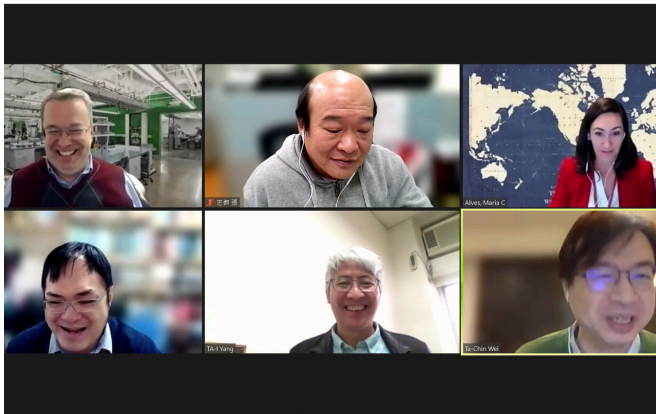


TEXAS A&M UNIVERSITY



中原大學

Chung Yuan Christian University



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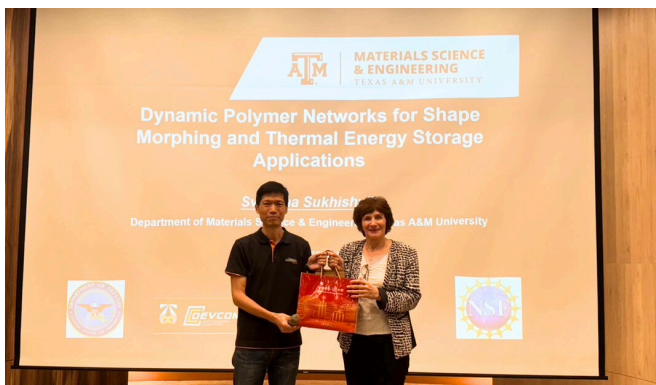
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CYCU 70 × Top 100 Global Partners: Forum on Next-Gen Sustainable Materials

聯榮工學講堂, Chungli, Taiwan, Oct. 3, 2025

PROGRAMME

Time	Activity
13:10-13:30	Registration
13:30-14:00	Opening Ceremony
14:00-14:25	Plenary Speaker: Prof. Tatsuya Okubo / The University of Tokyo Title: Zeolite: A Material for Sustainable Future.
14:25-14:50	Plenary Speaker: Prof. Hung-Jue Sue / Texas A&M University Title: Structure-Property Relationship of Cellulose Nanofiber-Reinforced PVP Nanocomposites.
14:50-15:15	Plenary Speaker: Prof. Tsair-Wang Chung / Chung Yuan Christian University Title: Implementing and Expanding the Impact of Taiwan–Japan–Indonesia Collaboration in Promoting Sustainable Materials of Biomass and Bioenergy through Industry–University Partnerships
15:15-15:40	Plenary Speaker: Prof. Raymond Lau / Nanyang Technological University Title: Unlocking Reactor Efficiency with 3D-Printed Catalyst Structures.
15:40-16:10	Group Picture/ Coffee Break
16:10-16:35	Keynote Speaker: Prof. Yukihiro Shimogaki / The University of Tokyo Title: Atomic Layer Process Design for the Beyond 1nm Era in ULSI: Atomistic Simulations Based on Quantum Chemistry and Neural Network Potentials
16:35-17:00	Keynote Speaker: Prof. Antoine Venault / Chung Yuan Christian University. Title: Design of Vapor-Induced Phase Separation Membranes for High-Performance Direct Contact Membrane Distillation
17:00-17:25	Keynote Speaker: Prof. Di Su / The University of Tokyo Title: Fatigue Assessment of steel Bridges Considering Material and Dynamic Effects.
17:25-17:30	Closing Ceremony
18:00-20:30	Banquet



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Tatsuya Okubo

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Presidential Advisor

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Zeolite: A Material for Sustainable Future

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Abstract

Toward sustainable future, it is very important timing to decelerate the climate changes. The University of Tokyo (UTokyo) is one of the first universities to employ sustainability as the management principle of the university. In 2021, we declare that we will become a carbon-neutral university by 2050. In April 2025, Center for Strategic Promotion of Green Transformation was established, and I have served as the founding director. First, UTokyo's strategy toward 2050 will be introduced.

Green transformation (GX) is a global task to realize sustainable future. There is no doubt that we all should play indispensable roles in the global GX toward carbon neutrality, nature positive and circular economy. We have worked on synthesis and application of zeolites since 1993. Zeolites have been widely utilized as catalysts, adsorbents and ion-exchangers. Recently, application has been expanded to automobiles, medical uses, nuclear waste management and beyond. Very recently, zeolites have been proposed to apply for direct air capture of carbon dioxide, ultimate negative carbon emission technology. Toward the grand challenges, further improvement as well as game-changing innovation are highly anticipated. Expected contribution of zeolite to GX will be introduced.

The synthesis and production of zeolites have been exclusively carried out based on the traditional knowledge and experiences. We have re-engineered them based on the elucidation of the formation mechanism. The production of zeolites has not been environmentally benign enough; still, consuming obnoxious chemicals and a lot of energy with a long production period. The wastes should be minimized and recycled. The ongoing production highly depends on the state-of-the-art synthesis of zeolite. We have moved toward the rational synthesis and production of zeolites. Simultaneously, the formation mechanism of zeolites from sub-nano to nanometer scale has been investigated. In the past 10+ years, we have made the following achievements. Finally, some of the topics will be introduced in the presentation.

- √ Seed-assisted, organic structure-directing agents (OSDA)-free synthesis of zeolites that has been exclusively synthesized with OSDAs and beyond.
- √ Ultrafast synthesis and production of zeolite on the order of seconds to minutes.
- √ Introduction of informatics approach to zeolite synthesis.
- √ Design of the starting materials and the aging control with an understanding of the aluminosilicate structure.
- √ Novel post-synthetic treatments for further introduction of superior function



蘇皇宇

Hung-Jue Sue

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Structure-Property Relationship of Cellulose Nanofiber-Reinforced PVP Nanocomposites

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Abstract

Cellulose nanofibers (CNF) have garnered significant attention due to their renewability, biodegradability, and superior nanofiber strength. The present study investigates how the CNF surface characteristics, diameter, and length influence the tensile properties of CNF-reinforced polyvinyl pyrrolidone (PVP).

By employing a simple film casting approach, three different types of CNF with distinctively different diameters and lengths were used as reinforcement to enhance tensile properties of PVP. The findings reveal that low-oxidation CNF (LCNF) gives the best overall property improvement against the other two CNF types, which include high-oxidation CNF (HCNF) and mechanically disintegrated CNF (MCNF). The incorporation of LCNF above its critical concentration for CNF network formation can most significantly enhance the tensile strength and modulus of PVP. At the same concentration level, HCNF can improve modulus, but fail to improve tensile strength due to its short CNF length. MCNF can form network in PVP due to its long length, but does not enhance modulus much due to its lack of adhesion to PVP matrix. The implication of the work for preparation of CNF-reinforced polymer nano composites is discussed.



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Implementing and Expanding the Impact of Taiwan–Japan–Indonesia Collaboration in Promoting Sustainable Materials of Biomass and Bioenergy Through Industry–University Partnerships

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Abstract

International industry–university collaboration in technology development and implementation remains limited. This study examines sustainable materials cooperation in the fields of bioresources and bioenergy, highlighting the potential of *Jatropha curcas*, a drought-tolerant energy crop, adaptable to tropical and subtropical regions—as a promising alternative to fossil fuels. The proposed integrated industrial chain for *Jatropha* seeks to establish a circular economy model through the comprehensive utilization of biomass resources, thereby addressing the tension between growing energy demand and resource scarcity. This approach not only strengthens local ecological development but also stimulates the growth of agriculture, forestry, biomass energy, carbon reduction, renewable resource utilization, and high-value organic processing industries.

While *Jatropha* oil was initially developed for biodiesel production, petroleum companies are now increasingly prioritizing sustainable aviation fuel (SAF). A patented degumming pretreatment technology developed at Chung Yuan Christian University (CYCU) has proven effective in improving crude oil quality and enhancing SAF yield. In addition, oil seed press cake and agricultural residues can be processed into refuse-derived fuel (RDF). Gasification of RDF produces syngas (CO , H_2 , CO_2), which can be used in gas turbines for power generation or catalytically converted into methanol as both a petrochemical feedstock and a fuel alternative.

Conventional industrial methanol synthesis employs $\text{Cu/ZnO/Al}_2\text{O}_3$ catalysts under 5–10 MPa and 230–270°C. Our laboratory studies confirmed that pressure significantly affects product distribution: lower pressures suppress methanol yield while favoring methane formation. Notably, $\text{Ni/Al}_2\text{O}_3$ catalysts exhibited methanol activity comparable to $\text{Cu/ZnO/Al}_2\text{O}_3$, and Ga-modified $\text{Ni/Al}_2\text{O}_3$ ($\text{Ga-Ni/Al}_2\text{O}_3$) doubled methanol concentration under low-pressure conditions. This enhancement is attributed to electronic structure modifications that improve active-site adsorption properties and increase selectivity toward methanol. These findings highlight the potential for catalyst innovation in low-pressure syngas-to-methanol conversion.

Beyond fuel and energy applications, Taiwan–Japan–Indonesia collaboration on sustainable biomass materials also extends to ESG-driven initiatives within circular economy models for agricultural waste. A notable example is the full utilization of pineapple leaves: CYCU, in partnership with Taiwanese and Japanese companies, pioneered the world's first hydro-mechanical fiber extraction system combined with enzymatic degumming technology. These innovations have enabled international collaboration and the successful deployment of pilot-scale production and verification in Indonesia, demonstrating a clear pathway for industry–university partnerships in advancing sustainable biomass utilization.



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Unlocking Reactor Efficiency with 3D-Printed Catalyst Structures

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Abstract

Packed bed reactors often suffer from poor heat distribution, high pressure drops, and poor catalyst utilization. This study investigates the integration of 3D-printed Periodic Open Cellular Structured (POCS) catalyst support as a strategy to overcome these limitations. Various structure designs and support materials were evaluated for their impact on flow uniformity, thermal management. Washcoating method is utilized to coat a model catalyst on selected structures and subsequent evaluated for catalytic performance. The presentation will highlight how structural design and flow engineering can significantly influence reactor efficiency, offering insights into the optimization of next-generation catalytic systems.



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Atomic Layer Process Design for the Beyond 1nm Era in ULSI: Atomistic Simulations Based on Quantum Chemistry and Neural Network Potentials

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Abstract

The scaling and integration of ultra-large-scale integrated (ULSI) circuits have now entered the era of 2 nm technology nodes, where over 10 billion Gate-All-Around (GAA) transistors can be integrated on a single chip. Gate lengths have reached approximately 12 nm at the 2 nm node. To fully exploit the high-speed performance of such transistors, advanced interconnect technologies are essential to reduce RC delay and improve reliability against electromigration.

Copper (Cu), the dominant interconnect material for decades, faces a significant increase in effective resistivity at line widths below 10 nm. For the beyond-1 nm era, alternative materials such as ruthenium (Ru), molybdenum (Mo), intermetallic compounds, directional conductors, and topological semimetals are under active investigation. Moreover, as metal pitch shrinks below 20 nm, precise film deposition technologies like atomic layer deposition (ALD) become indispensable.

To accelerate the development of ALD processes for new materials, our group has established a high-accuracy vapor pressure estimation method based on the COSMO-SAC model for novel metal-organic precursors. Furthermore, we employ atomistic simulations using neural network potentials (NNPs) trained on density functional theory (DFT) data to efficiently and accurately predict surface adsorption and reaction behavior. These simulations are closely integrated with experimental validation.

For instance, the reliability of Cu interconnects can be improved by forming selective Co metal caps. Area-selective deposition (ASD) is a promising approach to achieve this, yet maintaining selectivity remains challenging. We have investigated the reactivity of Co precursors on Cu and low-k dielectrics to identify ligands that preferentially react on Cu. However, minor Co nucleation still occurs on low-k surfaces due to byproduct interactions. To overcome this, we have developed an atomic layer etching (ALE) process that selectively removes these undesired nuclei. In designing this ALE step, we employed the COSMO-SAC method to identify favorable surface modifications that would convert Co species into volatile compounds. By combining ALD and ALE in a cyclic manner, we achieved robust area-selective Co metal cap formation with high selectivity.

In addition, the use of NNPs allows vibrational analysis of surface species, an area where conventional DFT is computationally prohibitive. This enables accurate estimation of surface reaction rates, which can be incorporated into kinetic Monte Carlo (kMC) or molecular dynamics (MD) simulations to model process evolution in ALD and CVD systems.

This presentation will highlight our recent progress in these simulation-based approaches to designing and optimizing atomic layer processes for the beyond-1 nm ULSI interconnects.



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Design of Vapor-Induced Phase Separation Membranes for High-Performance Direct Contact Membrane Distillation

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Abstract

Direct contact membrane distillation (DCMD) offers almost complete rejection of non-volatile contaminants, can make use of low-grade or waste heat, and is suitable for treating high-salinity effluents as well as water containing persistent fluorinated compounds. Despite these advantages, its wider application is hindered by modest water fluxes, substantial thermal energy demands, and susceptibility to membrane wetting and scaling, which compromise long-term performance. Recent advances-particularly in tailoring membrane morphology (e.g., re-entrant structures) and applying surface chemical modifications-have improved wetting resistance, but most reported fabrication strategies require multiple processing steps, increasing complexity. The vapor-induced phase separation (VIPS) technique, a controlled phase-inversion process, enables fine tuning of membrane architecture, especially for poly(vinylidene fluoride) and its copolymers, producing microfiltration membranes with exceptionally high hydrophobicity (water contact angles in air exceeding 150°). By optimizing the VIPS parameters, pore size can be precisely adjusted, making these membranes highly promising for DCMD, although their application in desalination has received little attention. In recent years, we have developed a range of VIPS membranes specifically for DCMD and will present their fabrication parameters and performance characteristics. Notably, even at a modest feed temperature of 60°C with a 35°C feed-permeate temperature difference, these membranes achieve fluxes of 25-35 LMH-comparable to electrospun membranes and exceeding most conventional phase-inversion membranes under similar conditions. Their wetting and scaling resistance, operational stability, and adaptability to diverse feedwaters will also be discussed.



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Fatigue Assessment of Steel Bridges Considering Material and Dynamic Effects

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Abstract

Fatigue damage is a primary concern for the durability of steel bridges, driven by repeated stress cycles from heavy traffic. This damage is exacerbated by dynamic effects, including stress concentrations and traffic-induced vibrations. Consequently, accurate fatigue life assessment requires methods capable of capturing these complex interactions.

To address this, a benchmark steel bridge model was developed for time-domain finite element simulations to evaluate dynamic stress responses under various traffic loads. The model accurately reproduced measured responses for both main and secondary members, validating its ability to capture local stress concentrations. Parametric studies revealed that vehicle load, speed, and particularly road surface roughness significantly affect dynamic stresses, highlighting the critical role of pavement maintenance in fatigue performance.

To more efficiently utilize dynamic axle loads from Bridge Weigh-In-Motion (BWIM) systems, a novel frequency-domain fatigue evaluation method is proposed. The method extends Dirlik's formula with a Gaussian Mixture Model to handle non-Gaussian stress histories and applies a damage accumulation rule. Enhancements such as modal transformation, vehicle-weight-based grouping, and signal time-compression further improve accuracy. Comparison with time-domain results demonstrates that the proposed method achieves equivalent fatigue life predictions while reducing computational time by over 99%, enabling scalable and efficient fatigue evaluations based on BWIM data.

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