HYDROGEN

A newsletter of the Centre for Hydrogen Innovations

2024 Issue #1

NUS National University of Singapore

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INSIDE

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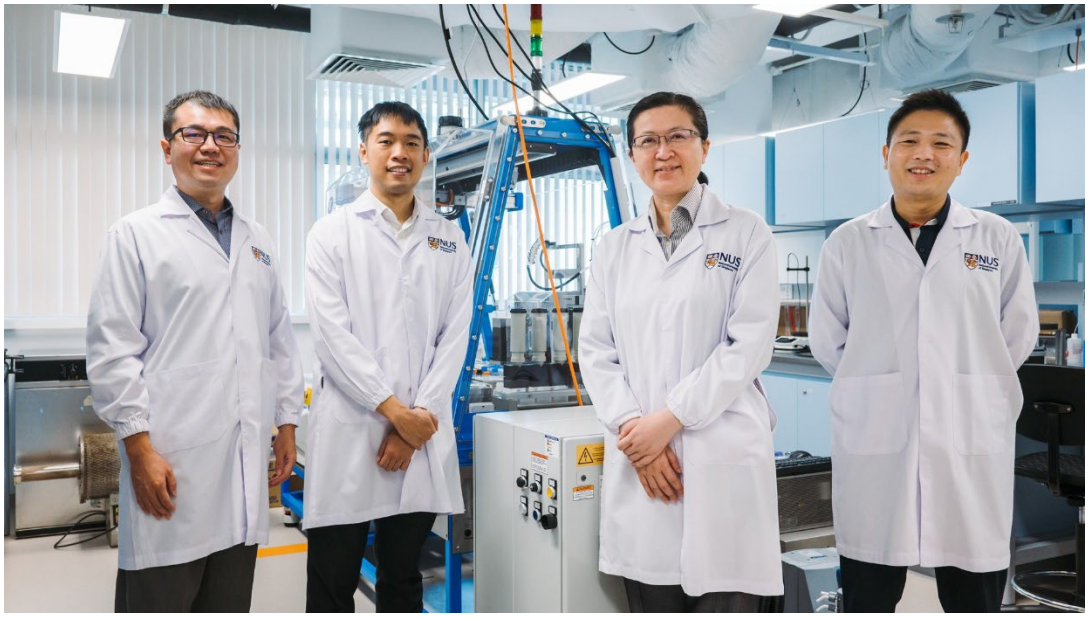
The cover page image illustrates hydrogen molecules using Adobe Firefly Generative AI.



Launch of HYDROGEN Newsletter

Welcome to the inaugural issue of HYDROGEN. Here you will find updates on our Centre activities and research news. We hope that the hydrogen community will find this useful for research collaborations with NUS CHI.

Renewed Leadership

Professor Yan Ning has been appointed as Director of the Centre for Hydrogen Innovations (CHI) from 1 September 2023. Yan Ning is based in the Department of Chemical and Biomolecular Engineering. He established the Lab of Green Catalysis in 2012, working on the conversion of renewable carbon sources, green chemistry and engineering, and catalyst development. Ning won the NUS Young Researcher Award (2019) and was awarded the NRF Investigatorship (Class of 2022).

We would like to thank our Founding Director, **Professor Liu Bin**, for her exceptional leadership and contributions to the CHI. She played a pivotal role in setting up the Centre in 2022, which was the first of its kind in Southeast Asia. Since then, we have supported 17 projects with a total value of S$4.2 M, funded 3 PhD scholarships, signed a Memorandum of Understanding (MoU) with ETH Zürich, established close interactions with Stanford University and Dalian Institute of Chemical Physics, Chinese Academy of Sciences, as well as invited 11 prominent experts for the Distinguished Speaker Series to date.

Feature

Visit by Head of Global R&D Planning, Siemens Energy

The Head of Global R&D Planning of Siemens Energy, Mr Frank Cziesla, accompanied by Vice President Strategy and Business Operations - Asia Pacific of Siemens Energy, Mr Sundar Chidambaram, and Accounts Manager of Siemens Energy, Mr Ong Chin Soon, visited the National University of Singapore on 9 November 2023.

The Siemens Energy delegation sat down to a research dialogue with the Vice Dean (Research) at the College of Design and Engineering (CDE) and Associate Vice President (Enterprise) – A/Prof Benjamin Tee, CDE Assistant Dean (Research) A/Prof Wang Qing, CDE Assistant Dean (Innovation) A/Prof Goh Yang Miang, and CHI Director Prof Yan Ning.

Representing NUS, Mr Charlie Chan gave an overview of the sustainability efforts at NUS. After that, there was a lively exchange between both parties discussing potential research collaborations and the modes of collaborations. They also talked about project management, education, Continuing Education and Training (CET), and using the latest AI technology such as ChatGPT in research.

About Siemens Energy

For more than 150 years Siemens Energy engineers have been spearheading the electrification of the world. Today they are a team of 96.000 sharing the same passion, vision, and values. Their diversity makes them strong and helps us to find answers together with our partners. Located in 90 countries, Siemens Energy operates across the whole energy landscape. From conventional to renewable power, from grid technology to storage to electrifying complex industrial processes. Their mission is to support companies and countries with what they need to reduce greenhouse gas emissions and make energy reliable, affordable, and more sustainable.

Upcoming Techno-Economic Analysis Tutorial by Professor Jaramillo

CHI is very honoured to have Professor Thomas F Jaramillo from Stanford University, who will be conducting a 1-hour educational tutorial on Techno-Economic Analysis for the CHI community in March 2024.

Techno-economic analysis (TEA) is a method for evaluating the economic performance of a technology, product, or service. It assesses the overall value of a technology, allowing analysts to objectively weigh benefits against costs.

We hope that this tutorial will cultivate the entrepreneurship spirit within our CHI community, and we look forward to hearing from Prof Jaramillo!

About Professor Thomas Jaramillo

Prof. Jaramillo earned a BS in chemical engineering at Stanford University, and his MS and PhD degrees in chemical engineering at the University of California, Santa Barbara. He pursued post-doctoral research as the Hans Christian Ørsted Postdoctoral Fellow at the Technical University of Denmark, Dept of Physics, before joining the Stanford faculty. His research efforts are aimed at developing catalyst materials and new processes to improve sustainability in the energy and chemical sectors.

Feature

Engagement with the Ministry of Environment and Climate Change (Qatar) and Earthna

Prof Koh Lian Pin from NUS Centre for Nature-based Climate Solutions (CNCS) hosted Dr Soud Al Thani (Director of Green Growth and Sustainable Development at the Ministry of Environment and Climate Change, Qatar), Francis Antony Jacob (Climate Change Specialist at Earthna, a non-profit policy research and advocacy centre under Qatar Foundation), together with their colleagues from the Ministry and Earthna on 1 November. CHI was invited as part of the NUS team to participate in this engagement with the Qatari delegation for collaboration opportunities. We had opportunities to:

- Discuss potential synergies and collaboration opportunities in the fields of Green Transition, Environmental pollution, Energy Security, Industrial Decarbonization and Environmentally Friendly Technologies with NUS that can address Qatar's specific needs and opportunities; and

- Explore how the collaboration between MECC, Qatar and the National University of Singapore (NUS) can support Qatar's National Vision 2030 to enhance lives by contributing to community benefits such as improving outcomes in the sustainability space.

We had a wonderful session, and it was great to learn from the team that QatarEnergy is building the world's largest "blue" ammonia plant with an annual production capacity of 1.2 million tonnes!

Visit by Head of Network for Asian Open Research (NAO), BASF

BASF
We create chemistry

The Head of Network for Asian Open Research (NAO) BASF, Dr Sunny Feng, visited CHI on 1 December 2023. NUS CHI and BASF NAO had great interactions, exchanging information on our respective research directions.

CHI and BASF are aligned in our directions towards net zero carbon emissions. CHI welcomes BASF to collaborate with our faculty members on innovative and sustainable solutions for applications in the field of hydrogen economy!

About NAO BASF

To expand research and innovation in Asia Pacific, BASF is closely collaborating with the region's leading universities and institutes within the platform of NAO, Network for Asian Open Research. NAO, one of eight BASF Academic Research Alliances, supports and promotes close collaboration in the field of advanced materials research, enabling all partners to extend their scientific horizons to develop sustainable solutions.

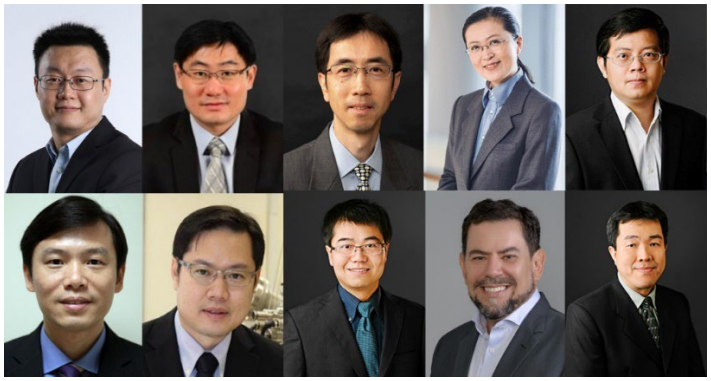
Spotlight

CHI @ Singapore International Energy Week (SIEW) 2023

Singapore's ambitious goal of achieving net-zero emissions by 2050 is contingent on technological advances, such as the availability of low-carbon technologies, for instance, hydrogen as an alternative energy source. Themed "Energy Transition Towards a Net Zero World", the 16th edition of the Singapore International Energy Week (SIEW) provided a platform for conversations between researchers, industry experts, policymakers and commentators on the best practices and solutions within the global energy space. SIEW 2023 was held at Marina Bay Sands from 23 to 27 October 2023.

This year, CHI is showcasing its cutting-edge research projects on swirling ammonia flame burners and 2D laminate-based membranes for hydrogen separation and purification from Professor Antonio H. Castro Neto's research group. A/Prof Panda was also at the conference to showcase his technology on smart hybrid microgrids using hydrogen fuel cells. CHI is proud to support NUS in her endeavours to net-zero emissions transition by pushing the boundaries of renewable energy technology research to create a sustainable energy future for Singapore.

Research Highlights



Clarivate names 10 CHI faculty among World's Most Influential Scientific Minds

Ten faculty members from CHI have been named in the 2023 Highly Cited Researchers™ list and among the World's Most Influential Scientific Minds.

Compiled by Clarivate, the annual list uses quantitative and qualitative analysis to identify researchers who demonstrate significant impact and influence in their chosen field by publishing several highly cited papers during the last decade. The names are drawn from the publications that rank in the top one per cent by citations for field and publication year in the Web of Science™ citation index.

According to Clarivate, Highly Cited Researchers contribute disproportionately to extending the frontiers of knowledge and innovations that make the world healthier, richer, more sustainable and more secure. The 2023 list includes 6,849 individual researchers from institutions in 67 countries and regions. The 10 CHI faculty members are as follows:

1. Professor Antonio Helio Castro Neto
2. Professor Chen Peng
3. Professor Chen Wei
4. Professor Lin Zhiqun
5. Professor Liu Bin
6. Professor Loh Kian Ping
7. Professor Xie Jianping
8. Professor Jason Xu Zhichuan
9. Associate Professor Sibudjing Kawi
10. Associate Professor Yan Ning

Efficient NH_3 Cool Flames

–By Xie Shumeng and Asst Prof Zhang Huangwei

Cool flames have long been considered a key process responsible for fuel combustion efficiency and are also an important phenomenon for fire safety. Traditionally, cool flames have been documented solely in mixtures featuring hydrocarbon fuels with prominent low-temperature chemistry, such as n-heptane and dimethyl ether. However, in our recent exploration of ammonia combustion, stable cool flames are observed based on a counterflow system for the first time, which is featured by lower combustion heat release and flame temperature, compared to conventional hot ammonia flames. The primary oxidization paths in the cool flame are also identified. This breakthrough enriches our understanding of unique ammonia flame characteristics and will guide the future exploration of ammonia-based laboratory-scale and real combustion technologies.

Ammonia Electrosynthesis Using Ru–Cu Cocatalyst

–By Prof Loh Kian Ping *et al.* (10.1021/jacs.3c10516)

Electrochemical synthesis of ammonia via the nitrate reduction reaction (NO_3RR) has been intensively researched as an alternative to the traditional Haber–Bosch process. Most research focuses on the low concentration range representative of the nitrate level in wastewater, leaving the high concentration range, which exists in nuclear and fertilizer wastes, unexplored. Herein, we demonstrate that a co-catalytic system of Ru/Cu2O catalyst enables NO_3RR in 1 M nitrate electrolyte, with 100% faradaic efficiency toward ammonia. Computational simulations reveal that adsorbed hydroxide on Ru nanoparticles promotes the hydrogen transfer rate via H-bonded water network on the Cu catalyst surface. Our work highlights the importance of engineering synergistic interactions in cocatalysts for addressing the kinetic bottleneck in electrosynthesis.

Events

Global Young Scientists Summit (GYSS) site visit to CHI

As one of the four NUS research centres that were selected for the 2024 Global Young Scientists Summit (GYSS) site visit, 18 nominated researchers from Finland, Switzerland, China, Japan, and Thailand among other countries visited CHI on 8 January 2024. They had a lab tour of CHI, where we introduced our research capabilities.

After that, CHI researchers gave poster presentations of their groundbreaking works in the field of hydrogen innovations. Here, the GYSS participants delved into the electrochemical production of liquid organic hydrogen carrier; grid-scale energy storage and on-demand hydrogen production; direct "liquid hydrogen" production via electrocatalysis; and the development of a test rig for model gas turbine combustor fuelled with ammonia and natural gas blends.