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recycling and end-of-life management. The session highlighted advances in chemical data, environmental fate studies, and circular economy considerations, while underscoring the knowledge gaps that must be addressed to enable safe recycling and sustainable management of tyre-chemicals.

The keynote was delivered by Linda Mitchell (Tyre Stewardship Australia), who highlighted the wide-ranging impacts of tyres, from the release of chemicals of concern in tyre and road wear particles to the risks of stockpiling and tyre fires. While circular economy approaches offer opportunities, she cautioned that tyre-derived products can also introduce new risks, calling for systems-level thinking across the tyre life-cycle. Divina Navarro (CSIRO Environment - Australia) presented early findings from the development of a national chemical database for end-of-life tyres. The database provides critical insights into the chemical composition of recycled tyre materials, supporting efforts to prevent hazardous substances from re-entering supply chains. While compounds such as HMMM and 6PPD-quinone are highly leachable and already detected in Australian stormwater, their ecological risks in the Australian context remain poorly understood. These findings highlight the need to better understand chemical risks to avoid reintroducing hazardous substances into new products. Daryll Anne Dimapilis (Tokyo Metropolitan University) reported that recycled rubber degrades faster and releases by-products more readily, while tyre and road wear particles persist longer, having often already undergone environmental



aging. She emphasised the need for improved recycling processes and safer material design. In the final talk, Rai Kookana (University of Adelaide) discussed the mobility of tyre-derived chemicals such as 6PPD and its toxic breakdown product, 6PPD-quinone. He emphasised the importance of understanding partitioning between dissolved and particulate phases for assessing exposure and designing mitigation strategies, such as bioretention ponds. He also highlighted major knowledge gaps around fate, transformation, and toxicity of tyre-associated chemicals.

The symposium underscored the urgent need to improve understanding of tyre-related chemicals and their environmental behaviour. It called for collaborative, multidisciplinary solutions to support safe recycling and sustainable management. Active discussion and engagement from participants reinforced the importance of this global challenge and laid the groundwork for potential future collaborations.

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From L to R: Ms. Dimapilis, Dr. Navarro, Dr. Mitchell & Prof. Kookana

Carbon Sequestration, Utilisation and Capture

by Diane Purchase and Weiping Wu

The escalating urgency of climate change has intensified global efforts to develop and apply advanced technologies for carbon sequestration, utilisation, and capture (CCUS). To foster international dialogue and knowledge exchange, a one-day symposium titled Evaluation of Advanced Technologies for Carbon Sequestration,



Presenters and project leads at the symposium (L to R: Dr Sadanari Jindou, Dr Lee Peng Teh, Dr Bipul Saha, Dr Tsuneyuki Yamane, Prof. Diane Purchase, and Dr Michelle Bailly).

Utilisation and Capture was convened on 17 July 2025 at the Kuala Lumpur Convention Centre, Malaysia.

The symposium was a joint initiative of two IUPAC projects: Harmonizing Carbon Sequestration Measurement (project 2022-010-2-600) and Advanced Technologies for Carbon Sequestration and Capture (project 2023-023-1-600). Both projects are funded the Chemistry and the Environment Division (Div VI), in partnership with the Committee on Chemistry and Industry (COCI) and the Organic and Biomolecular Chemistry Division (Div III). Held under the auspices of the 50th IUPAC World Chemistry Congress, the symposium was chaired by Diane Purchase (Middlesex University, UK) and brought together leading researchers, industry practitioners, and policy experts from across Asia, Europe, and the Americas.

Participants explored innovative pathways for reducing atmospheric CO₂ through material science, biotechnology, catalysis, and systems engineering. The keynote address, delivered by Peng Wang of the GuangZhou Institute of Energy Conversion, Chinese Academy of Sciences, offered a strategic overview of China's digital energy transition and set the stage for subsequent discussions. Distinguished invited speakers, including Tsuneyuki Yamane (Toray Techno Co., Ltd., Japan) and Bipul Behari Saha (Shree Chanakya Education Society, India) brought critical perspectives on industrial innovation and challenges faced by developing nations in implementing CCUS.

The contributions of each speaker are grouped into four major themes and are as follows:

Theme 1. Digital and Strategic Approaches to Energy Transition and Policy

Speakers in this theme provided strategic and policy-level insights into the global carbon challenge,

with a particular focus on national implementation and international standardisation.

Keynote speaker Peng Wang opened the symposium by setting the scene for China's national strategy for carbon peaking and neutrality. His presentation highlighted how digital technologies, including smart energy platforms and big data systems, are being integrated into China's roadmap for achieving carbon neutrality by 2060. As a leading researcher in energy systems, Professor Wang provided a macro-level perspective that grounded the technical sessions in geopolitical and economic context.

Bipul Saha, an educator and policy advocate from India, contributed the developing country viewpoint. His talk explored the barriers to implementing CCUS in lower- and middle-income nations, including financial, technical, and regulatory limitations. He highlighted the need for targeted policy support and international cooperation to ensure that CCUS solutions are globally inclusive.

Diane Purchase provided an international governance perspective and presented interim findings from two IUPAC projects she leads. These initiatives aim to harmonise carbon accounting practices and develop a standardised assessment framework for CCUS technologies. The projects promote comparability and best practices across sectors, accelerating responsible and transparent CCUS deployment.

Theme 2. Materials Innovation for Carbon Capture

Three researchers presented their research in advanced materials for CO₂ capture, focusing on performance, structure, and stability.

Shanshan Shang, from the South China University of Technology, presented her team's work on



Speakers at the symposium
From top L: Prof. Peng Wang, Dr Xue (Ida) Chen; from bottom L: Dr Shanshan Shang, Dr Syawal Mohd Yusof, Dr Zixu Yang and Dr Nur Diyan Mohd Ridzuan.



amine-functionalised, hierarchically porous porphyrin-based MOFs. She demonstrated how careful design of pore structure and chemical functionality significantly improved direct air capture performance, particularly under variable humidity.

Syawal Mohd Yusof, representing both Universiti Putra Malaysia and Universiti Kebangsaan Malaysia, led an investigation into MnO nanoparticles for CO₂ capture. His research revealed how nanoparticle size directly influences surface area, porosity, and adsorption efficiency, offering valuable insights into the design of next-generation adsorbents.

Lee Peng Teh, from the Universiti Kebangsaan Malaysia, led a study on modifying the sulfonated MOF UiO-66-SO₃H using a dual-ligand strategy. Her work focused on enhancing surface area and tuning basic sites to improve CO₂ adsorption. She also evaluated the material's recyclability and stability, a key parameter for commercial viability.

Theme 3. Industrial and Chemical Engineering Solutions for CO₂ Utilisation

Three speakers addressed real-world industrial challenges and chemical transformation processes for converting captured CO₂ into high-value products.

Xue (Ida) Chen, a senior scientist at The Dow Chemical Company (USA), shared her direct experience in developing and scaling amine-based solvents for CO₂ capture. She traced the evolution from laboratory research through pilot-scale testing to full

commercial deployment, demonstrating how these innovations are driving decarbonisation across multiple sectors.

Zixu Yang, from the East China University of Science and Technology, presented his research on Fe-based composite catalysts for CO₂ hydrogenation to olefins. He explored structural and mechanistic factors affecting catalytic selectivity and durability, highlighting how operando spectroscopy can guide catalyst optimisation for sustainable petrochemical production.

Nur Diyan Mohd Ridzuan, from Universiti Teknologi PETRONAS (Malaysia), presented the use of reduced graphene oxide (rGO) as a support material for Ni-based catalysts in CO₂ methanation. Her results showed that Ni/rGO catalysts achieved higher CO₂ conversion and CH₄ selectivity compared to conventional systems, demonstrating strong potential for integration into power-to-gas technologies.

Theme 4. Circular Economy and Bio-Based CO₂ Conversion

Experts from industry and academia working at the interface of biotechnology and circular material systems presented their research on the transformation of CO₂ into useful resources.

Tsuneyuki Yamane, Invited Speaker from Toray Techno Co., Ltd., Japan, presented the Toray Group's greenhouse gas reduction strategy, grounded in circular economy principles. His talk covered material and chemical recycling, along with the development of CO₂-derived

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and plant-based feedstocks, offering an industry-wide perspective on sustainability and innovation.

Sadanari Jindou from Meijo University, Japan, presented a synthetic biology platform using genetically engineered *Synechococcus elongatus* to convert atmospheric CO₂ into bio-ethylene. He described how engineered enzyme complexes improve catalytic efficiency, illustrating the potential of microbial platforms in carbon-negative manufacturing.

Final word

From digital infrastructure for national energy transitions to nanoscale materials, industrial catalysts, and engineered microbes, the symposium reflected the depth and diversity of current CCUS research and implementation strategies. It highlights the value of international collaboration and knowledge exchange. It was evident that there is a shared commitment to developing practical and scalable solutions for climate mitigation in the scientific community. Continuing interdisciplinary cooperation, supported by enabling policies, will be essential in accelerating the deployment of advanced CCUS technologies worldwide.

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Chemistry Board Games by TYCN: Making Chemistry Fun and Interactive

by Nutchapong Suwanwong and Chanat Aonbangkhen

Chemistry education comes alive when learning meets playing, and board games are turning science into an

exciting, hands-on experience! Since its inception in 2023, Thailand Younger Chemists Network (TYCN) has been pioneering the use of chemistry-themed board games as interactive teaching and networking tools that enhance engagement, stimulate discussion, and inspire curiosity among learners of all ages. These games bridge scientific concepts with play-based learning, transforming abstract chemistry ideas into hands-on experiences that promote teamwork, problem-solving, and creative thinking. It is a new, innovative way to make chemistry more fun for everyone!

To put this concept into action, TYCN, in collaboration with the Chemical Society of Thailand (CST), organized "Chemistry Boardgame Day by TYCN" at the 27th IUPAC International Conference on Chemistry Education (ICCE2024) in Pattaya, Thailand, 15-16 July 2024. More than 200 participants, including professors, teachers, students, scientists, and researchers from around the world, joined to explore how this interactive platform can transform chemistry education. A special guest from the IUPAC, Marietjie Potgieter (Chair of IUPAC Committee of Chemistry Education), also joined us to explore this activity which promotes creativity,

