Agency for Science, Technology and Research
SINGAPORE

Imperial College London

A*STAR-IMPERIAL COLLEGE LONDON JOINT SYMPOSIUM & WORKSHOP IN SUSTAINABILITY

A GREENER FUTURE WITH SUSTAINABLE ENERGY AND CATALYSIS

DATE

22 – 23 September 2022

VENUE

Institute of Sustainability for Chemicals, Energy and Environment ($ISCE^2$)
1 Pesek Road, Jurong Island
Singapore 627833

Content

About the A*STAR – Imperial College London Joint Symposium & Workshop on Sustainability

Climate change is a global challenge that needs to be addressed by numerous stakeholders, from governments, private and governmental organisations, and individuals. To this end, researchers across the world has answered the call, ideating processes and technologies towards a sustainable future.

The A*STAR – Imperial College London (ICL) Joint Symposium and Workshop on Sustainability held on 22 and 23 September 2022 aims to bring together minds from both ICL and the local research community to share their efforts to address the wide range of issues pertaining to our theme of "A Greener Future with Sustainable Energy and Catalysis". Invited speakers will share their perspectives on topics such as carbon upcycling, small molecule activation, high-throughput chemistry, and environmentally friendly catalysis.

The Joint Symposium and Workshop also commemorates the signing of a Memorandum of Understanding (MoU) between Imperial College London and A*STAR's Institute of Sustainability for Chemicals, Energy and Environment (ISCE^2) to establish a joint research laboratory in the field of Sustainable Energy and Catalysis. With the MoU, both parties would have access to state-of-the art equipment and technical expertise to enable cutting edge advances and nurture the next generation of scientific thought leaders to realise tangible solutions to climate change.

This event aims to be a platform for meaningful scientific exchange and to pave the way to mutually beneficial collaborations.

Committee Co-Leads

Prof Kuo-Wei Huang, ISCE^2

Dr Yun Zong, Research Office

Programme Committee

Prof Kuo-Wei Huang, ISCE^2

Dr Christina Pang, ISCE^2

Dr Siti Nurhanna Riduan, Research Office

Dr Yun Zong, Research Office

Dr Kevin Chong, Research Office

Event Committee

Dr Julian Chan, ISCE^2

Dr Kevin Chong, Research Office

Dr Russell Hewitt, ISCE^2

Mr Don Lim, ISCE^2

Mr Eddie Lin, ISCE^2

Dr James David Nobbs, ISCE^2

Dr Christina Pang, ISCE^2

Mr Iskandar Shahril Mohd Rawi, ISCE^2

Dr Jayasree Seayad, ISCE^2

Ms Norjana Taib, Research Office

Dr Martin van Meurs, ISCE^2

Dr Cun Wang, ISCE^2

A*STAR – Imperial College London Joint Symposium on Sustainability

Day 1: 22nd September 2022

08:30-09:15 Arrival and Registration

09:15-09:25 Opening Address by Deputy Chief Executive (Research), A*STAR, **Prof Andy Hor**

Session 1: Rethinking Sustainability through Homogeneous Catalysis

Chair: Prof Kuo-Wei Huang

09:25-10:15

Prof Mark Crimmin, Imperial College London
Sustainable Chemistry with Main Group Reagents

Assistant Prof Ming Joo Koh, NUS
Sustainable Chemical Synthesis through Nonprecious Metal Catalysis and Radical Chemistry

Dr Charles Romain, Imperial College London
New Methodologies and Catalytic Systems for Making Sustainable Polymers

Dr Davin Tan, IMRE, A*STAR
Embracing Mechanochemistry – Sustainability and Catalysis in the Solid State without Bulk Solvents

10:15-10:35 **Block Q&A**

10:35-11:10 *Tea Break & Networking*

Session 2: The Role of Small Molecule Activation in the Energy Challenge

Chair: Assistant Prof Ming Joo Koh

11:10-12:25

Prof Nicholas Long, Imperial College London
Controlling Bio-Polymerisation Reactions via Switch Catalysis

Prof Kuo-Wei Huang, ISCE² & IMRE, A*STAR
Fuelling the Future

Prof George Britovsek, Imperial College London
Novel Diphosphine Ligands in Palladium-Catalysed Hydroformylation and Alkoxycarbonylation of Alkenes

Associate Prof Shaozhong Ge, NUS
Cobalt/Copper-Catalysed Selective Hydrosilylation of Alkynes in CO_2 atmosphere

Dr Andrew Ashley, Imperial College London
Efficient N_2 Fixation by a Simple Fe(N_2)(diphosphine)$_2$ Complex

12:25-12:50 **Block Q&A**

12:50-13:50 *Lunch & Networking*

A*STAR – Imperial College London Joint Symposium on Sustainability

Day 1: 22nd September 2022

Session 3: Rejuvenating Our Environment with Biomass Conversion and Carbon Upcycling

Chair: Associate Prof Shaozhong Ge

13:50-14:55	**Dr Philip Miller, Imperial College London** *Catalytic Hydrogenation of Levulinic Acid to ɣ-Valerolactone and Beyond* **Dr Lili Zhang, ISCE², A*STAR** *Sustainable Energy and Materials from Circular Economy Perspective* **Associate Prof Han Sen Soo, NTU** *Photocatalytic Biomass and Plastics Upcycling by Homogeneous Catalysis* **Dr Melanie Weingarten, SIFBI, A*STAR** *"BREAD from Air"* **Dr Dan Kai, ISCE² & IMRE, A*STAR** *Development of Functional Materials from Lignocellulosic Biomass*
14:55-15:20	**Block Q&A**
15:20-15:45	*Tea Break & Networking*

Session 4: Formulating Greener Processes: Automation and High Throughput Chemistry

Chair: Dr Lili Zhang

15:45-16:20	**Dr Rebecca Greenaway, Imperial College London** *High-Throughput Approaches for the Discovery of Supramolecular Organic Materials* **Associate Prof Jie Wu, NUS** *On-Demand Automated Synthesis of Organic Small Molecules* **Dr Chee Kok Poh, ISCE², A*STAR** *Modified Fischer-Tropsch Reaction for the Conversion of CO_2 to Greener Hydrocarbons*
16:20-16:45	**Block Q&A**

17:00	**Departure from ISCE²@Jurong Island**
18:30-21:00	**Symposium Dinner** *(for invited guests)*

A*STAR – Imperial College London Joint Workshop on Sustainability

Day 2: 23rd September 2022

09:00-09:35	**Arrival & Registration** *Light refreshments*
09:35-11:20	**Dialogue with Prof Xian Jun Loh, Executive Director, ISCE², A*STAR** *The Future of Sustainability Research in Singapore* **Dialogue with Prof Kuo-Wei Huang, Director, ISCE², A*STAR** *Moving Forward Together: Realising Sustainability with International Partnerships*
11:20- 12:35	*Lunch & Networking*
12:15-12:35	**MoU Signing Ceremony** *(for selected attendees only)* *Imperial College London and ISCE², A*STAR*
12:35-14:05	**Dialogue with Imperial College London Delegates** *Sustainability Research Efforts at Imperial College London*
14:05-15:20	**Poster Session & Networking** **ISCE² Facilities Tour** *(for pre-registered participants only)*
15;20-15:45	*Tea Break & Networking*
15:45-15:55	**Closing Remarks by Prof Xian Jun Loh**, ED, ISCE² & IMRE, A*STAR
16:00	**Departure from ISCE²@Jurong Island**

~ Session 1 ~

Rethinking Sustainability
through Homogeneous Catalysis

Prof Mark R. Crimmin

Professor of Organometallic Chemistry, Faculty of Natural Sciences, Imperial College London

Mark R. Crimmin graduated from Imperial College London in 2004 and completed a MSc by research in organic synthesis at Bristol University under the supervision of Prof. Aggarwal. He received his PhD in main group chemistry and catalysis from Imperial College London in 2008 supervised by Prof. Mike Hill (now at Bath) and Prof. Tony Barrett. In the same year, he was awarded a Royal Commission for the Exhibition of 1851 research fellowship which he took to UC Berkeley to study with Prof. Bob Bergman and Prof. Dean Toste. In 2011, he returned to London as a Royal Society University Research Fellow, initially at UCL and now back at Imperial. He was appointed as a lecturer in 2011, Senior Lecturer in 2016, Reader in Organometallic Chemistry in 2019, and full Professor in 2021.

Sustainable Chemistry with Main Group Reagents

In this short lecture I will introduce 3 topics.

(i) **Complexity from small molecules** (CO, CO_2, H_2) will highlight the possibility of using C1 building blocks to make complex organic products which contain at least three carbon atoms through combining C1 units on metals.

(ii) **Molecular Editing with Metals** will focus on emerging methods for the editing of molecular scaffolds including aromatic ring systems such as furans relevant to biomass. The methods of choice will be those that install a metallic element into the ring, allowing a point for further chemical manipulation and transformation of one type of aromatic ring into another (e.g. furan to pyridine).

(iii) **Circular Chemistry of Fluorine** finally I will describe methods for the recycling and reuse of fluorine containing waste products such as HFC-23 (trifluoromethane), SF_6, and PTFE.

Dr Ming Joo Koh
President's Assistant Professor,
Department of Chemistry,
Faculty of Science,
National University of Singapore

Ming Joo (MJ) Koh was born and raised in Singapore. He received his BSc. degree (First Class Honors) in Chemistry & Biological Chemistry from Nanyang Technological University in 2012, before heading to Boston College for his Ph.D. and post-doctoral studies under the supervision of Prof. Amir Hoveyda from 2012 to 2018. In June 2018, MJ joined the Department of Chemistry at the National University of Singapore as the first President's Assistant Professor. MJ's current research focuses on developing sustainable and practical catalytic solutions that address critical challenges in chemical synthesis through nonprecious metal catalysis and radical chemistry. His work has been published in reputable scientific journals, including *Nature Catalysis*, *Nature Chemistry*, *Nature Synthesis*, *Chem* and *JACS*. MJ is a recipient of the NUS Inauguration Grant (2019), Asian Core Program Lectureship Awards for Japan, Korea, China and Thailand (2019, 2022), Excellent Young Teacher Award (2020), Innovators Under 35 (TR35) Asia Pacific Award (2021), TCI-SNIC Industry Award in Synthetic Chemistry (2021), Thieme Chemistry Journals Award (2022) and C&EN's Talented 12 Award (2022).

Sustainable Chemical Synthesis through Non-Precious Metal Catalysis and Radical Chemistry

Chemical manufacturing is a key pillar of the global economy and plays a crucial role in the modern human society. Chemical catalysis is an indispensable tool to promote reactions that enable access to various classes of chemicals, ranging from small-molecule medicines to polymeric materials. Despite considerable advances made in this area, much of it depends on the use of exorbitant and scarce noble metals to prepare catalysts. Furthermore, such precious metal-derived catalysts can only mediate a limited range of reactions. As a result, longer synthetic sequences are often needed to convert a starting material to the desired target product. Unfortunately, each step in a chemical synthesis process consumes energy, resources and time, and generates waste (spent carbon-based solvents and other by-products) that has to be treated or incinerated. Consequently, this leads to more CO_2 and other toxic emissions that contribute to global warming, climate change and other undesirable environmental problems. To address these challenges, we focus on the research of sustainable catalysis, where we develop nonprecious catalyst systems derived mainly from abundant base metals such as iron and nickel. In this talk, an overview of our efforts in various innovative approaches to transform cheap and abundant feedstock chemicals to value-added products with lower environmental footprint will be presented.

Dr Charles Romain
Lecturer in Chemistry,
Faculty of Natural Sciences,
Imperial College London

Charles Romain completed his PhD thesis at the University of Strasbourg under the supervision of Dr. Stephane Bellemin-Laponnaz and Dr. Samuel Dagorne, before leaving for London in 2012 to join the group of Prof. Charlotte K. Williams at Imperial College London. After a few exciting years working with CO_2, bio-based monomers and catalysts design, Charles joined both the groups of Prof. Jason Hallett (Chemical Engineering) and Prof. George Britovsek (Chemistry) in 2016 to work on biomass deconstruction and valorization. In 2016, Charles was awarded a Junior Research Fellowship at Imperial college London and started his independent research career. Since 2022, Charles is a lecturer in the Department of Chemistry at Imperial College London. His research interests encompass catalyst design, polymerisation catalysis, non-covalent interactions, bio-based and sustainable materials. Alongside his research, Charles promotes the use of data repositories for the publication of FAIR data.

New Methodologies and Catalytic Systems for Making Sustainable Polymers

New technologies are urgently needed to develop truly sustainable materials, i.e. made from renewables, featuring useful properties while having end-of-life options that will contribute towards building our circular economy. Making such sustainable materials is challenging and it requires innovative strategies to access “advanced” polymers made from renewables. With our existing synthetic tools optimised for fossil resources, such innovative strategies are limited.

After a brief overview of our strategies i) to source materials from renewable resources by investigating new reactions, ii) to efficiently make materials by developing new catalysts, and iii) to improve material end-of-life, this talk will provide further details on our recent findings exploiting non-covalent interactiions in polymerisation catalysts.[1]

1. (a) Gesslbauer, S., et al., *Dalton Trans.* **2018,** *47*, 10410; (b) Gesslbauer, S., et al., *ACS Catal.* **2019,** *9*, 7912; (c) Baker, C. A., et al., *Chem. Commun.* **2021,** *57*, 12524; (d) Gesslbauer, S., et al., *ACS Catal.* **2021,** *11*, 4084.

Dr Davin Tan
Scientist II, Institute of Materials Research and Engineering (IMRE), A*STAR

Davin Tan obtained his Ph.D. at McGill University in Montreal, Canada. He is an experienced synthetic organic and inorganic chemist, and his research interests mainly involve solid-state chemistry, catalysis, sustainability and green chemistry. He specializes on mechanochemistry and supramolecular chemistry, creating organic compounds, active pharmaceutical ingredients and drug products that exhibit anti-diabetic, anti-inflammatory and anti-cancer properties. He was awarded the Ludo-Frevel Crystallography Scholarship and the Bill and Christina Chan Fellowship in Chemistry in 2015. He has published >40 peer-reviewed articles, of which 14 are highly cited (>20 cites) in high impact scientific journals, including four review papers and one book chapter.

Embracing Mechanochemistry – Sustainability and Catalysis in the Solid State without Bulk Solvents

Climate change has become a major global problem and many governments, in commitment to the 2021 United Nations Climate Change Conference or COP26 agreements, have created their own net-zero targets to reduce their nation's carbon emissions. Within Singapore's context, the proposed Green Plan 2030 include creating sustainable products, increasing the energy efficiency and reducing the carbon emissions of processes in Jurong Island. One of the key strategies to achieve this is to reduce the amount of chemical waste generated by chemical reactions. As chemists, we need to be more conscientious of the environmental footprint of our research, especially the amount of liquid waste that is generated in our laboratories, which can be significant when translating reactions to multi-kilogram scales. These liquid or solvent waste are typically transported to an incineration facility to be burnt, producing CO_2 and other toxic gas that are then released to the environment. To this end, more and more researchers are adopting solvent-free, solid-state mechanochemical methodologies that are consume less energy and produce less waste. In this short talk, I will highlight some of the recent advancements in this field, as well as my research interests involving the use of mechanochemistry to create pharmaceutical products and inorganic materials.

~ Session 2 ~

The Role of Small Molecule Activation in the Energy Challenge

Prof Nicholas Long FRSC

Sir Edward Frankland BP Endowed Chair in Inorganic Chemistry,
Faculty of Natural Sciences,
Imperial College London

Nicholas Long FRSC is the Sir Edward Frankland BP Endowed Professor of Inorganic Chemistry at Imperial College London (246 publications, h index = 52, 3 patents). He possesses wide-ranging experience and expertise in synthetic inorganic and organometallic chemistry and his interests are focused on switchable catalysis and ligand design, functional magnetic and inorganic solar cell materials, and biomedical imaging chemistry and probe design. Nick is a graduate of the University of Durham (BSc) and the University of Exeter (PhD) and held the Adrian Research Fellowship at the University of Cambridge before being appointed to a Governors' Lectureship at Imperial College London in 1995. He has successfully graduated 55 PhD students and generated grant income of around £30M. He is Deputy Director of EPSRC Centre for Doctoral Training in Medical Imaging (KCL/ICL), is a Royal Society Wolfson Research Merit Award Holder (2018-22), won the 2006 Royal Society of Chemistry Prize for Organometallic Chemistry, and the 2020 Royal Society of Chemistry Frankland Award. In 2021, he became a Fellow of the European Academy of Sciences and served on the UK REF2021 Chemistry panel.

Controlling Bio-Polymerisation Reactions via Switch Catalysis

"Switch" polymerisation catalysis is receiving attention as a promising strategy in polymer synthesis to control monomer enchainment via external stimulus of a single catalytic species. Our focus is on polylactic acid (PLA), a flagship biopolymer, being both bio-derived and industrially compostable, which is currently industrially obtained by the Sn-catalysed ring-opening polymerisation (ROP) of lactide, the dimer of lactic acid. This presentation will demonstrate new methodologies and catalysts that allow finer and unprecedented polymerisation control via switch catalysis e.g. (i) electrochemical and (ii) metal cooperativity. (i) Tagging of a redox-active ferrocene group (i.e. a redox tuner) enables redox control, switching catalysts "on" and "off" in lactide ROP. This strategy can bring redox-control to well-known catalysts and establish a new design principle for redox-switchable catalysts. (ii) Hetero-bimetallic catalytic species can outperform their homo-bimetallic counterparts in cyclic ROP, and the use of two different metals can enable the complementary reactivities offered by each metal to be exploited, either in tandem or synergistically. Our recent work revealed that the combination of a Ti-salen complex with a silver salt enables a unique hard/soft heterobimetallic cooperativity in lactide ROP, leading to significant activity at room temperature.

Prof Kuo-Wei Huang
Director, Division of Catalysis and Reaction Engineering, Institute of Sustainability for Chemicals, Energy and Environment (ISCE^2),
Principal Scientist II, Institute of Materials Research and Engineering (IMRE), A*STAR

Kuo-Wei Huang received his B.S. from National Taiwan University as a Yuan T. Lee Fellow and Ph.D. from Stanford University as a Regina Casper Fellow. Prior to joining KAUST as a founding faculty member, he was an Assistant Professor in National University of Singapore and a Goldhaber Distinguished Fellow at Brookhaven National Laboratory. The research interests of his group include CO_2 utilization, hydrogen storage, small molecules activation (particularly on the PN^3(P) ligand platform his group has developed and pioneered) and kinetic and DFT studies of transition metal and organocatalysis. He has received numerous awards, including Appreciation of distinguished teaching contribution, Ministry of Education, Saudi Arabia (2017), Rising Stars Lectureship, 41st International Conference on Coordination Chemistry (2014), and Asian Rising Stars Lectureship, the 15th Asian Chemical Congress (2013). He was recently highlighted in "Pioneers and Influencers in Organometallic Chemistry" in *Organometallics* in 2020. https://doi.org/10.1021/acs.organomet.0c00056

Fuelling the Future

In 2021, the estimated world population of 7.0 billion people consumed ~14 Gtoe of energy (at an average rate of 19.0 TW). Globally, burning of carbon-based fossil fuels supplies over 81% of the energy demand, and hence the prospering industrial societies are responsible for the observed increase in carbon dioxide levels form preindustrial 280 ppm to a new record high in 2021, 414.72 ppm. The constantly increasing atmospheric CO_2 concentration is highly likely to result in global warming, sea level rise and ocean acidification. To reduce the environmental footprint of modern societies and address the limitations of fossil recourses, the projected increase in global energy demand must go along with the implementation of low-carbon energy production and carrier systems. In this presentation, the current energy status and future options will be discussed and compared. It will then be concluded by introducing our research efforts in utilizing formic acid as a NET-ZERO hydrogen/energy carrier and e-fuel.

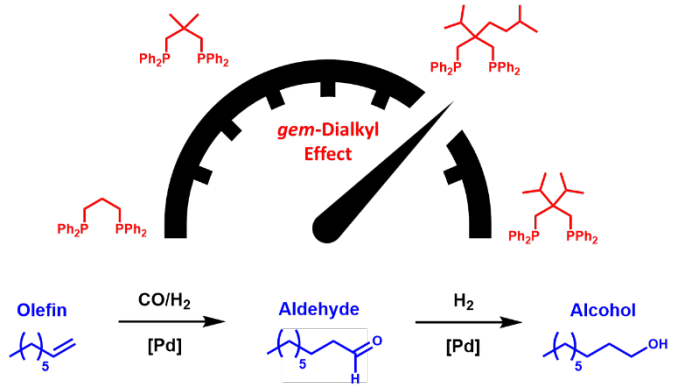
Prof George Britovsek FRSC

Professor of Chemistry,
Faculty of Natural Sciences,
Imperial College London

George Britovsek is a Professor of Chemistry, at Imperial College London. He obtained both his MSc equivalent and PhD degrees from Technical University of Aachen, Germany. He then pursued postdoctoral studies, first at the University of Tasmania, Australia, and subsequently at Imperial College London. Since his PhD studies, *George Britovsek* has been interested in the catalytic properties of transition metal complexes. His current research program involves the design and application of homogeneous and heterogeneous catalysts for applications in *carbon management*. This includes the development of renewable carbon resources for chemical synthesis based on small (alkanes, ethylene, syngas, carbon dioxide) and large molecules (biomass, lignin) as well as the development of decarbonised energy solutions based on hydrogen. A range of catalytic reactions are being investigated, including oxidation, hydrogenation and de-hydrogenation, carbonylation, alkene oligomerisation, polymerisation and de-polymerisation, which are underpinned by mechanistic studies. Many research projects are in collaboration with industrial partners.

Novel Diphosphine Ligands in Palladium-Catalysed Hydroformylation and Alkoxycarbonylation of Alkenes

The *gem*-dialkyl effect, known as the mutual repulsion between two geminally substituted alkyl groups on a carbon chain, can alter bond angles, promoted cyclisation and stabilise small ring structures.[1] The application of the *gem*-dialkyl effect to bidentate ligands has been reported to increase chelate stability,[2] alter ligand bite angle and improve product selectivity.[3]



A series of novel C_3-bridged diphosphine ligands with *gem*-dialkyl groups of varying steric bulk on the central carbon have been synthesised and characterised. The impact of the *gem*-dialkyl effect on coordination behaviour and catalytic performance in Pd-catalysed olefin carbonylation has been investigated.[4] Furthermore, we have investigated a series of phobane-derived diphosphine ligands to direct selectivity between alkoxycarbonylation and hydroformylation in palladium-catalysed alkene carbonylations.[5]

1. Jung, M. E.; Piizzi, G., gem-Disubstituent Effect: Theoretical Basis and Synthetic Applications. *Chem. Rev.* **2005,** *105* (5), 1735-1766.

2. Arthur, K. L.; Wang, Q. L.; Bregel, D. M.; Smythe, N. A.; O'Neil, B. A.; Goldberg, K. I.; Moloy, K. G., The gem-Dialkyl Effect as a Test for Preliminary Diphosphine Chelate Opening in a Reductive Elimination Reaction. *Organometallics* **2005,** *24* (19), 4624-4628.

3. van Rijn, J. A.; Siegler, M. A.; Spek, A. L.; Bouwman, E.; Drent, E., Ruthenium-Diphosphine-Catalyzed Allylation of Phenols: A gem-Dialkyl-Type Effect Induces High Selectivity toward O-Allylation. *Organometallics* **2009,** *28* (24), 7006-7014.

4. Tay, D. W. P.; Nobbs, J. D.; Romain, C.; White, A. J. P.; Aitipamula, S.; van Meurs, M.; Britovsek, G. J. P., gem-Dialkyl Effect in Diphosphine Ligands: Synthesis, Coordination Behavior, and Application in Pd-Catalyzed Hydroformylation. *ACS Catal.* **2020,** *10*, 663-671.

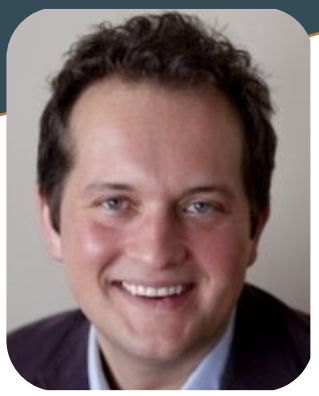
5. Tay, D. W. P.; Nobbs, J. D.; Aitipamula, S.; Britovsek, G. J. P.; van Meurs, M., Directing Selectivity to Aldehydes, Alcohols, or Esters with Diphobane Ligands in Pd-Catalyzed Alkene Carbonylations, *Organometallics* **2021**, *40*, 1914-1925.

Prof Shaozhong Ge
Dean's Chair Professor,
Department of Chemistry,
Faculty of Science,
National University of Singapore

Shaozhong Ge received his B.A. in polymer chemistry from University of Science and Technology of China in 2002 and M. Sc. in chemical engineering from Åbo Akademi University (Finland) in 2004. Then, he moved to Univeristy of Groningen in Netherland to continue his graduate study. He studied organo rare earth metal catalysts for olefin functionalization and polymerization, and obtained his Ph.D. degree in 2009 from University of Groningen under the supervision of Prof. Dr. Bart Hessen. From 2010 to 2014, he worked for Prof. John F. Hartwig as a postdoc research associate, developing nickel- and palladium-catalyzed (asymmetric) C-C and C-N cross-coupling chemistry in University of Illinois at Urbana-Champaign and University of California at Berkeley. In January of 2015, he joined the Chemistry Department at National University of Singapore as an Assistant Professor, and was promoted to associate professor with tenure in January of 2021. Currently, Dr. Ge holds the Dean's Chair Associate Professorship in the Chemistry Department at NUS.

Cobalt/ Copper-Catalysed Selective Hydrosilylation of Alkynes in CO_2 Atmosphere

Metal-catalyzed selective hydrosilylation of alkynes has been extensively studied because this transformation provides a straightforward synthesis of versatile vinylsilanes. In the past few years, we have identified several cobalt catalysts for hydrosilylation reactions of unsaturated hydrocarbons. During our continuous efforts in developing selective sequential hydrosilylation and carboxylation of alkynes with carbon dioxide, we found that hydrosilylation reactions of terminal alkynes with Ph_2SiH_2 conducted with a cobalt/copper bimetallic catalyst in the presence of carbon dioxide could selectively afford vinylsilanols. Carbon monoxide could be detected in this reaction. In this talk, the discovery of this unexpected hydrosilylation of alkynes with bimetallic cobalt/copper catalysts and possible reaction pathway leading to the formation of vinylsilanols will be discussed.



Dr Andrew E. Ashley
Senior Lecturer in Catalysis of Renewable Fuels Synthesis,
Faculty of Natural Sciences,
Imperial College London

Andrew Ashley obtained both his MChem degree and DPhil in organometallic chemistry from the University of Oxford (Christ Church, 1998-2006). He held a Junior Research Fellowship (JRF; Balliol College Oxford, 2008) where he commenced independent research investigating homogeneous methods for the conversion of CO_2 to hydrocarbon fuels, discovering a non-metal mediated route to the synthesis of CH_3OH from CO_2 and H_2. In 2010 he moved to London and became an Imperial College JRF and non-stipendiary Royal Commission for the Exhibition of 1851 Research Fellow, followed by the award of a prestigious Royal Society University Research Fellowship in 2012. His research interests target the development of new catalytic hydrogenation methodologies, both metal and non-metal (e.g. 'frustrated' Lewis pairs) based. These are subsequently used in the transformation of small molecules concerned with energy applications, such as the fixation of N_2 to NH_3 or N_2H_4, and CO_2 or CO to liquid fuels. In 2015 Andy was the winner of the BASF Catalysis Award, which is presented to an outstanding young researcher in the field of catalysis.

Efficient N_2 Fixation by a Simple $Fe(N_2)(diphosphine)_2$ Complex

The development of homogeneous catalysts capable of efficiently fixing N_2 with H_2 under mild conditions has posed a grand challenge for over 60 years, since the first transition metal-N_2 complex was discovered. Focus on Fe as a candidate metal platform for such transformations has been stimulated by its presence in both anthropogenic (Haber-Bosch process) and biological (nitrogenases; Fe/Mo, Fe/V and Fe-only) N_2-to-NH_3 fixation systems.

We report herein the remarkably efficient catalytic activity of the simple complex $Fe(N_2)(Et_2PCH_2CH_2PEt_2)_2$ for the fixation of N_2, using excess H^+ sources and reductant. Uniquely, catalytic formation of N_2H_4 results, which provides a direct process for the conversion of N_2 to a high-energy fuel. Mechanistic insights into this reaction will be discussed, where intermediates have been spectroscopically observed and/or isolated, and further supported by computational calculations.

~ Session 3 ~

Rejuvenating our Environment with Biomass Conversion and Carbon Upcycling

Dr Philip Miller
Reader in Applied Synthesis,
Faculty of Natural Sciences,
Imperial College London

Philip Miller is a Reader in the Department of Chemistry at Imperial College London. He has previously held an EPSRC Fellowship jointly at Imperial College and Arhus University investigating novel radiolabelling processes. His research is focused on the areas of homogeneous catalysis, flow chemistry, microfluidics and radiolabelling strategies for imaging applications. He has published >50 peer reviewed papers, has received grant income from EPSRC, the Royal Society, Research England (GCRF), CRUK and is a Co-I on the IC/King's College 'Next generation molecular imaging' programme grant. He has ongoing collaborations with GSK, BASF, Chemetall, CSIR (South Africa), Institute of Cancer Research, Invicro, and King's College London.

Catalytic Hydrogenation of Levulinic acid to ɣ-Valerolactone and Beyond

Levulinic acid (LA) is a biomass derived molecule that has attracted attention as a sustainable platform chemical that can be converted to higher value products such as ɣ-valerolactone (GVL). GVL can act as a green fuel additive, solvent and fine chemical intermediate, and hence has commercial value. Our group has explored a range homogeneous catalysts based on tri and bi-dentate phosphine transition metal complexes that have proved effective for the hydrogenation of LA to GVL. In this talk, our recent work using dicyclohexylphosphine palladium catalysts will be presented whereby we investigate both molecular hydrogen and formic acid (FA) as sources of hydrogen for LA conversion to GVL. The reaction with FA proceeds via a dehydrogenation process to generate H_2 and CO_2, and concomitant hydrogenation of LA rather than by direct transfer hydrogenation, achieving yields ranging 33-78% of GVL. FA was also found to dehydrate to H_2O and CO as evidenced by a qualitative colourimetric test and the formation of CO-bridged palladium dimers, which is thought to poison the catalyst and limit the yield. Under standard hydrogenation conditions with molecular hydrogen, near-quantitative yields of GVL at 150 °C and 15 bar H_2.

Dr Lili Zhang
Senior Scientist I,
Deputy Director, Catalysis & Reaction Engineering
Institute of Sustainability for Chemicals, Energy and Environment (ISCE^2), A*STAR

Lili Zhang is a senior scientist at the Institute of Sustainability for Chemicals, Energy and Environment (ISCE^2). Her expertise is in green catalysis, sustainable processes, waste upcycling, hydrogen gas production, and carbon-based materials and their applications in energy storage and catalysis. Lili was a process engineer at Micron between 2004 and 2006, and a research engineer in 2010 and 2011 at the National University of Singapore. She subsequently continued her research at the University of Texas at Austin as a research fellow, before returning to Singapore in 2013. Lili has been listed as a global Highly Cited Researcher, with recognizes world-class researchers with greatest impact on the research community.

Sustainable Energy and Materials from Circular Economy Perspective

Carbon negative and efficient energy recovery with sustainable processes that could reduce greenhouse gas (GHG) emissions are among the greatest challenges of the 21st century. Therefore, resource and value recovery from the waste streams and developing processes and technologies with low GHG emissions to meet growing energy demand in a sustainable manner is of great significance. On the other hand, development of sustainable processes and technologies with atom economic and environmentally friendly methods for the production of chemicals and materials are highly desirable. In this talk, I will briefly talk about some 'green' processes with the focus on the upcycling the waste to valuables, reducing environmental pollution, sustainable chemical processes and efficient energy storage and conversion capability.

Prof Han Sen Soo
Associate Professor,
School of Chemistry, Chemical Engineering and Biotechnology,
Nanyang Technological University

Han Sen Soo is an Associate Professor at the new School of Chemistry, Chemical Engineering and Biotechnology at Nanyang Technological University (NTU) Singapore. He graduated from MIT with Bachelor's and Master's degrees and completed his Ph.D. work at U.C. Berkeley. Subsequently, he joined the Lawrence Berkeley National Laboratory as a postdoctoral fellow, working on materials and nanotechnology for artificial photosynthesis. Han Sen started his independent career at NTU in 2012. The overarching theme of his research program is the development of artificial photosynthesis systems by using solar and other forms of renewable energy to catalyze the production of fuels and chemical feedstocks from "waste" materials. Some of the latest breakthroughs from his group are the application of metal halide perovskites as photocatalysts for organic synthesis, and the demonstration of a way to use light to upcycle non-biodegradable plastics into formic acid, which will be discussed during his presentation.

Photocatalytic Biomass and Plastics Upcycling by Homogeneous Catalysis

The increasingly severe effects from global climate change have stimulated the search for alternative and more sustainable chemical feedstocks beyond fossil fuels. In this context, materials such as non-food biomass and plastics, which have traditionally been considered as "waste", are attractive feedstocks that are currently under-explored.[1] Our team has attempted to use solar energy to convert these abundant but often recalcitrant precursors into small molecules and platform chemicals. I will present our efforts at applying molecular vanadium complexes for selective, ambient condition, photoredox carbon-carbon bond cleavage reactions.[2] We conducted detailed kinetic measurements to identify the fastest catalyst and the critical functional groups required in the substrates.[3] The vanadium photocatalysts were then utilized for the carbon-carbon bond cleavage and oxygenation of over 30 substrates, including unactivated, commercially sourced alcohols and even non-biodegradable plastics (**Figure 1**).[4] We propose that these vanadium coordination complexes can be integrated into artificial photosynthetic systems for the upcycling of a wider range of plastics and the production of solar fuels.[5,6]

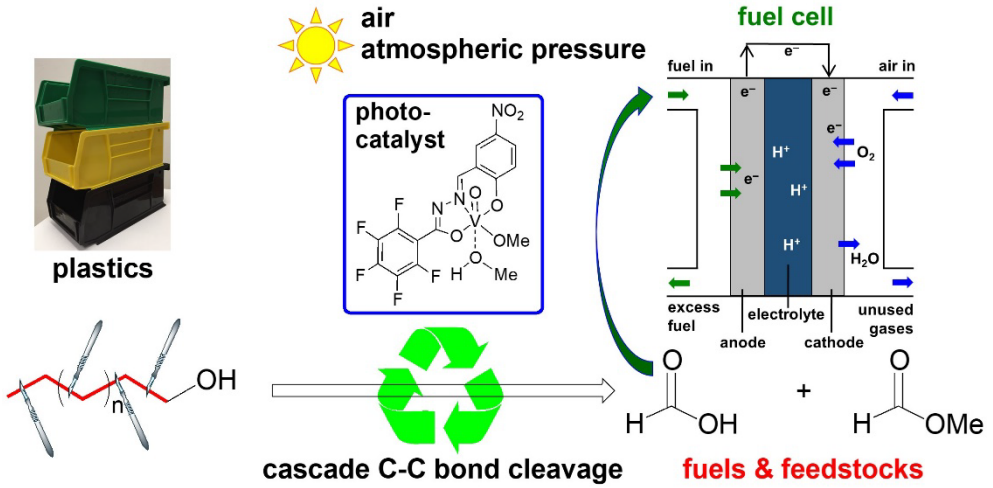


Figure 1. Photocatalytic upcycling of non-biodegradable plastics into fuels

1. Dokić, M.; Chin, K. F.; Soo, H. S. Photoelectrochemical Cells for Artificial Photosynthesis: Alternatives to Water Oxidation, *Trends Chem.* **2020**, *2*, 485-488.

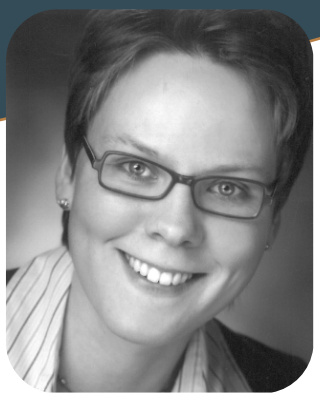
2. Gazi, S.; Ng, W. K. H.; Ganguly, R.; Moeljadi, A. M. P.; Hirao, H.; Soo, H. S. Selective Photocatalytic C–C Bond Cleavage Under ambient Conditions with Earth Abundant Vanadium Complexes, *Chem. Sci.* **2015**, *6*, 7130-7142

3. Gazi, S.; Dokić, M.; Moeljadi, A. M. P.; Ganguly, R.; Hirao, H.; Soo, H. S. Kinetics and DFT Studies of Photoredox Carbon-Carbon Bond Cleavage Reactions by Molecular Vanadium Catalysts under Ambient Conditions, *ACS Catal.* **2017**, *7*, 4682-4691.

4. Gazi, S.; Dokić, M.; Chin, K. F.; Ng, P. R.; Soo, H. S. Visible Light Driven Cascade Carbon-Carbon Bond Scission for Organic Transformations and Plastics Recycling, *Adv. Sci.* **2019**, *6*, 1902020.

5. Zhao, X.; Boruah, B.; Chin, K. F.; Dokić, M.; Modak, J. M.; Soo, H. S. Upcycling to Sustainably Reuse Plastics, *Adv. Mater.* **2021**, 2100843.

6. Chu, S.; Zhang, B.; Zhao, X.; Soo, H. S.; Wang, F.; Xiao, R.; Zhang, H. Photocatalytic Conversion of Plastic Waste: From Photodegradation to Photosynthesis, *Adv. Energy Mater.* **2022**, *12*, 2200435.



Dr Melanie Weingarten
Director, Biotransformation
Singapore Institute of Food and Biotechnological Innovations (SIFBI), A*STAR

Melanie Weingarten is Head of the Biotransformation Department at the Singapore Institute of Food and Biotechnology Innovation (SIFBI), A*STAR. She is leading the SFS Future Foods grant "Alternative Protein Production Platform – from lab to pilot scale" connecting to the Food Tech Innovation Center, a co-development of Temasek and A*STAR. Before joining in April 2021, she worked as a Senior Researcher at BASF SE, Ludwigshafen in Germany in the departments "White Biotechnology Research" and "Process Research & Chemical Engineering" from August 2008 to March 2021. She was responsible for synthesis and process development for projects in nutrition and health chemistry, aroma chemicals, crop protection, pharma cosmetics and biopolymers. Her educational background is in chemistry and physics having studied as a fellow of the German National Merit Foundation at RWTH Aachen in Germany and at UC Berkeley in USA. She graduated (Dr. rer. nat.) under the supervision of Prof. A. Fürstner at the Max-Planck-Institute for Coal Research in Germany in metalorganic chemistry and natural product synthesis followed by a post-doctoral stay at MIT, USA with Prof. B. Imperiali in biochemistry and microbiology.

"BREAD from Air"*

A very crucial challenge for mankind is to balance the tremendous demand for high-quality proteins while mitigating environmental impacts like increased greenhouse gas emissions resulting e.g. from livestock rearing.

"Bread from air" describes the goal chemists and chemical engineers followed beginning of 20th century motivated by finding alternatives for natural "Guano" fertilizer from South America being transported tediously to e.g. Europe. World-scale production of ammonia, the Haber-Bosch process was inaugurated in 1913 at BASF, The Chemical Company in Germany and honored with 3 Nobel prizes.

This talk will connect to this Haber-Bosch journey and elucidate how our greenhouse gas burdens e.g. carbon dioxide can be turned into powerful solutions for our burning challenges by developing world-class technologies and using entrepreneurial spirit!

*Dr. A. Hermann, Physikalische Blätter 1965

Dr Dan Kai
Senior Scientist I, Institute of Materials Research and Engineering (IMRE), A*STAR

Dan Kai obtained his PhD degree at the National University of Singapore, and he joined A*STAR in 2013. Currently, he is leading research group "Green Infinity" to develop advanced technologies on converting food/argi-waste into value-added products. He has strong publication record and industry collaboration experience on developing advanced sustainable materials from lignocellulosic biomass. He has published over 80 peer reviewed research papers with a total citation of 6000+, H-index of 40 and Field-Weighted Citation Impact of 3.16. Dr Kai is recognized in the Top 2% Scientists Worldwide in a study from Stanford University in both 2020 and 2021 (Nanotechnology & Biomedical Engineering).

Development of Functional Materials from Lignocellulosic Biomass

In light of the incessant consumption of raw materials in the world today, the search for green and sustainable resources is ever pressing. Lignocellulosic biomass, being the most naturally abundant materials, have always been treated as agricultural/food waste and used in low-value applications. Our group “Green ∞” will focus on the development of functional materials based on lignocellulosic materials and other bio-resources. In this talk, Dr Kai will present the advanced modification chemistry for generating functional lignin-based polymers integrated with both the intrinsic features of lignin and additional properties of the grafted polymers. He will also show some case studies on how to convert food/agri waste into functional materials for various applications.

~ Session 4 ~

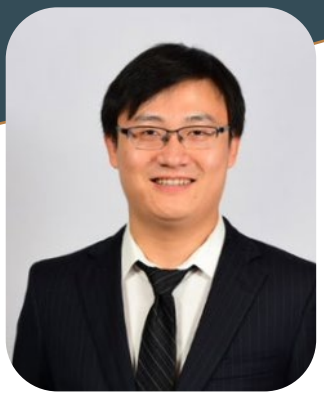
Formulating Greener Processes: Automation and High Throughput Chemistry

Dr Rebecca Greenaway
Royal Society University Research Fellow & Lecturer in Chemistry,
Faculty of Natural Sciences,
Imperial College London

Rebecca Greenaway is a Lecturer and Royal Society University Research Fellow (URF) at Imperial College London. She completed her DPhil at the University of Oxford in 2013 under the supervision of Prof. Ed Anderson. She then worked with Prof. Andy Cooper FRS as a postdoctoral researcher at the University of Liverpool, before being awarded a URF in 2019 allowing her to establish an independent research career. In May 2020 she joined the Department of Chemistry at Imperial, where she now serves on the management team for the EPSRC Centre for Rapid Online Analysis of Reactions (ROAR), the management board for ATLAS – a new high-throughput automation facility for accelerated materials research, and she is the automation lead in the recently launched Institute for Digital Molecular Design and Fabrication (DigiFAB). Becky is also on the early career advisory board for ChemPlusChem. Current research in the group focusses on the accelerated discovery of functional molecular organic materials assembled using dynamic covalent strategies. This includes the development of high-throughput automated workflows, and also of non-conventional phases of porous materials such as liquids, liquid crystals, and glasses.

High-Throughput Approaches for the Discovery of Supramolecular Organic Materials

Supramolecular synthesis and dynamic covalent chemistries are powerful strategies for the self-assembly of a range of complex molecular architectures and porous materials from multiple precursors in a one-pot reaction. For example, imine condensations can be used to form macrocycles, catenanes, knots, rotaxanes, porous organic cages and covalent organic frameworks. We are particularly interested in porous organic cages, discrete shape-persistent molecules containing permanent molecular cavities accessible through windows. Unlike more established porous materials, such as zeolites and metal-organic frameworks, which are typically extended framework structures, these molecular materials offer a number of advantages, such as solution processability. For example, they can be processed into porous liquids which combine the mobility of a liquid with the properties of a microporous solid, and fundamentally differ to conventional liquids in that they contain permanent, empty, accessible cavities. In this talk, I will give an overview of how these materials can be synthesised using a range of enabling technologies, including flow chemistry, mechanochemistry, and high-throughput automation, enabling both their scale-up and the ability to screen a broad synthetic space. I will also briefly introduce how merging high-throughput automation with large-scale computational screening in a combined hybrid workflow can further streamline the discovery process.

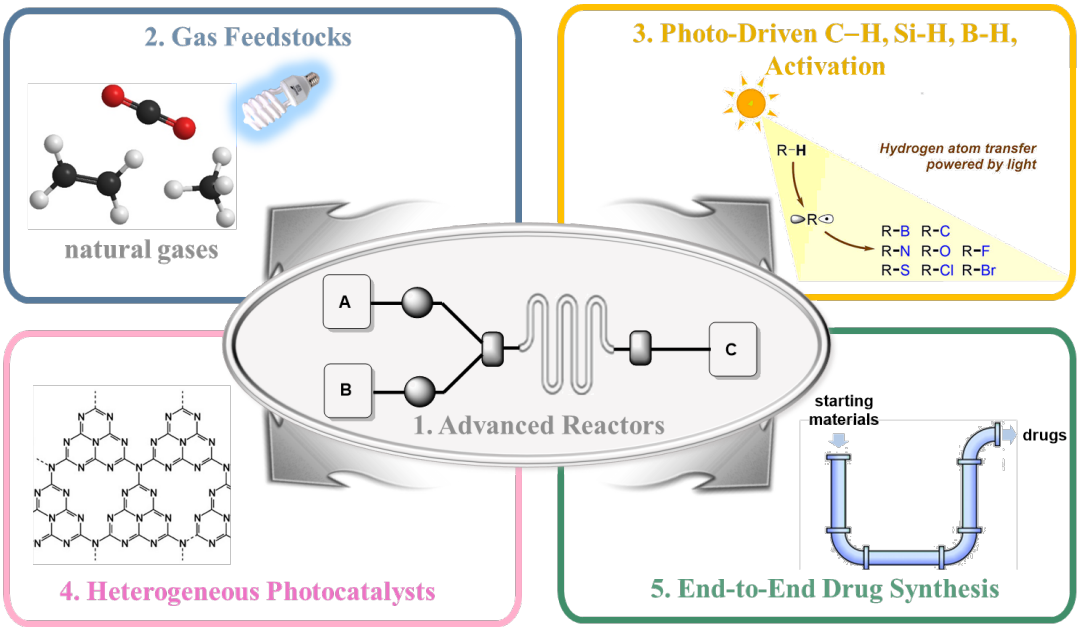


Prof Jie Wu
Associate Professor,
Department of Chemistry,
Faculty of Science,
National University of Singapore

Jie Wu was born and raised in Sichuan province in China. He received his BSc. Degree in Chemistry from Beijing Normal University. From 2006-2012, he pursued his PhD study with Prof. James S. Panek at Boston University working on natural product total synthesis and joined BU-CMLD to work on diversity orientated synthesis directed by Prof. John A. Porco. In his postdoc research at MIT with Prof. Timothy Jamison and Prof. Alan Hatton, Dr. Wu has been exposed to the hard core of continuous flow chemistry. Since joining NUS in July 2015, his research group at NUS Chemistry Department focuses on new synthetic methodology development using photocatalysis assisted by advanced flow technologies. His group is also interested in the development of advanced flow technologies for on-demand and automated synthesis of functionalized organic molecules. In July 2021, Dr. Wu was promoted to tenured associate professor. Dr. Wu's research group has published more than 50 high-impact papers (e.g. Nature Chemistry, Nature Synthesis, Chem, JACS, ACIE, Nat. Commun.) since he joined NUS chemistry department, and these works have been frequently featured in public media or highlighted in scientific journals. Dr. Wu is a recipient of Tokyo Chemical Industry-SNIC Industry Award in Synthetic Chemistry (2021), NUS Young Research Award (2021), Yong Scientist Award (2020), Asian Core Program Lectureship Award (2017-2022), Thieme Chemistry Journal Award (2019), and NUS Chemistry Department Young Chemist Award (2018).

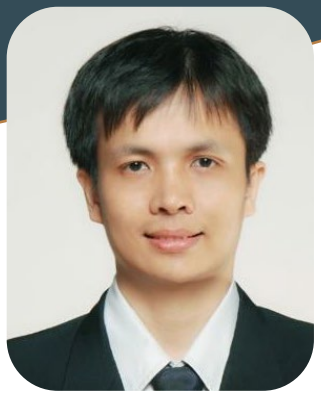
On-Demand Automated Synthesis of Organic Small Molecules

Our research group focus on synthesis of fine chemicals using inexpensive natural gases and hydrocarbons as feedstocks under visible-light irradiation. Our research group at NUS has recently invented a "stop-flow" micro-tubing (SFMT) reactor platform, which represents an ideal laboratory bench model for the real world flow reactor in reaction discover applications.[1] In this context, we envision that the SFMT system provides an effective tool for developing visible-light promoted gas/liquid reactions and would be more suitable than continuous-flow technique for screening as visible-light promoted photoredox transformations are slow in many cases. In this talk, I will briefly introduce our recent progress on photochemical transformations using cheap feedstocks assisted by continuous-flow and stop-flow reactors.[2]



Compared to stepwise batch synthesis, multistep continuous flow synthesis enables the combination of multiple synthetic steps into a single and uninterrupted reactor network, thereby circumventing the need to isolate intermediates, and enabling automated synthesis. However, despite many advantages and much progress in end-to-end API continuous-flow synthesis, several hurdles still need to be overcome. For instance, solvent and reagent incompatibility between individual steps, build-up pressure of reactors, substrate dispersion, and requirement of regeneration of reagent and scavenger columns. I this talk, I will present our recent progresses in this research field, which enables a novel automated API synthesis platform.

1) F. Xue, H. Deng, C. Xue, D. K. B. Mohamed, K. Y. Tang, J. Wu, *Chem. Sci.* **2017**, *8*, 3623. 2) a) J. Hou, A. Ee, W. Feng, J. Xu, Y. Zhao, J. Wu, *J. Am. Chem. Soc.* **2018**, *140*, 5257-5263. b) X. Fan, J. Rong, H. Wu, Q. Zhou, H. Deng, J. D. Tan, C. Xue, L. Wu, H. Tao, J. Wu, *Angew. Chem. Int. Ed.* **2018**, *57*, 8514-8518. c) H. Deng, Q. Zhou, J. Wu, *Angew. Chem. Int. Ed.* **2018**, *57*, 12661. d) J. Hou, A. Ee, H. Cao, H. Ong, J. Xu, J. Wu, *Angew. Chem. Int. Ed*. **2018**, *57*, 17220. e) J. Li, Y. Luo, H. Cheo, Y. Lan, J. Wu, *Chem* **2019**, *5*, 192. f) X. Fan, P. Xiao, Z. Jiao, T. Yang, X. Dai, W. Xu, J. D. Tan, G. Cui, H. Su, W. Fang, J. Wu, *Angew. Chem. Int. Ed.* **2019**, *58*, 12580. g) C. Liu, J. Xie, W. Wu, M. Wang, W. Chen, S. B. Idres, J. Rong, L.-W. Deng, S. A. Khan, J. Wu, *Nat. Chem.* **2021**, *13*, 451.



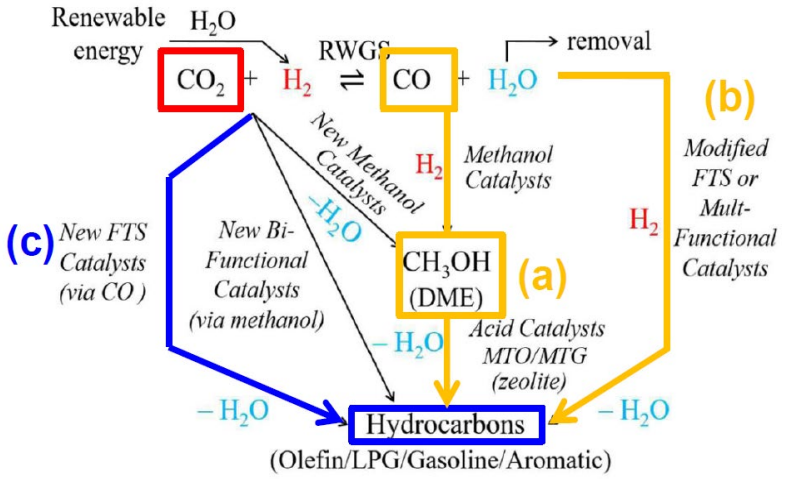
Dr Chee Kok Poh
Senior Research Scientist,
Institute of Sustainability for Chemicals, Energy and Environment (ISCE^2), A*STAR

Chee Kok Poh is currently scientist III at the Institute of Sustainability for Chemicals, Energy and Environment (ISCE^2), A*STAR. He graduated with a Bachelor's degree in Physics from the University of Malaya (1999) and obtained PhD in Physics from NUS in 2014 while working in A*STAR. Chee Kok's current research activities are focused on catalyst development for sustainability; other research interests include electrocatalysis, surface science, energy materials, quantum chemistry simulation, and machine learning. He has published 7 patents and more than 50 research papers on catalysis, material science and related topics.

Modified Fischer-Tropsch Reaction for the Conversion of CO_2 to Greener Hydrocarbons

CO_2 emission in 2010 was reported to be 49 Gt_{CO2eq}, and 35% (17 Gt_{CO2eq}) of the GHG emissions were due to power generation where 81.3% were from fossil fuels[1]. The ideal decarbonization strategy appears to be the adoption of hydrogen, a fuel without carbon. However, hydrogen technologies are not matured yet. There is a requirement in R&D in hydrogen storage, fuel cells for power generation, and establishment of renewable hydrogen supply chain and infrastructure. Therefore, it is unlikely to be ready soon. In contrast, "Carbon Capture, Utilisation and Storage" has been recognised by Intergovernmental Panel on Climate Change and International Energy Agency[2] as one of the strategies for mitigating climate change in the transitional period to global low-carbon economy.

ISCE^2 has been working with IHI Corp, Japan on CO_2 conversion to hydrocarbons for years. By utilising hydrogen produced from renewable energy sources, CO_2 can be converted to hydrocarbons via modified Fischer-Tropsch reaction. Combining our expertise in catalyst development, reactor design, and process engineering, we have achieved significant improvements and bringing the technology closer to commercialization. Further development to bring a breakthrough in next generation catalysts for CO_2 conversion could be achieved by the Accelerated Catalyst Development Platform (ACDP) established by ISCE^2.



1. Climate Change, 1st ed., Cambridge University Press, United Kingdom, 2014.

2. H. Kheshgi, H. de Coninck, J. Kessels, Carbon dioxide capture and storage: Seven years after the IPCC special report, Mitig. Adapt. Strateg. Glob. Chang. 17 (2012) 563–567. https://doi.org/10.1007/s11027-012-9391-5.

3. H. Yang, C. Zhang, P. Gao, H. Wang, X. Li, L. Zhong, W. Wei, Y. Sun, A review of the catalytic hydrogenation of carbon dioxide into value-added hydrocarbons, Catal. Sci. Technol. 7 (2017) 4580–4598. https://doi.org/10.1039/C7CY01403A.

Poster Exhibition

	Presenter	Title
1	**Dr Cun Wang (ISCE²)**	New Organic Catalysts for the Production of Bisphenol A Polycarbonate with Enhanced Weather Resistance
2	**Dr James Nobbs (ISCE²)**	New Secondary Phosphine Synthons for Sustainable Catalysis
3	**Dr Jun Yang Ong (ISCE²)**	Life Cycle PMI (lcPMI): Applying a Life Cycle Thinking towards the Evaluation of Additives for Water-based Palladium-catalysed Cross-coupling Reactions
4	**Ms Min Hui Lam (ISCE²)**	Formic Acid Coproduction by Electrochemical Cathodic CO_2 Reduction and Anodic Methanol Oxidation
5	**Mr Tze Yuen Yeo (ISCE²)**	Alternative Sand from CO_2 and Waste Materials
6	**Dr Albertus Denny Handoko (IMRE)**	Boosting CO_2 Conversion to C_{2+} with Amino Acid Functionalisation
7	**Dr Wan Ru Leow (ISCE²)**	Electrosynthesis of Ethylene Oxide from CO_2 and Water Only
8	**Dr Wan Ru Leow (ISCE²)**	Redox-mediated Selective Oxidation of Toluene into Benzaldehyde
9	**Dr Jie Zheng (ISCE²)**	Integrating Recyclable Polymers into Thermoelectric Devices for Green Electronics
10	**Dr Ying Chuan Tan (ISCE²)**	Food Waste-derived Material for Enhancing Electrochemical Conversion of CO_2
11	**Dr Ping Sen Choon (ISCE²)**	Bio-based Isocyanate-free Polyurethanes: from Chemistry to Applications
12	**Dr Zhennan Liu (ISCE²)**	Enhancing PET Breakdown with an Engineered Tag and Expression Conditions
13	**Dr He-Kuan Luo (ISCE²)**	Sustainable PET Depolymerization for Plastic Circular Economy
14	**Mr Qi Hua Ng (ISCE²)**	Carbon Capture and Utilisation Translational Testbed (CCUTT): Accelerating Energy Transition in Singapore
15	**Dr Balamurugan Ramalingam (ISCE²)**	Safe and Convenient Reactor Prototype for the On-demand Generation of Hazardous Reagents for Organic Synthesis
16	**Ms Pancy Ang (ISCE²) & Dr Srinivasa Reddy Mothe (ISCE²)**	The Virtue of Weakness: Sustainable Polymers for Encapsulation via Cyclic Ketene Acetals
17	**Dr Vivek Arjunan Vasantha (ISCE²)**	Functional Microreactors: Surface-Active Colloidal Micro/Nanoparticles
18	**Dr Satyasankar Jana (ISCE²)**	High Performance Cool Coatings for Built and Environment
19	**Dr Choon Wee Kee (ISCE²)**	^{18}F-Trifluoromethanesulfinate Enables Direct C–H ^{18}F-Trifluoromethylation of Native Aromatic Residues in Peptides
20	**Dr Balaji Balagurunathan (SIFBI)**	Biotransformation Capability Group @ SIFBI
21	**Ms Ying Sin Koo (ISCE²)**	Biocatalytic Alcohol Oxidation for Pharmaceutical Manufacturing
22	**Dr Guangrong Peh (ISCE²)**	Application of the Flavin-dependent Enzyme PrnC for Green and Efficient Halogenation of Pyrrole Derivatives

About the Institute of Sustainability for Chemicals, Energy and Environment (ISCE²), A*STAR

The Agency for Science, Technology and Research (A*STAR) is Singapore's lead public sector R&D agency. Through open innovation, we collaborate with our partners in both the public and private sectors to benefit the economy and society. As a Science and Technology Organisation, A*STAR bridges the gap between academia and industry. Our research creates economic growth and jobs for Singapore, and enhances lives by improving societal outcomes in healthcare, urban living, and sustainability. A*STAR plays a key role in nurturing scientific talent and leaders for the wider research community and industry. A*STAR's R&D activities span biomedical sciences to physical sciences and engineering, with research entities primarily located in Biopolis and Fusionopolis. For ongoing news, visit www.astar.edu.sg

The Institute of Sustainability for Chemicals, Energy and Environment (ISCE², pronounced "I-S-C-E-squared") was established by A*STAR in 2022 to support Singapore's sustainability goals, including the Singapore Green Plan and Zero Waste Masterplan, through strong partnerships with academia, public agencies, and industry.
ISCE² aims to help industries transition to renewable carbon and green chemistry, accelerated by digitalization and automation in three focus areas:

- Decarbonisation, which focuses on reducing carbon dioxide emissions through conversion to fuels, chemicals, construction materials, etc;
- Green materials, including the development of environmentally friendly products which are biodegradable and circular materials which can be recycled and upcycled;
- Green processes, that reduce carbon footprint and solvent waste, and improve energy efficiency, for example in sustainable pharmaceutical manufacturing.

With its core competences in organic and biomolecular chemistry, sustainable polymers, formulation technologies, catalysis, and process R&D, the institute will advance R&D in areas such as low-carbon technologies, carbon life cycle assessment, sustainable materials and green manufacturing processes.

About the Department of Chemistry, Imperial College London

The Chemistry Department at Imperial College London is one of the largest in the UK, and consistently ranks high in league tables (e.g. 3rd and 5th in Europe in the 2020 Times Higher Education Ranking and 2020 QS World University Ranking respectively). Research activities cover the full range of fundamental theoretical and experimental chemistry, as well as across other disciplines such as materials, engineering, biology and medicine. The Department is structured into seven cross-disciplinary Research Themes: i) Chemical Biology and Healthcare; ii) Energy; iii) Environmental and Green Chemistry; iv) Imaging, Sensing and Analytical Chemistry; v) Materials and Molecular Design; vi) Synthesis and Catalysis; vii) Theoretical, Computational and Data-driven Chemistry.

In 2018, all research activities of the Department moved into the Molecular Sciences Research Hub (MSRH), a new £170M building underpinned by £80M of funding from the UK Government. The new building with state-of-the-art facilities and infrastructure, located in Imperial College's White City campus, brings together academics, corporate partners, entrepreneurs and the local community to co-exist and co-create on an unprecedented scale.

Within the Synthesis and Catalysis theme, there are activities on:

- **Sustainable chemical manufacturing**, including: biomass-to-molecules, biomass-to-materials, CO_2-to-molecules, CO_2-to-plastics, N_2-to-molecules, chemistry with electrons or photons, chemistry with sustainable elements.
- **Chemical recycling and the circular economy**, including repurposing fluorochemicals, depolymerisation of plastics, and re-use of precious metals.
- **Digital chemistry**, including reaction automation, flow chemistry and reaction technology that collects and processes reaction data.
- **Molecular editing/Late-stage functionalisation** of complex molecules and materials through targeted catalysis and selective reagents.
- **Fragment, Lead-Oriented Synthesis and synthetic drug-design and agrochemistry** targeting new chemical motifs and bioisosteres for medicinal or agrochemistry along with the synthesis and manufacturing of new drugs.
- **Biological probes, imaging agents and polymers for drug-delivery**, for understanding biological systems and applications in healthcare.
- **Designer materials**, from molecular precursors and through modification of properties by synthetic methods.
- **Detection, sequestering and separation** of contaminates in water, waste streams or raw materials inputs.
- **Discovery chemistry**, including the discovery of the unknown, be it new types of molecules, new bonding interactions between elements or new mechanisms to make and break chemical bonds.


Agency for
Science, Technology
and Research
SINGAPORE


Imperial College
London