2023

LAB OF GREEN CATALYSIS

Green Catalysis Lab

YEARBOOK

National University of Singapore
Yan Group

LAB OF GREEN CATALYSIS

CONTENTS

Editorial team

Jung Mu Nam
Yilian D. Chen
Fang Xiao

OVERVIEW

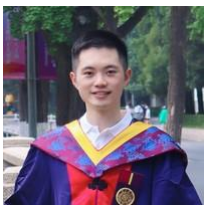
Prof. Yan Ning

He received his B.Sc. and Ph.D. degrees in Chemistry from Peking University, working with Prof. Kou Yuan from 2000 to 2009. After a Marie Curie Fellowship at École Polytechnique Fédérale de Lausanne in Switzerland with Prof. Paul Dyson, he joined National University of Singapore in 2012 and set up the Green Catalysis Lab. He was promoted to tenured associate professor in 2018. His group focuses on the catalytic transformation of renewable resources and heterogeneous catalysis.

Among the awards he received are the inaugural "Green Chemistry for Life" Young Scholar Award from UNESCO in 2014, the inaugural G2C2 Young Research Award from Global Green Chemistry Center Network in 2015, "Energy, Environment and Sustainability Early Career Award" from Royal Society of Chemistry in 2017, "Sustainable Chemistry & Engineering Lectureship Award" from American Chemistry Society in 2018, "Young Researcher Award" from NUS in 2019, and "NRF Investigatorship" from the Singapore Government in 2021. He is or was part of the editorial team of numerous international journals, such as ACS Catalysis, ACS Sustainable Chemistry & Engineering, Catalytic Science & Technology and Molecular Catalysis.

New members

Research Fellow



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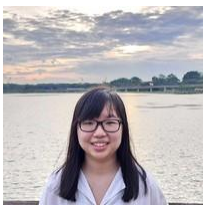

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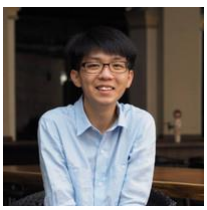

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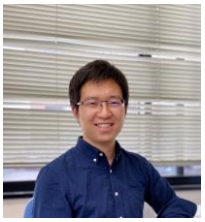

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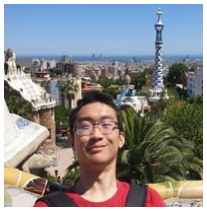

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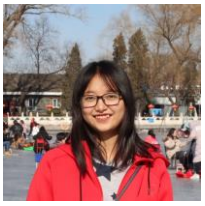

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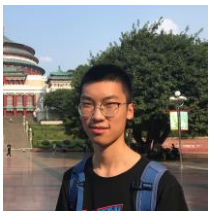
- 2023



Yuan Qixin

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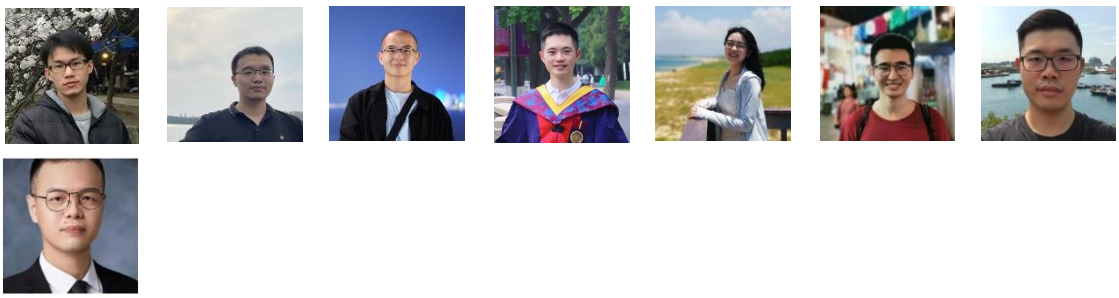
- 2021-2023

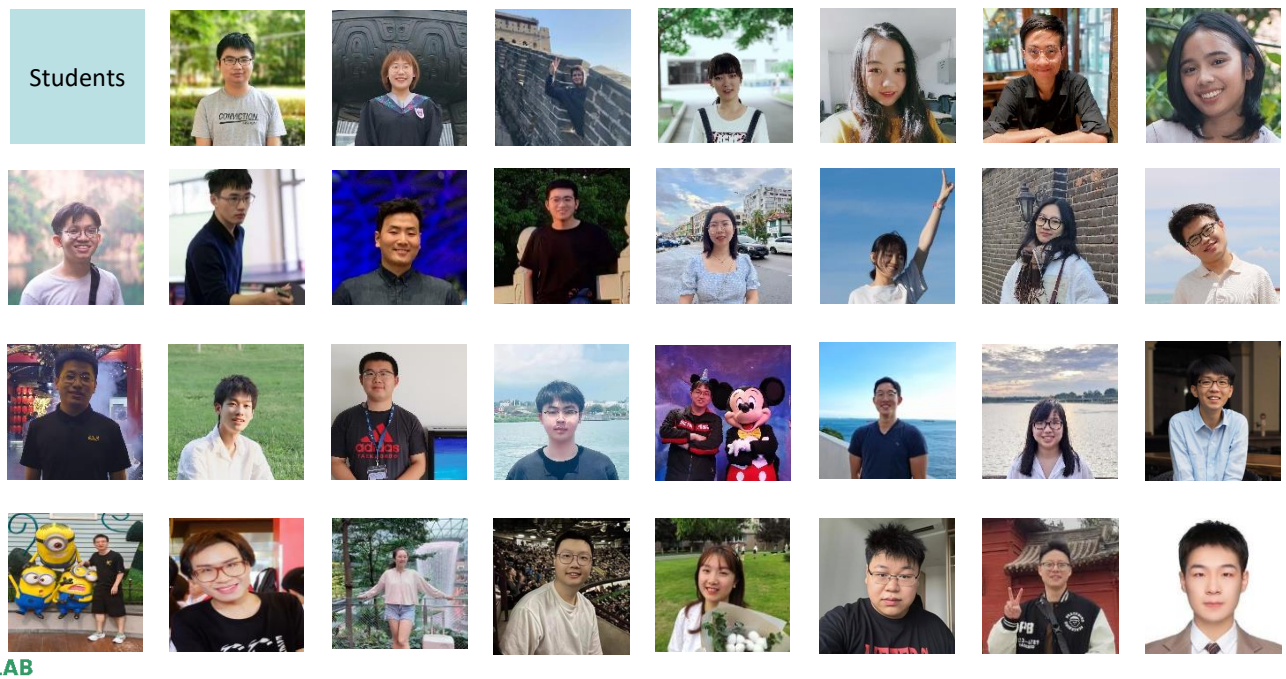
Current members

Our group currently has 8 post-doctoral research fellows, 21 PhD candidates, and 10 Master students.

Staffs



Students



LAB OF GREEN CATALYSIS

RESEARCH FACILITIES

Our laboratory is well-equipped for catalyst preparation, characterisation and testing.

laboratory Venues

E8-05-13

E8-05-14

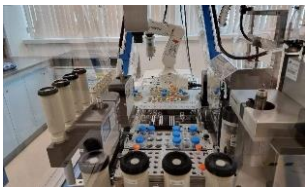
E8-05-10

New Lab!

E8-01-05

This year, we are pleased to announce the addition of a new laboratory, Room 01-08. In total, our group now possess two individual laboratories, Rooms 05-13 and 05-14, in addition to shared public laboratory rooms located in Rooms 05-10 and 01-08 with other groups.

Catalyst preparation



Catalyst synthesis robot

Our laboratory is equipped with an advanced catalyst synthesis robot for automated processing, which is now relocated in room E8-01-05.

Glove box

We acquired a glove box for ensuring a controlled atmosphere, essential for handling sensitive substances and conducting experiments with high precision and safety.

Ball mill

The ball mill in our group is used for grinding materials into fine powder, enhancing particle size reduction and uniformity.

Oven

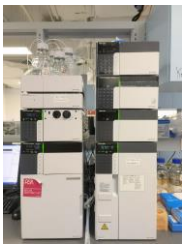
Centrifuge

The oven and centrifuge are essential tools; the oven for precise temperature control in sample preparation, and the centrifuge for rapid and efficient separation of mixtures.

Catalyst Characterization

The chemisorption analyzer, equipped with a built-in TCD, is used for characterizing catalyst surfaces through TPR/TPD/TPO and pulse chemisorption analyses.

Chemisorption Analyzer



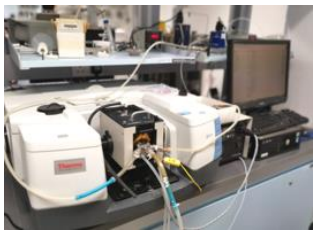
High Performance Liquid Chromatography (HPLC)

The two HPLCs in our lab are essential for separating, identifying, and quantifying components in complex mixtures with high efficiency and precision.

Mass Spectroscopy (MS)

MS is a powerful analytical technique for identifying unknown compounds and elucidating molecular structure and composition.

An in situ FTIR spectrometer in our lab allows for real-time monitoring of chemical reactions and molecular analysis.



In situ FTIR spectrometer

Offline GC

Online GC

Offline GC and Online GC are used for separation and analysis of volatile compounds.

Circular dichroism (CD) spectrometer

Our CD is indispensable for analyzing molecular chirality and conformation with high precision and accuracy.

Catalyst Testing

2-Channel reactor

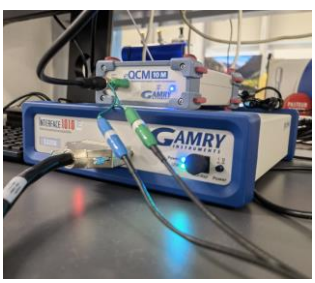
4-channel reactor

High-pressure flow reactor

Microwave reactor

We acquired a 2-channel fixed-bed reactor, a 4-channel fixed-bed reactor, a High-pressure flow reactor, a microwave reactor and many batch reactors for high-temperature and high-pressure reactions.

Our laboratory is currently equipped with 4 advanced electrochemical workstations. They are capable of executing a wide range of electrochemical techniques, notably including electrochemical impedance spectroscopy (EIS), which significantly enhances the quality of our electrochemical testing.



Electrochemical workstation

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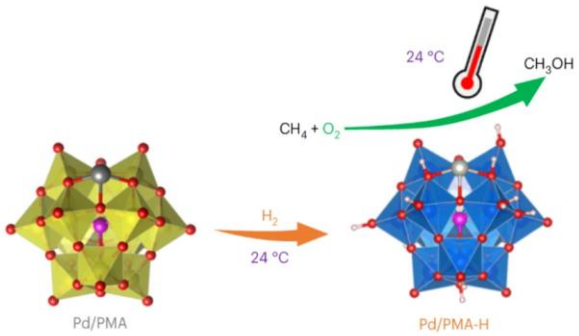
RESEARCH OUTCOMES

Catalyst design

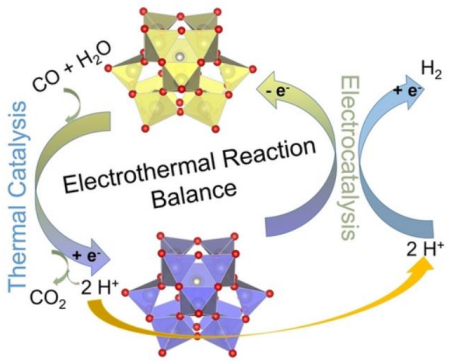


Graphical Abstract for *Nature Catalysis* paper.

In 2023, we continuously made outstanding contributions in catalyst design. First, We communicated a uniquely process combines thermal CO oxidation on a silicomolybdic acid-supported Pd single-atom catalyst with electrocatalytic hydrogen evolution. The process was facilitated by phosphomolybdic acid as a redox mediator at a moderate anodic potential. The catalyst demonstrated high efficiency, achieving stable hydrogen production with high purity (Angewandte Chemie International Edition). Next, inspired by the class of enzymes called methane monooxygenases, we designed a Pd-supported caesium-exchanged phosphomolybdate catalyst. By conducting kinetics, spectroscopy, spectrometry studies, and DFT calculations, we found that the reduced catalyst exhibited considerable activity for the aerobic oxidation of methane to methanol at room temperature, offering potential for industrial-scale methane upgrading (Nature Catalysis).

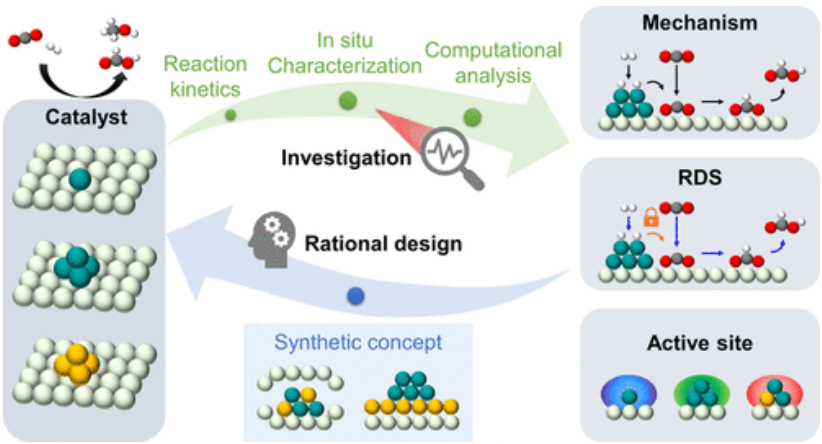
Representative Publications

- J. Chang *et al.* Electrothermal Water–Gas Shift Reaction at Room Temperature with a Silicomolybdate based Pd Single-Atom Catalyst. *Angewandte Chemie International Edition*, **2023**, e202218265.
- H. Yan *et al.* Enhancing polyol/sugar cascade oxidation to formic acid with defect rich MnO2 catalysts. *Nature Communications*, **2023**, 14, 4509.
- S. Wang *et al.* H2-reduced phosphomolybdate promotes room-temperature aerobic oxidation of methane to methanol. *Nature Catalysis*, **2023**, 6, 895–905.
- Y. You *et al.* Distinct selectivity control in solar-driven bio-based α-hydroxyl acid conversion: a comparison of Pt nanoparticles and atomically dispersed Pt on CdS. *Angewandte Chemie International Edition*, **2023**, e202306452.



Graphical Abstract for *Angew. Chem. Int. Ed.* paper.

Green energy

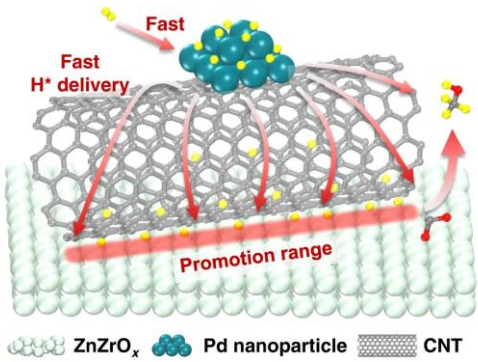


Graphical Abstract for *Accounts of Materials Research* paper.

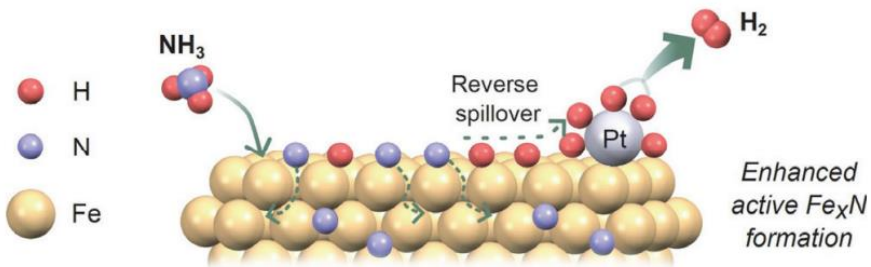
This year, we have made gratifying progress in CO_2 conversion and ammonia decomposition. First, we proposed a catalyst that incorporated hydrogen activation and delivery functions through the optimized integration of ZnZrOx and Pd supported on carbon nanotubes. Our catalyst provided a promising solution for developing next-generation CO_2 hydrogenation with both high activity and long-term stability (Nature Communications). Then, we investigated the effects of Pt addition on FexN formation in ammonia decomposition. Our results showed that even a slight Pt addition significantly enhanced the FexN formation rate, increasing it over threefold. This study provided an improved understanding of the active species formation mechanism of Fe catalysts in ammonia decomposition and offers a simple strategy for improving their catalytic performance (Chinese Journal of Catalysis). Looking forward to greater progress in next year!

Representative Publications

- K. Lee *et al.* Engineering nanoscale H supply chain to accelerate methanol synthesis on ZnZrOx. *Nature Communication*, **2023**, 14, 819.
- K. Saradima *et al*. Highly dispersed Pt boosts active FexN formation in ammonia decomposition. *Chinese Journal of Catalysis*, **2023**, 50, 297-305.
- K. Lee et al. Mechanism-Guided Catalyst Design for CO2 Hydrogenation to Formate and Methanol. *Accounts of Materials Research*, **2023**, 4, 9, 746–757



Graph published in *Nature Communication* paper.



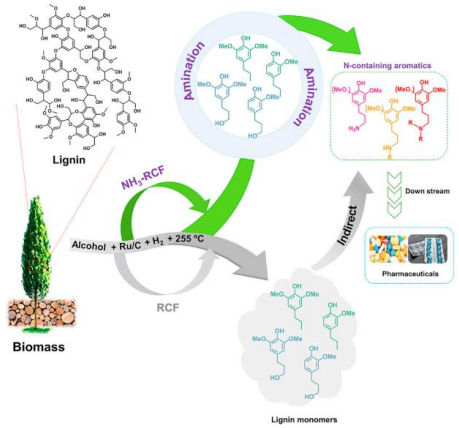
Graph published in *Chinese Journal of Catalysis* paper.

Preparation of Renewable Nitrogen-Containing Compounds

This year, We have achieved further success in converting biomass into high-value nitrogen-containing compounds. Our team has pioneered a single-step catalytic strategy for producing phenolic amines directly from wood lignin via reductive fractionation in an aqueous ammonia-alcohol mixture. This work exemplified the possibility for the production of N-functional compounds from lignin, expanding the options for the lignin-first strategy in biomass refinery (Chem). Then, we communicated a convenient one-pot synthesis of N,N-dimethyl chitosan oligosaccharide from chitin, highlighting its potential use in anti-fungal applications (ChemSusChem). Anticipate more groundbreaking work from our biomass team!

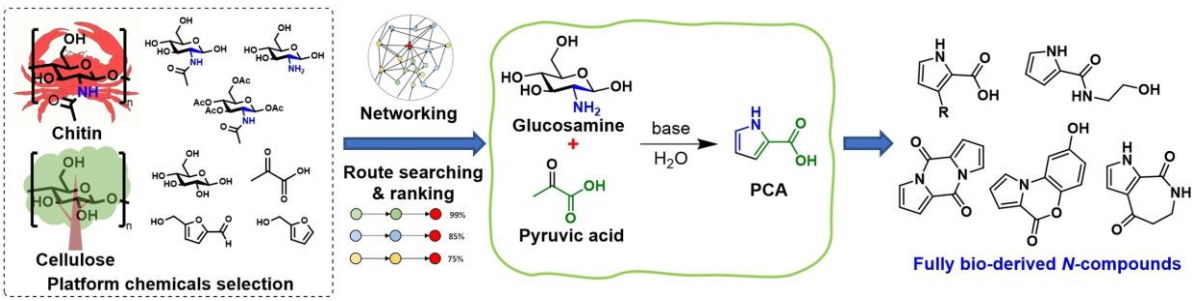
Representative Publications

- J. Ma *et al*. Single-step conversion of wood lignin into phenolic amines. *Chem*, **2023**, 9, 2869-2880.
- J. Cheng *et al*. One-Pot Chitin Conversion to High-Activity Antifungal N, N-Dimethyl Chitosan Oligosaccharides. *ChemSusChem*, **2023**, e202300591



Graphical Abstract for *Chem.* paper.

Waste Refinery and Utilization



Graphical Abstract for *ChemSusChem* paper.

Building on our biomass conversion expertise, this year we ventured into novel synthetic pathways, swiftly attaining breakthroughs. Our March paper reported a method for electrocatalytic amino acid synthesis from biomass-derived keto acids using carbon nanotubes, a testament to innovative catalysis (Green Chemistry). Following this, we communicated an automated discovery for synthesizing pyrrole-2-carboxylic acid from cellulose and chitin, illuminating the potential of automated route searches in green chemistry (ChemSusChem).

Representative Publications

- Y. Xiao *et al*. Electrocatalytic amino acid synthesis from biomass-derivable keto acids over ball milled carbon nanotubes. *Green Chemistry*, **2023**, 25, 3117-3126.
- T. Trang *et al*. Synthesis of pyrrole-2-carboxylic acid from cellulose- and chitin-based feedstocks discovered by the automated route search. *ChemSusChem*, **2023**, e202300538W.

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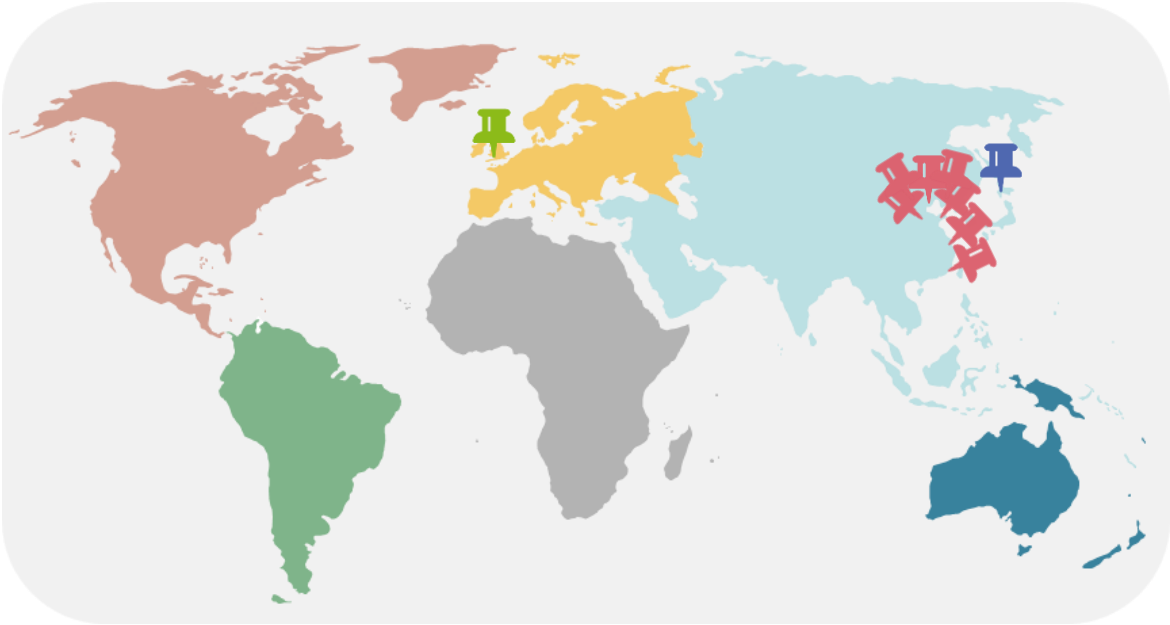
COLLABORATION

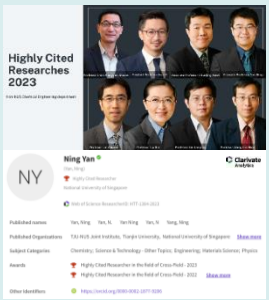


China: We continued collaborations with Prof. Feng Xiang and Prof. Liu Yibin from China U of Petroleum, Prof. Han Buxing from ICCAS, Prof. Liu Haichao from Peking U and Prof. Wang Ye from Xiamen U. In addition, we established new collaborations with Prof. Zhang Tao from DICP, Prof. Jin Fangming from Shanghai Jiao Tong U, Prof. Yu Qi from Shaanxi U of Technology and Prof. Li Xingang from Tianjin U. Moreover, we started collaborations with our former group members such as Prof. Yan Hao from China U of Petroleum and Prof. Song Song from Tianjin U. Our collaborations lead to several publications in journals including *Nature Communications*, *ACS Catalysis* and *Angewandte Chemie International Edition*.

Japan: Our collaboration with Prof. Shinya Furukawa from Hokkaido on Development of a Highly Stable Ternary Alloy Catalyst for Dry Reforming of Methane was published in *ACS Catalysis*.

United Kingdom: Collaborated with Prof. Graham J. Hutchings from Cardiff University on H2-reduced phosphomolybdate promotes room-temperature aerobic oxidation of methane to methanol, which was published in *Nature Catalysis*.

AWARDS

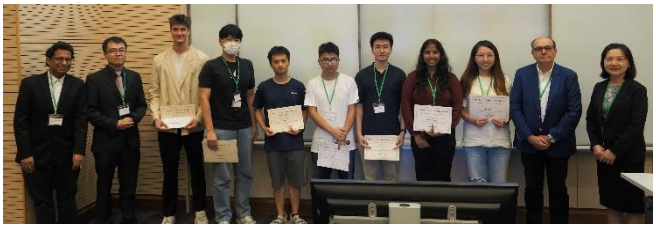


Highly Cited Researchers in 2023

Prof. Yan has been listed as a Highly Cited Researcher 2023 (Chemistry) by Clarivate, among 45 NUS researchers this year. This honor is in recognition of his outstanding and impactful scholarly accomplishments.

4th Southeast Asia Catalysis Conference

Maxim Dickieson won the Gold Award for poster presentation, while **Sikai Wang** and **Hua An** attained the Bronze Award.



China International College Students' Innovation Competition 2023 (CICSIC 23)

Maxim Dickieson won the Second Runner-Up for CICSIC 23 for "Waste-to-Value: Green and Efficient Method to Convert Shell Waste into High-value Chitin Product".

TJU–NUS Joint Institute awards

Our PhD students under the TJU-NUS Joint Institute **Sikai Wang**, **Hua An**, **Jinquan Chang**, **Pingping Wei** and **Di Xu** won the Best Research Report Awards at the third annual research workshop.

天津大学–新加坡国立大学福州联合学院
第三届博士研究生学术研讨会
"最佳研究报告奖"获奖学生名单
（2019 级、2020 级、2021 级）

分论坛	年级	姓名		
催化方向	2019级	王思恺 Wang Sikai	韩小玉 Han Xiaoyu	王　伟 Wang Wei
	2020级	安　华 An Hua	常金全 Chang Jinquan	卫萍萍 Wei Pingping
	2021级	许　迪 Xu Di	郝子文 Hao Ziwen	张　妍 Zhang Yan

天津大学–新加坡国立大学福州联合学院
"最佳学业成绩奖"获奖学生名单
(2021 级)

序号	姓　名	CAP 成绩
1	吕静宽 Lyu Jingkuan	4.92
2	Nguyen Thai Thien Phuc	4.92
3	孙玉立 Sun Yuli	4.9
4	丁怡水 Ding Yishui	4.8
5	刘　炽 Liu Chi	4.8
6	龙　昱 Long Yu	4.8

In addition, **Nguyen Thai Thien Phuc** achieved the Best Academic Performance Award.

ALUMNI UPDATES

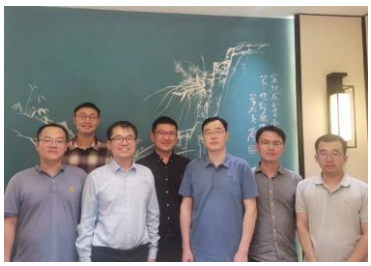
What's happening?

Tweet

Yu Zhou— Professor at Nanjing University of Technology

Visiting Scholar

As the epidemic came to a close, Dr Zhou and Prof. Yan were able to reunite in Nanjing this year and have a scholarly discussion!



Yaxuan Jing—Assistant Professor & Gusu Young Professor at Nanjung University

Exchange Ph. D.

Dr Jing published 5 peer reviewed papers this year.

After his postdoc research, he joined Nanjing University, Suzhou Campus, as a Tenure-track Assistant Professor & Gusu Young Professor. He will continue to focus on the catalytic conversion of waste plastics and biomass.

Qiming Sun— Distinguished Professor of Jiangsu Province, Soochow University

Research Fellow

Dr Sun's research group grew to fifteen and one of the graduate student published a research paper in JACS, which was selected as ESI highly cited paper. Dr Sun published one paper on Angew Chem for the first time as the corresponding author!

He was invited to serve as a member of the editorial board of Journal of Petrochemical Universities and a young executive editorial board of Chemical Journal of Chinese Universities and Chemical Research in Chinese Universities.

When he attended the annual meeting of the Chinese Chemical Society, he met many former members of Yan's group, and shared the good times of the past.

Ricca Rahman Nasaruddin— Assistant Professor at International Islamic University Malaysia

Research Fellow

She safely delivered her third baby in March 2023. The baby is now 9 months old. On the right is the photo of her and her baby.

Furthermore, I also received a "Young Promising Researcher Award - Second Place"

Kyungho Lee— Senior Researcher at Korea Institute of Energy Research

Research Fellow

Dr Lee has published five papers this year, three of which are on CO2 hydrogenation under the guidance of Yan. He actively participates in Korean academic society to promote his research done in our group. Also, he was able to attend the end-of-year party and made happy memories with us.

Max Joshua Huelsey— Research Fellow at MIT

Research Fellow and PhD.

He would like to share that on 4th October 2023, His son Quinn Yang (attached photo) was born and both him and his mother (who also happens to be a Green Catalysis Lab alumna) are doing splendidly.

Joanne Zimmer—PhD Candidate at Technical University of Darmstadt

DAAD undergraduate scholar

She started her PhD in the group “Soft Matter at Interfaces” under the supervision and guidance of Prof. Dr. Regine von Klitzing. She is working on the topic of “Microgel-stabilized aqueous Pickering foams” which she find extremely interesting, and she is very motivated to conduct research in the field of interfacial-chemistry and physics.

She also got to travel around many parts of the world. The furthest destination was Seoul, South Korea where she spent Christmas and New Years.

She also attended a conference in Liverpool this summer.

Lombardo Loris Giovanni— Postdoctoral Researcher at Kyoto University

Exchange MSc.

Dr Giovanni is now working in the laboratory of Prof. Horike since 2021 and is still focusing on CO_2 reduction and valorization to small molecules and materials.

He also wishes all the best for 2024 to the members of the Lab of Green Catalysis!

MILESTONES

JAN

Prof Yan hosted a New Year's Day BBQ Party! 🎉

FEB

Our work in promote a ZnZrOx catalyst by incorporating hydrogen activation and delivery functions through integration of ZnZrOx and Pd supported on carbon nanotube has been published in Nature Communications! 📚

Prof. Shinya Furukawa and his team visited NUS and a joint workshop was held. A series of exciting presentations on recent research works was given by members of both teams. 🎓

MAY

We've hosted Southeast Asia Catalysis Conference! Bringing experts in the field together for discussion was quite the pleasure. 💐 The conference had many memorable moments including invited lectures, industry talks and oral/poster presentations! 😄

Prof Yan was appointed as Editor-in-Chief of Molecular Catalysis! 🎉

Welcome to our new Editor-in-Chief

Elsevier is pleased to announce the appointment of **Prof. Ning Yan as Editor-in-Chief** of *Molecular Catalysis*. Prof. Yan is the Dean's Chair Associate Professor in the department of Chemical and Biomolecular Engineering and leads the Green Catalysis Lab at the National University of Singapore, and is President of the Singapore Catalysis Society.

JUL

Chem

CellPress

Volume 9, Issue 10, 12 October 2023, Pages 2869-2880

Article

Single-step conversion of wood lignin into phenolic amines

Jieran Ma [1], Duy Le [2], Ning Yan [1,3]

Our paper on single-step conversion of wood lignin into phenolic amines was published exemplifying the potential for production of N-functional compounds from lignin. 🎓

It was quite the pleasure to have Prof. Chunshan Song from The Chinese University of Hong Kong join us for our seminar series on CO2 capture and utilization for sustainable chemicals and fuels, followed by great discussions.! 🤝

AUG

We have completed the first partial lab commissioning for the high pressure 4-channel flow reactor (left). It is quite exciting to have the first piece of equipment operating in our new lab space!

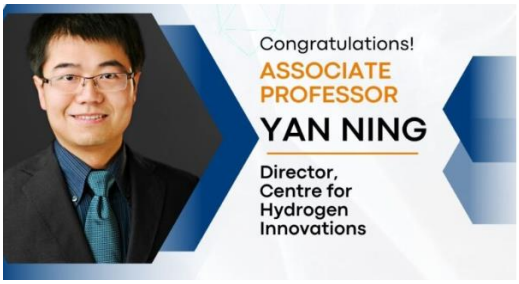
Prof Yan was hosted by Green Catalysis Lab alumni in Bangkok! Seated right to left are Meen, Ice, Prof. Napida, and Pond.

We were invited to write a research article in Chem Catalysis reporting a combined battery and biomass refining system.

SEP

The Tianjin University (TJU) - NUS Joint Institute in Fuzhou is coming together nicely, seeing the impressive infrastructure after years of work was quite the pleasure!

Congratulations to Mu Nam for passing his cQE!



Prof Yan was appointed as Director of Centre for Hydrogen Innovations

OCT

Prof. Yan attended the International Conference on Carbon Neutrality.

Our work using a defect-enriched MnOx catalyst to promote biomass conversion to formic acid was published in Nature Communications.

NOV

Congratulations to Prof. Yan on becoming one of the Clarivate World's Most Influential Scientific Minds 2023 List!

DEC

Our group held an annual celebration for two days. We had Dr. Lee Kyungho and Prof. Chen Xi, the alumni back to Singapore too. Hope everyone enjoyed visiting, games and the fancy dinner!

LAB OF GREEN CATALYSIS

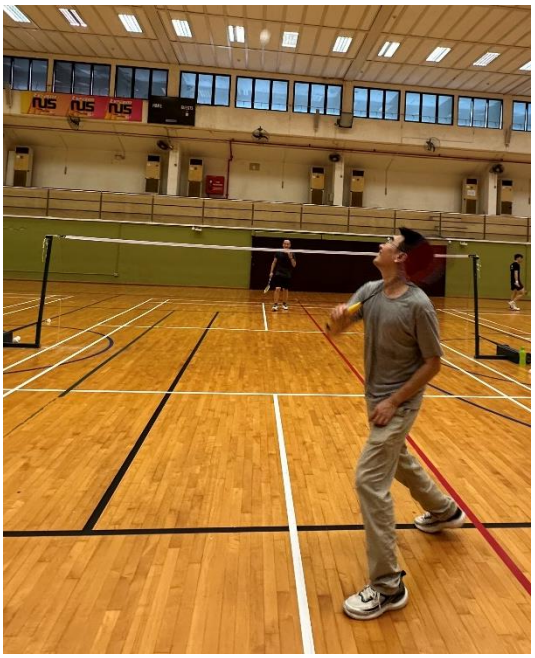
GROUP ACTIVITIES

NUS-Hokkaido Joint Workshop

Visit from Prof. Shinya Furukawa and his team

Sharing session of recent works by members of both teams

Regular Badminton Session



GROUP ACTIVITIES

Opening Ceremony of the Tianjin University (TJU) – NUS Joint Institute in Fuzhou

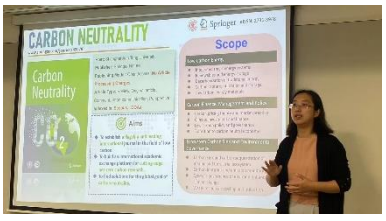
The team in Fuzhou had a good time during the ceremony

Annual Celebration

Visits from Dr. Lee Kyungho and Prof. Chen Xi

Bowling

Garden by the Bay



Sharing session

Escape Room

Dinner and Karaoke

Lucky Draw