ISSUE #3

NUS National University of Singapore | Centre for Hydrogen Innovations

✦ February 2025 ✦

HYDROGEN

Newsletter of the Centre for Hydrogen Innovations

Speakers and attendees of the CHI-ETHZ Symposium

Strengthening collaborations through the CHI-ETH Zurich Symposium

On the 3rd of September 2024, we were very happy to welcome our friends from ETH Zurich for a full-day symposium on "Replacing Fuels by Chemistry". We kicked off the morning with welcoming addresses by Prof Yan Ning (CHI Director) and Prof Javier Pérez-Ramírez (NCCR Catalysis Director).

For the rest of the day, CHI professors and our ETH Zurich guests took turns presenting their latest research developments. A common highlight throughout the speeches was the close connections already existing between CHI and ETH Zurich researchers, which we certainly believe will continue in future.

In the morning, Prof Christophe Copéret (ETH Zurich & NCCR Catalysis) discussed advanced catalyst characterisation techniques, Prof Wang Qing (NUS & CHI) introduced materials designed for redox-mediated processes, Prof Gonzalo Guillén-Gosálbez (ETH Zurich & NCCR Catalysis) talked about sustainability metrics for chemical systems, A/Prof Jason Yeo (NUS) presented his work on electrosynthesis of oxygenates and hydrocarbons, and Prof Christoph Müller (ETH Zurich & NCCR Catalysis) discussed the characterisation of model materials for CCUS.

After a buffet lunch, we continued with more talks in the afternoon. A/Prof Lu Jiong (NUS & CHI) introduced the single-atom and two-atom catalyst systems developed in his lab, Asst Prof Victor Mougel (ETH Zurich) showed how he took inspiration from nature to design electrocatalysts, and A/Prof Zhao Dan (NUS & CHI) showed the latest developments in CO_2 capture technologies.

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Finally, we ended the seminars where we began with Prof Pérez-Ramírez and Prof Yan presenting recent advancements in catalysis discovered in their respective labs.

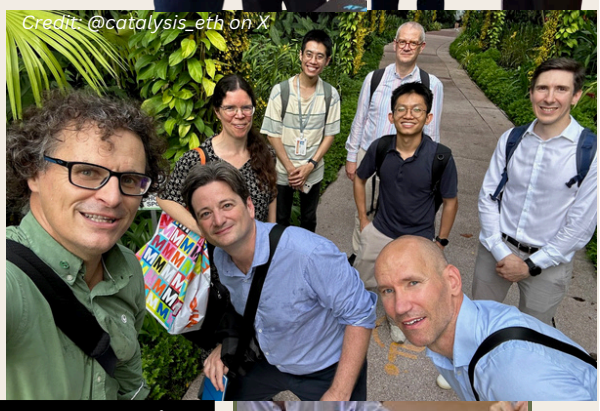
The agenda ended with a panel discussion among the ETH Zurich professors, in which the discussion went beyond the science and into how education and policies play just as crucial of a role in decarbonising our future chemicals industry.

The ETH delegation's visit included much more than the symposium. Throughout the week, we had memorable dinners sampling a variety of local cuisines. Our PhD students also had the opportunity to interact with our guests by taking them to Singapore's signature sights like Gardens by the Bay and the Botanical Gardens.

We thank our ETH Zurich friends once again for visiting us here in Singapore all the way from Switzerland, and to our audience for their engagement throughout the symposium. We hope to meet again very soon!

Panel discussion

Tokens of appreciation were given to each speaker



Credit: @catalysis_eth on X

Introducing the ETHZ delegation to local cuisines and sights

Supporting next generation climate technology solutions together with Breakthrough Energy Fellows

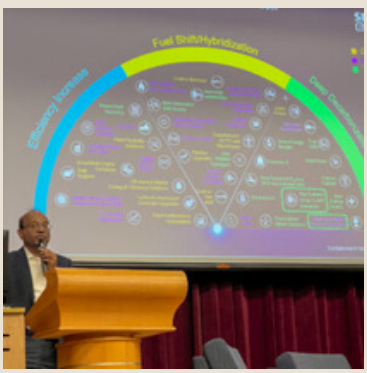
Recently, Breakthrough Energy established BE Fellows - Southeast Asia, in collaboration with Temasek and Enterprise Singapore. The BE Fellows program aims to support early-stage innovators tackling the world's greatest climate challenges.

On the first of November, the BE Fellows - Southeast Asia team and CHI co-organised a pitching session in NUS for the Breakthrough Energy Explorer Grant. It funds up to US$250K for research projects that are generally being conducted by a university lab or research entity but require further technical exploration before they would be ready to join the full-time Fellowship. Eight research teams from NUS/NTU were selected from a pool of 20 candidates to pitch to Dr John Lemmon (Senior Director of Innovation, Breakthrough Energy).

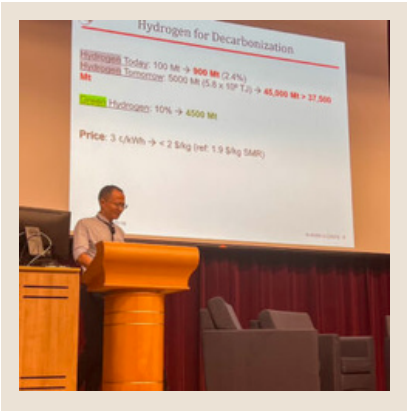
Private quick pitch sessions for CHI teams to BEF, held at NUS

The pitching sessions were followed by a workshop with the theme of "Emerging Hydrogen Technologies". Throughout the afternoon, we heard perspectives on the topic from academia, industry, and government agencies.

We started the workshop with an introduction from Dr John Lemmon on Breakthrough Energy's activities and their strategy for hydrogen end-use. Dr Eric Toone (Chief Technical Officer, Breakthrough Energy) then taught us the importance of looking around the corner to where future energy demand will be and how hydrogen is the "Swiss army knife of chemistry" for meeting such demand.



"Hydrogen is the Swiss Army knife of chemistry"



Panel discussion

Networking session

Mr Desmond Chua, Director at the Low-Carbon Energy Research Coordinating Office, introduced the program and how it has helped Singapore come closer to its goal of 50% hydrogen in its power sector by 2050.

Visiting us from NTU, A/Prof Su Pei-Chen presented her research on solid-oxide fuel cells while A/Prof Hong Li discussed his perspectives on hydrogen for decarbonisation. Dr Sundar Chidambaram, Vice President Strategy & Market Development of Siemens Energy, gave his perspective with an overview of Siemens Energy's use of methanol and ammonia as hydrogen vectors.

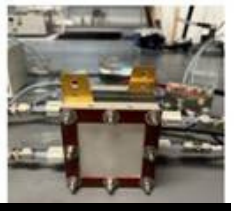
Finally, Dr Lemmon, Dr Toone, and Dr Chidambaram returned to the stage with a very special guest, Prof Sir Konstantin Novoselov, Nobel Laureate and Tan Chin Tuan Centennial Professor here at NUS, for a panel discussion. "It's really refreshing to see that there are landslides in hydrogen in recent years", says Prof Novoselov, who though most well known for graphene discovery, has in recent years been very interested in the applications of 2D materials in industry, including in hydrogen-adjacent fields. Our panel of experts talked not only of the scale of technological breakthroughs needed in hydrogen, but the secret to achieving these breakthroughs, which is simply (or maybe not so simply) to find the right people to do it! And what's the next challenge after hydrogen they said? Carbon technologies may just be the answer.

The workshop ended with a networking session over light refreshments. We're happy to have had the opportunity to collaborate with BEF in many fronts on our shared mission to accelerate the deployment of critical climate technologies, and look forward to more in the future!

Exhibiting CHI's latest innovations at Singapore International Energy Week

At this year's Singapore International Energy Week (SIEW), CHI was present to support the NUS Energy Solutions Hub (NESH) booth with exhibits of prototypes from two of our faculty. NESH was soft-launching its cross-disciplinary research platform designed to harness and amplify the collective strengths of NUS' extensive energy research capabilities.

At this booth, we showcased Prof Wang Lei's electrolyser for one-step hydrogenation of toluene to methylcyclohexane, which furthers the use of liquid organic hydrogen carriers. The other exhibit features Prof Lum Yanwei's ammonia fuel cell, which can generate carbon-free electricity at mild conditions and high power densities.



Ammonia fuel cell

CHI signs MOU with SEAS for collaborative "Introduction to Hydrogen Energy" programme

The Asia Clean Energy Summit (ACES) also took place during SIEW. ACES exhibited many new innovations in clean energy and fostered collaborations between key players in the region. Among those new collaborations officiated during the event is CHI's commitment with the Sustainable Energy Association of Singapore (SEAS) to provide the "Introduction to Hydrogen Energy" programme.

SEAS is a non-government and non-profit business association that represents the interests and provides a common platform for companies in the Sustainable Energy Sector to meet, discuss, collaborate, and undertake viable projects together. Their mission is well aligned with one of our own to nurture a talent pool that is equipped to shape and lead the hydrogen revolution.

CHI and SEAS will participate equally in the development and delivery of this programme, which will prepare young leaders for careers in green energy. The MOU signing ceremony was witnessed by Ms Low Yen Ling, Senior Minister of State, Ministry of Culture, Community and Youth & Ministry of Trade and Industry, and Mr Edwin Chew, Chairman of SEAS.

Visit by Philippines Department of Energy to CHI facilitates dialogue on hydrogen tech and policy

We were honored to host a visit from the Secretary of the Department of Energy of the Philippines, H. E. Raphael P.M. Lotilla, and his delegation on January 16, 2025. The delegation engaged in a dialogue regarding the use of hydrogen for energy applications and learned more about

- Recent advancements in hydrogen production, storage, and utilization; and
- Challenges faced by existing hydrogen technologies and the solutions CHI is developing

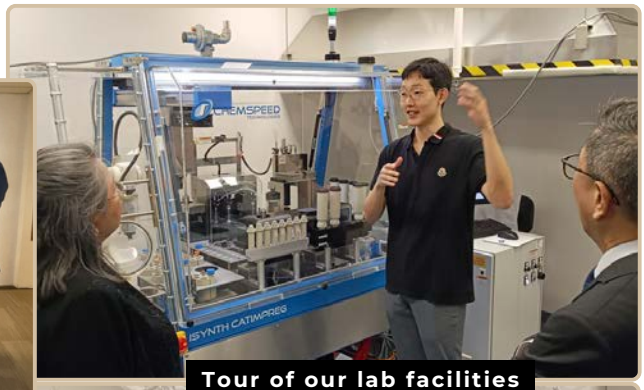
Prof Koh Lian Pin, NUS Vice President (Sustainability and Resilience) and Chief Sustainability Scientist, gave the welcome address. An exciting introduction to the NUS Energy Solutions Hub (NESH) was given by Prof Lee Poh Seng (Coordinating Director of NESH), and CHI Associate Director Jackson shared an overview of CHI. A robust discussion on all things hydrogen was had by the party.

CHI had the honour to show the Secretary the state-of-the-art facilities housed in our lab. Before the Secretary took his leave, he presented a booklet of the Philippine Energy Plan 2023-2050 to Prof. Koh as well as Jackson (on behalf of the CHI director).

The delegation expressed that the experience and insights shared by CHI will help augment the Philippines' ongoing efforts to integrate hydrogen into its clean energy strategy.

Welcome address by Prof Koh Lian Pin

Secretary Raphael Lotilla presents a booklet



Tour of our lab facilities

Introduction to NESH by Prof Lee Poh Seng

Distinguished Speaker Series

Prof. Shinya Furukawa

18 September 2024

Prof. Furukawa from Osaka University delivered a talk on catalysts for unconventional electro-assisted reactions, for example electric-field catalysis and plasma catalysis. He showed how his combination of unique catalyst design and electro-assistance allows for reactions to go beyond the thermodynamic equilibrium limit.

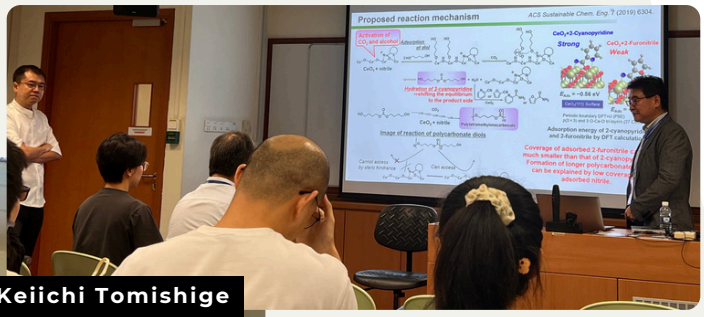
Prof. Johannes Lercher & Prof. Keiichi Tomishige

12 December 2024

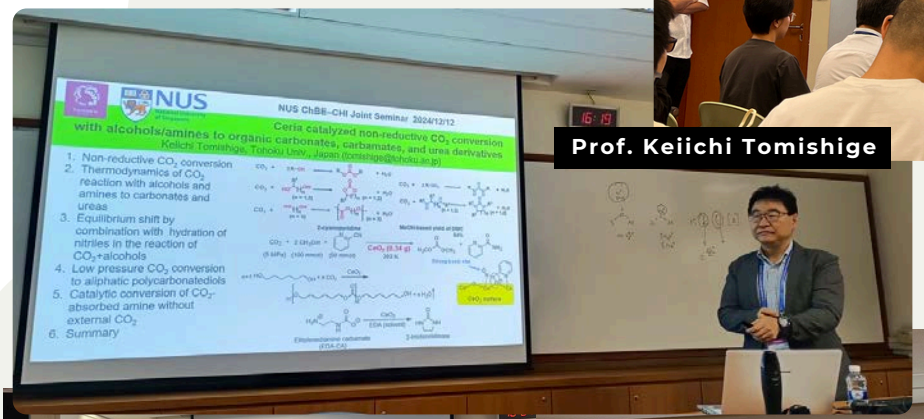
Together with the Department of Chemical and Biomolecular Engineering (ChBE), we held a double feature that afternoon with back-to-back talks from two great catalysis experts.

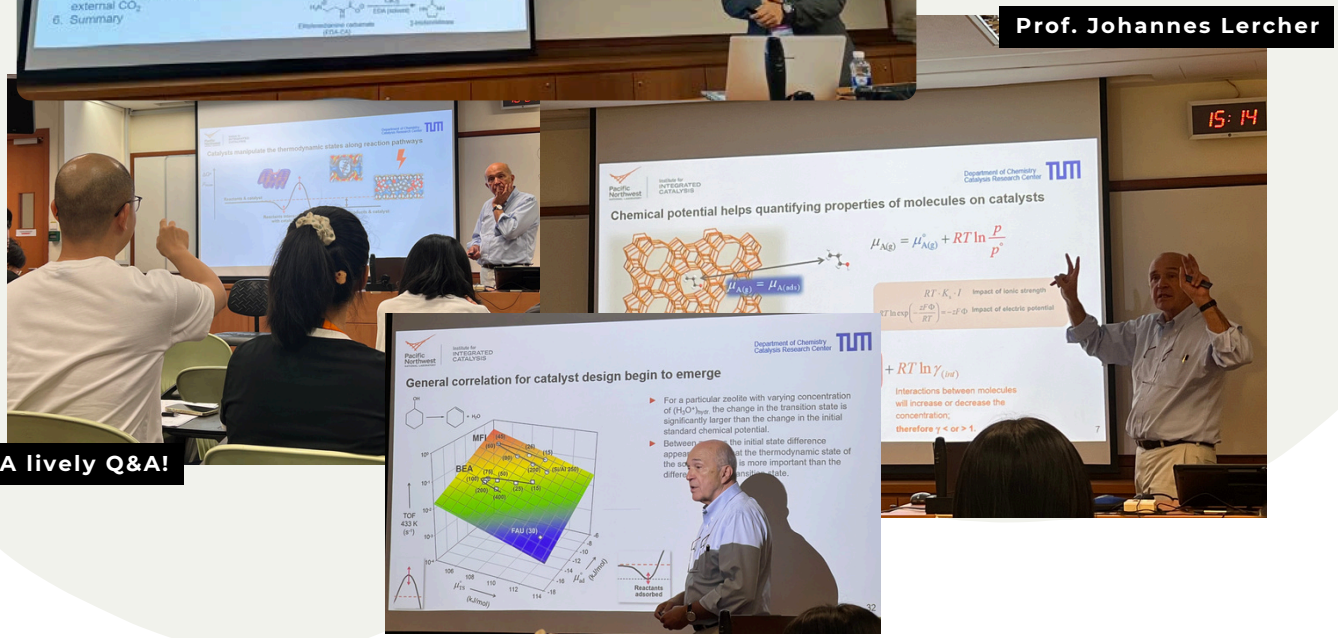
Prof. Johannes Lercher of the Technical University of Munich and the Pacific Northwest National Laboratory brought us back to basics with his talk entitled Influencing Catalysis by Water and Other Solvents. He taught us new ways to look at the fundamentals of catalysis that confounded even our research fellows during the Q&A session!

Prof. Keiichi Tomishige of Tohoku University then presented his work on non-reductive CO_2 conversion with alcohols/amines to carbonates, carbamates, and urea derivatives, which his group has been researching for 25 years. The reactions he developed could replace the use of toxic phosgene in industry.



Prof. Keiichi Tomishige





Prof. Johannes Lercher

A lively Q&A!

Prof. Wang Aiqin

13 December 2024

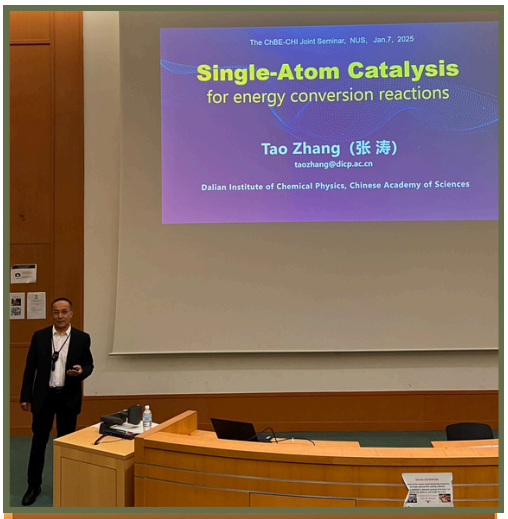
In our next ChBE-CHI joint seminar, we hosted Prof. Wang Aiqin from the Dalian Institute of Chemical Physics (DICP), Chinese Academy of Sciences, for a talk on December 13, 2024. Prof. Wang presented her work on the sustainable production of biomass-derived diols and amines, which will pave the way for the development of bio-based polymers as diols and amines are widely used monomers in the polymer industry.

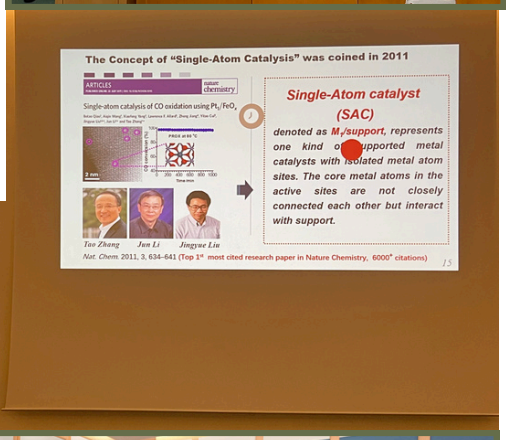
Prof. Zhang Tao

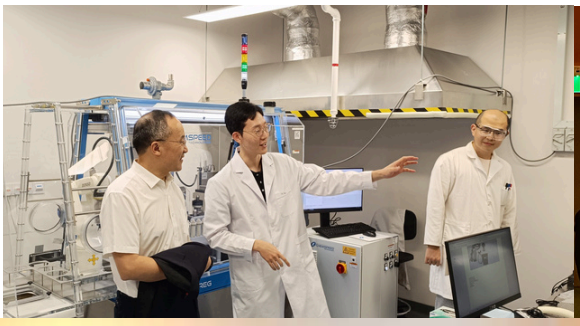
7 January 2024

In another ChBE-CHI joint seminar, we had another honoured guest from DICP, Prof. Zhang Tao, who gave a talk on single-atom catalysis for energy conversion reactions. Prof. Zhang's group has been researching single-atom catalysts for 14 years. He took us on a journey from the inspiration to conception of single-atom catalysts, how it became one of the most hot topics in catalytic materials today and has been explored for numerous energy conversion reactions, and what the future holds for the field. He is particularly optimistic that with its well-defined structures, artificial intelligence can be well exploited to efficiently discover the next best single-atom catalyst materials.

After his talk, Prof. Zhang also dropped by our lab to view our high-end catalysis equipment and snap a quick picture!







Prof. Zhang Tao together with CHI staff

Congratulations

Recently awarded grants and achievements

Prof Liu Bin and A/Prof Lu Jiong win nation's highest science and technology awards

Photos: National Research Foundation, Singapore

The President's Science and Technology Awards, organised by the National Research Foundation, honours the exceptional contributions of researchers based in Singapore who have also helped to advance the country's strategic research priorities.

NUS Tan Chin Tuan Centennial Professor Liu Bin is 2024's sole winner of the President's Science Award (PSA). She received this prestigious accolade for her team's breakthrough discovery of the role of carbazole isomers in room temperature phosphorescence of carbazole, resolving a 95-year debate in the field. She was presented the award by Singapore President Tharman Shanmugaratnam.

Assoc Prof Lu Jiong won the Young Scientist Award for developing novel catalysts that significantly advance sustainable chemical manufacturing processes. This award is presented to researchers under 40 who have contributed to Singapore R&D and have the potential to be world-class researchers in their field.

13 CHI faculty among 2024's most Highly Cited Researchers in the world!

Thirteen members of CHI were ranked among the world's most influential scientists in Clarivate's annual list. These were, from left to right and top to bottom in the picture: Prof. Yan Ning, Prof. Antonio H. Castro Neto, Prof. Chen Peng, Prof. Xie Jianping, Prof. Lin Zhiqun, Prof. Praveen Linga, A/Prof. Zhao Dan, Prof. Jason Xu Zhichuan, Prof. Ho Ghim Wei, A/Prof. Sibudjing Kawi, Prof Loh Kian Ping, Dr Seh Zhi Wei, and Prof. Chen Wei.

Prof Praveen Linga received inaugural Gas Science and Engineering Distinguished Scientist Award

The award was given for the first time in 2024 by the Journal of Gas Science and Engineering to six senior scientists who have made significant contributions to the field. Prof. Linga's research focuses on clathrate (gas) hydrates, energy storage, carbon dioxide capture and storage, and energy recovery technologies.

Photo: NUS College of Design & Engineering

Photo: NTU School of Materials Science & Engineering

Prof Jason Xu Zhichuan awarded a 2024 TÜBA International Academy Award by the President of Turkey

Prof. Jason Xu Zhichuan was awarded the 2024 Turkish Academy of Sciences (TÜBA) Academy Prize in the category of Basic and Engineering Sciences for his pioneering research on electrochemistry of materials and electrocatalysis for renewable energy applications. Among his many discoveries, Prof. Xu's work on the oxygen evolution reaction has been crucial in developing green hydrogen production. He was presented the award by His Excellency Recep Tayyip Erdoğan, President of Turkey, and Professor Muzaffer Şeker, President of TÜBA, at the TÜBA-TÜBİTAK Science Awards Ceremony on December 18, 2024.

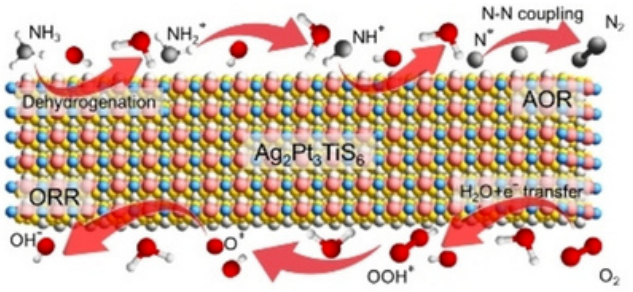
CHI researchers receive S$3.3 million in grant funding

We are proud of our faculty members who in the past six months have collectively been awarded S$3.3 million in grant funding.

Prof. Yan Ning received about S$3 million for two projects under the new CREATE Thematic Programme in Decarbonisation. Singapore's National Research Foundation will be investing S$90 million into this programme, which is awarded to nine projects spanning hydrogen utilisation and non-fossil-fuel based pathways to produce aviation fuel and high-value chemicals. Prof. Yan is a Co-PI and NUS lead in the Sustainable Manufacture of Molecules and Materials (SM3) project, which aims to shift Singapore's chemical manufacturing to a more circular and sustainable system. He is also a Co-PI in the Sustainable Chemical Conversion of Biomass project.

Two grants from industry have also been awarded. Prof. Praveen Linga will be continuing his research on hydrogen storage in clathrate hydrates with support from Chevron Singapore. With funding from a CHI seed grant and S$5,000 industry cash support from Offgrid Energy, Prof. Wang Lei will be unleashing the power of direct borohydride fuel cells towards cost-efficient stationary powering devices with high power density.

Research Highlights



***Angew. Chem. Int. Ed.* 2024, e202418691**

Enhanced low-temperature ammonia fuel cell electrocatalysis using a multi-element catalyst

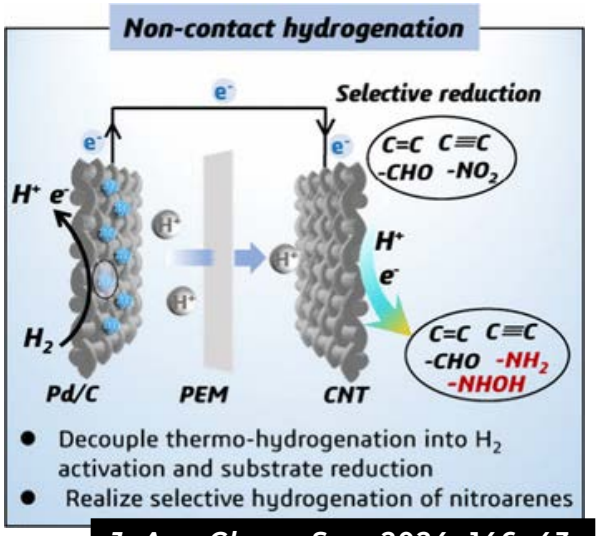
-T. Wu, K. Dhaka, M. Luo, F. Huang*, K. Exner*, Y. Lum*, et al.

One of the key technologies for realising the use of ammonia as a hydrogen carrier is low-temperature ammonia fuel cells for on-demand electricity generation. However, the efficiency of such systems is limited by sluggish ammonia oxidation and oxygen reduction reactions. Prof Lum and team have developed a bifunctional $Ag_2Pt_3TiS_6$ electrocatalyst in which Pt and Ti atoms work cooperatively to generate activities exceeding that of commercial Pt/C.

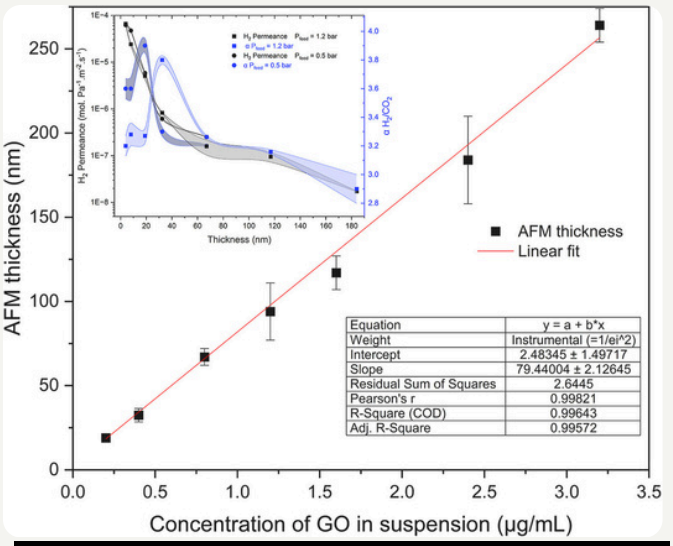
Selective nitroarenes reduction via non-contact hydrogenation

-H. An, G. Sun*, N. Yan*, et al.

In traditional hydrogenation, where H_2 and substrates with unsaturated bonds are activated on the same catalyst (contact mode), competitive hydrogenation of multiple reducible groups often occurs. This paper introduces a new method for hydrogenation where hydrogen activation and susbtrate reduction occur in separate cells, connected by a proton exchange membrane, allowing for 100% selective reduction of the substrates.



***J. Am. Chem. Soc.* 2024, 146, 43, 29315–29324**



***Int. J. Hydrogen Energy* 2024, 90, 646-654**

Separating H_2 and CO_2 using graphene oxide laminated membranes

-J. A. G. Carrio*, A. H. Castro Neto, et al.

Separating hydrogen for applications that require high purities like fuel cells remain challenging. Two-dimensional materials such as graphene are promising for this task due to their high hydrogen permeation properties. This study examines the use of commercial and cost-effective graphene oxide to fabricate multilayer graphene membranes, identifying an optimal membrane thickness range and graphene oxide quantity,