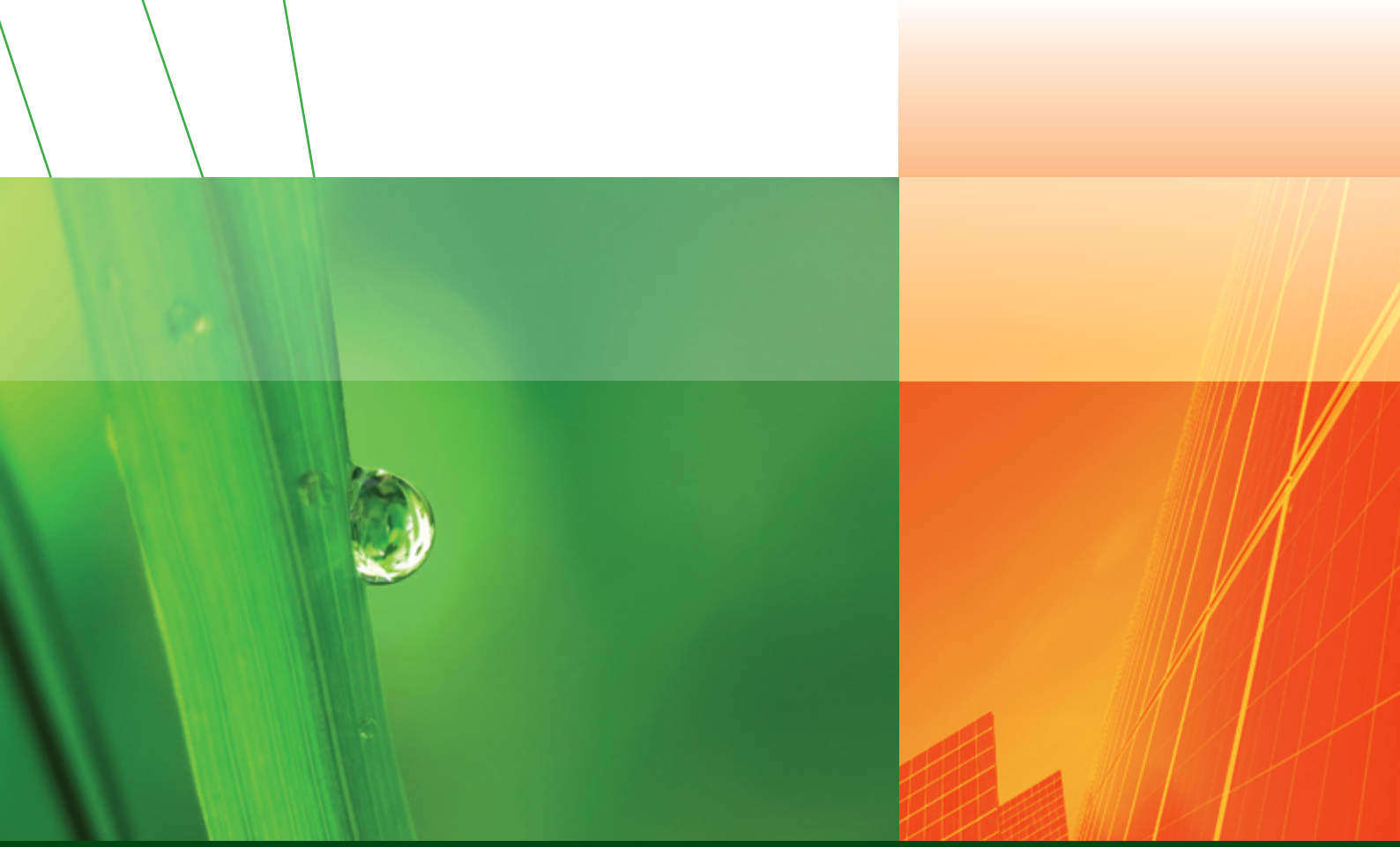
Agency for Science, Technology and Research
SINGAPORE

Australian Academy of Science

Australian Government
Department of Innovation Industry, Science and Research

Australia-Singapore **Energy Workshop**

University House
Canberra, 15–16 June 2009



Agency for Science, Technology and Research
SINGAPORE

Australian Government
Department of Innovation Industry, Science and Research

Australia-Singapore Energy Workshop

University House
Canberra
15-16 June 2009

Australian Academy of Science

Australia-Singapore Energy Workshop

University House, Canberra
15-16 June 2009

Welcome message from the President of the Australian Academy of Science

Dear Colleagues,

On behalf of the Australian Academy of Science I would like to welcome the Singaporean delegation from the Agency for Science, Technology and Research (A*STAR), participating in the **Australia-Singapore Energy Workshop.** We are delighted that this delegation is being led by Professor Charles Zukoski, Chairman of A*STAR's Science and Engineering Research Council.

Energy is an important issue for both our economies. By using leading-edge research and technological development, researchers can tap into new energy sources and ensure that conventional energies can be used more efficiently. This workshop will provide Australian and Singaporean participants the opportunity to examine these and other related issues, as well as to discuss potential areas for mutual scientific cooperation.

I would like to express my gratitude to Professor Andrew Holmes, Peter Laver and Dr Khiang Wee Lim, for agreeing to be the Australian and Singaporean convenors of the workshop. I thank participants from both countries for generously giving their time to ensure the success of this meeting.

The Academy also acknowledges the financial support of the Australian Government's Department of Innovation, Industry, Science and Research for this event.

Professor Kurt Lambeck
President
Australian Academy of Science

Contents

Sunday, 14 June 2009, Day 1

Arrival of A*STAR delegation

6:30pm **Drinks, The Common Room, University House**

7:00pm **Informal Dinner**
Welcome and introductions

Monday, 15 June 2009, Day 2

7:00-8:30 **Breakfast**

9:00 **Official Welcome and preview of the day**
Prof Andrew Holmes and Dr Peter Laver

9:10 **Remarks**
His Excellency Mr Albert Chua, High Commissioner, Singapore

9:20-9:45 **Plenary presentation**
Prof Charles F. Zukoski, Chairman of the Science and Engineering Research Council (SERC)

9:45-10:10 **Plenary presentation:** *Australia's energy future: Meeting our future energy demand*
Dr John Wright, Advisor, CSIRO Energy Transformed Flagship Program

10:10-10:30 **Morning tea break**

10:30-11:00 Dr Tom Beer
CSIRO Energy Transformed Flagship Program
and
Dr Deborah O'Connell
CSIRO Sustainable Ecosystems
Sustainable production of biofuels and bioenergy in Australia

11:00-11:30 Dr Jeffrey Obbard
Science and Engineering Research Council (SERC)
Institute of Chemical and Engineering Sciences, A*STAR
An overview of the SERC Bioenergy Program

11:30-12:00 Professor Jinchuan Wu
Institute of Chemical and Engineering Sciences, A*STAR
Technical progresses in producing biodiesel, biogas and bioethanol from renewable resources

12:00-12:30 Dr Sasi Nayar
South Australian Research and Development Institute
A second generation microalgal biodiesel biorefinery for sustainable production of biofuels and value-added products

12:30-1:30 **Lunch**

1:30-2:00 Dr Pui Kwan Wong
Institute of Chemical and Engineering Sciences, A*STAR
Catalysis for sustainable fuels and chemicals

2:00-2:30 Dr Louis Wibberley
CSIRO Energy Technology
Achieving a 60% reduction in CO_2 from coal-based generation without capture

2:30-3:00 Dr Yvonne Chow
Institute of Chemical and Engineering Sciences, A*STAR
Microalgae utilisation of carbon dioxide for the production of useful chemicals

3:00-3:30 **Afternoon tea break**

3:30-4:00 Dr Yugen Zhang
Institute of Bioengineering and Nanotechnology, A*STAR
N-Heterocyclic carbenes related catalytic systems in biomass conversion and CO_2 fixation

4:00-4:30 Dr Xiangdong Yao
University of Queensland, ARC Centre of Excellence for Functional Nanomaterials,
Nanoporous carbon confined ammonia borane for hydrogen storage

4:30-5:00 **End-of-day wrap-up**

6:30-7:00 **Drinks at the Shine Dome, Australian Academy of Science**

7:00-9:00 **Official Dinner, Shine Dome**

Tuesday, 16 June, Day 3

7:00-9:00 **Breakfast**

9:15-9:30 **Preview of the day**

9:30-10:00 Dr Calum Drummond
CSIRO Materials Science and Engineering
Advanced materials for high performance energy storage devices

10:00-10:30 Professor Jianyi Lin
Institute of Chemical and Engineering Sciences, A*STAR
PEM fuel cells, supercapacitors and H_2 generators: An overview of the studies on energy storage devices at ICES

10:30-11:00 **Morning tea break**

11:00-11:30 Dr Gerry Wilson
CSIRO Molecular and Health
The Victorian Organic Solar Cell Consortium (VICOSC): A case study of organic photovoltaic research in Australia

11:30-12:00 Mrs Sylvia Tulloch
Dyesol Industries
Dye solar cell research and commercialisation at Dyesol

12:00-12:30 Dr Furong Zhu
Institute of Materials Research Engineering, A*STAR
Translucent polymer solar cells

12:30-1:30 **Lunch**

1:30-2:00 Dr William Lilley
CSIRO Energy Technology
Intelligent energy distribution systems

2:00-2:30 Dr Jianying Zhou
Institute for Infocomm Research, A*STAR
Intelligent energy distribution systems: Demands and challenges

2:30-3:30 **End-of-day wrap-up.** ***The Way Forward*** (identification of major themes of the conference, areas for future collaboration, etc).

Australian delegates depart for airport

6:30-9:00 Dinner at the Ottoman Restaurant (A*STAR delegation)

Wednesday, 17 June 2009, Day 4
(For A*STAR delegation only)

7:00-8:30	**Breakfast**
9:00-3:00	**Site visits to the Australian National University**
3:30-4:30	**Site visit to Dyesol Industries**
7:35	**Fly to Melbourne**

Thursday, 18 June 2009, Day 5

7:00-8:30	**Breakfast**
9:30-1200	**Site visits to the University of Melbourne**
12:00-1:30	**Lunch**
2:00–4:00	**Site visits to Monash University**
7:00-9:00	**Dinner: Red Emperor Restaurant, South Bank**

Friday, 19 June 2009, Day 6

7:00-8:30	**Breakfast**
9:30-12:00	**Site visits CSIRO (Clayton)**
12:00-1:30	**Lunch**

Professor Charles F Zukoski

Chairman, Science and Engineering Research Council (SERC)
A*STAR
1 Fusionopolis Way
#18-10 Connexis North
Singapore 138632 SINGAPORE
Email: charles_zukoski@a-star.edu.sg

Biography

Prof Charles F. Zukoski is a chemical and biomolecular engineer, whose professional work now focuses on leading, enabling and supporting research initiatives, technology transfer and the economic development. He was a Fulbright scholar at the University of Melbourne in 1992. As Vice Chancellor for Research at the University of Illinois at Urbana-Champaign from 2002-2008, Prof Zukoski is a member of the United States National Academy of Sciences (NAS). Prof Zukoski serves as the Chairman of the Science and Engineering Research Council (SERC). He leads the council and the seven A*STAR research institutes in charting new directions and strategies that will sustain economic growth in Singapore, a city-state with 4.5 million inhabitants.

Workshop convenors

Professor Andrew Holmes

ARC Federation Fellow and
Inaugural VESKI Fellow
Bio21 Institute
University of Melbourne Parkville Victoria 3010 AUSTRALIA
Email: aholmes@unimelb.edu.au

Biography

Andrew Holmes was an undergraduate at the University of Melbourne and completed a PhD degree with Professor Franz Sondheimer at University College London. He worked as a postdoctoral fellow on the final stages of the synthesis of vitamin B12 with Professor A. Eschenmoser. He was at Cambridge for thirty-two years, then moved to Imperial College from where he is on long term leave of absence seconded as an ARC Federation Fellow and Inaugural VESKI Fellow at the Bio21 Institute in the University of Melbourne and CSIRO Molecular and Health Technologies, Clayton.

Professor Holmes's research interests span a range of natural and non-natural synthetic targets. His polymer research spans a range of functional and electroactive polymers. A recent interest has been the use of phosphoinositides to probe downstream signalling processes in protein kinases that has revealed many new proteins involved in intracellular signalling pathways. The work of his group on polymeric light emitting diodes has excited considerable attention and spawned a totally new research area. Further potential applications of conjugated polymers in the fields of field effect transistors and solar cells are also possible.

Professor Holmes is a co-recipient of the Descartes Prize 2003. He is a Fellow of the Royal Society, London, a Fellow of the Australian Academy of Science, and a Fellow of the Australian Academy of Technological Sciences and Engineering. He is currently a member of Council at the Australian Academy of Science.

He was Chairman of the Editorial Board of Chemical Communications from 2000-2003 and has been an Associate Editor of Organic Letters since April 2006.

Mr Peter Laver

Vice President, Australian Academy of Technological Sciences and Engineering
197 Royal Parade
Parkville Victoria 3052 AUSTRALIA
Email: plaver@ozemail.com.au

Biography

Peter Laver is vice president of the Australian Academy of Technological Sciences and Engineering (ATSE), a position he has held since 2005. He is chairman of Australian Building Codes Board and of the Energy Steering Committee. Previous appointments have included chancellor of Victoria University of Technology from 1995 to 2000, chairman of the Victorian Learning and Employment Skills Commission from 2001 to 2004, chairman of the Energy Research and Development Corporation from 1994 to 1999, and chairman of Ceramic Fuel Cells Ltd from 1999 to 2002.

In recent years he has chaired a range of bodies including those responsible for building regulations in Australia, for training in Victoria, for government investment in energy research and development, for CSIRO energy research activities, and for advising the Australian Government on education, training and research policy.

All of Peter's career (from 1959 to 1998) was spent with BHP Co Ltd or its subsidiaries. He retired in 1998 as group general manager and senior vice president, BHP Minerals Environment, Safety and External Affairs. He completed a BEng (metallurgical) (Hons) in 1962 at the University of Melbourne and undertook an Advanced Management Programme at Harvard University in 1984. In 2001 he was awarded the Centennial Medal and was made a Member of the Order of Australia in 2005.

Workshop convenors

Dr Khiang Wee Lim

Program Director, Singapore International Graduate Award
A*STAR Graduate Academy
20 Biopolis Way
#07-01 Centros
Singapore 138668 SINGAPORE
Email: lim_khiang_wee@a-star.edu.sg

Biography

Khiang-Wee LIM is the Executive Director of the Institute of Materials Research and Engineering (IMRE) and concurrently Programme Director at the A*STAR Graduate Academy. At A*STAR, he has also been Executive Director of the Singapore Institute of Manufacturing Technology and Deputy Executive Director of the Science and Engineering Research Council. He graduated in Electrical Engineering from the University of Malaya and completed his DPhil in Engineering Science at Oxford University. Prior to A*STAR, he held academic appointments at the National University of Singapore and the University of New South Wales in Sydney. In professional activities, he is currently the Vice President of the Asia Nano Forum and a member of the Standards Council of Singapore as well as the Engineering Accreditation Board of Singapore.

Dr Tom Beer

CSIRO

Energy and Transformed Flagship

111 Station Street

Aspendale Victoria 3195 AUSTRALIA

Email: tom.beer@csiro.au

Abstract

Sustainable production of biofuels and bioenergy in Australia (joint presentation with Deborah O'Connell)

Australia has large biomass resources that are available, or are potentially available for biofuels and bioenergy.

The size of these resources is unknown and preliminary estimates indicate that second generation biofuels could provide from 25% to 80% of Australian liquid fuel consumption. CSIRO is researching enzymes and algae to find ways to increase the potential second generation feedstocks. But the sustainability of this biomass is unknown. We seek to develop sustainability frameworks that incorporate carbon verification, feedstock supply issues and social aspects.

Biography

Tom Beer leads the Transport Biofuels Stream of the Energy Transformed Flagship of CSIRO. He founded the Risk Special Interest Group of the Clean Air Society of Australia and New Zealand, of which he is a Fellow, specifically to examine issues related to atmospheric emissions and health. He is an international expert on environmental risk management, including greenhouse gas and air quality issues and particularly their application to transport and to health. He was part of the team that won the CSIRO Chairman's medal in 2000 with his component being the analysis of greenhouse gas emissions from hybrid electric vehicles.

From 2001 to 2006 he applied life-cycle assessment and risk assessment methods to alternative transport fuels and co-ordinated a number of influential studies. The study conducted for the Australian Greenhouse Office on fuels for heavy vehicles (http://www.environment.gov.au/settlements/transport/comparison/index.html) was used to set determinations under the Diesel and Alternative Fuels Grants Scheme, and was followed

with a study on fuels for light vehicles. He has undertaken similar studies for industry – in particular Shell (Shell Aquadiesel), Caltex (2% Biodiesel) and the Australian LPG Association (LPG). In 2003 Dr Beer led a consortium of researchers to examine the appropriateness of the Government's 350ML biofuels target, and from 2003 to 2006 he led another consortium of researchers in examining the life-cycle of greenhouse gas emissions from maize (a possible feedstock for ethanol).

Dr Beer is President of the International Union of Geodesy and Geophysics (IUGG) and is Leader of the Hazards Science Theme of the International Year of Planet Earth. Dr Beer chaired the meeting at the Hungarian Academy of Sciences that, in June 2002, adopted the Budapest Manifesto on Risk Science and Sustainability (http://www.iugg.org/publications/reports/budapest.pdf). During 1995 he was Science Adviser to the Environment Protection Agency in Canberra and undertook a risk review of national environmental priorities. Subsequently, Dr Beer undertook two of the preparatory studies for the National Environment Protection Measure for Ambient Air Quality. He was a lead author for the Atmosphere Theme Report of the Australian 2001 and 2006 State of the Environment reports.

Dr Beer has been a member of the Australian Academy of Science National Committee for the Environment. He was part of the World Bank team examining the National Greenhouse Strategy for Thailand. He has been a lead author, and an expert panel member for the Intergovernmental Panel on Climate Change (IPCC), which was awarded half of the 2007 Nobel Peace Prize.

Dr Beer is the author of fourteen books, over 100 articles in refereed journals, a similar number of book chapters and papers in conference proceedings, and over 44 specialised consultancy reports.

Dr Yvonne Chow

Institute of Chemical and Engineering Sciences, A*STAR
Department of Industrial Biotechnology
1 Pesek Road
Jurong Island 627833 SINGAPORE
Email: yvonne_chow@ices.a-star.edu.sg

Abstract

Microalgae utilisation of carbon dioxide for the production of useful chemicals

Algal photosynthetic carbon assimilation already serves as a sink for 30% of the earth's CO2. They are also a sustainable source of biomass since they do not require arable land and do not interfere with food supply. The purpose of our research is to maximise these advantages and at the same time exploit microalgae to produce chemicals of value, providing a greener alternative route to chemicals that may currently be manufactured from fossil fuels or involve toxic chemical processes. Downstream processing is one of the major challenges of microalgae systems, and its cost of this unit operation is one of the key factors hindering the commercialisation of microbial biodiesel. Working with microalgae to produce chemicals of higher value minimises this cost gap to a certain extent. Health products of extremely high value are being sourced from microalgae, such as Omega-3 unsaturated fatty acids and antioxidants. There are also other chemicals to be discussed which have a bigger market demand and show potential to be produced from microalgae. The enormous biodiversity of microalgae has been estimated to be between 200,000 and several million species. It is an almost untapped resource since to date only a few of the more robust species are used commercially. Singapore lies in a region of high biodiversity, hence it makes sense for us to begin our search in the environment for a novel strain suited to the production of the target chemical compound.

Biography

Yvonne Chow graduated from the University of New South Wales in Sydney in 1998, with a Bachelor of Chemical Engineering and Doctor of Philosophy. She was awarded the Malcolm Chaikin Foundation scholarship as well as the Australian Postgraduate Research Award, majoring in Biotechnology and Bioprocess Engineering. After working for 4 years at the National Science & Technology Board (now renamed Agency for Science, Technology and

Research) managing research funding and various schemes to promote R&D in Singapore, she went on to join the newly established A*STAR Institute of Chemical & Engineering Sciences in 2003. In this institute, she has been doing research on biocatalysis and industrial biotechnology, employing enzymes or microorganisms to produce commercially useful fine as well as bulk chemicals via environmentally friendly routes. Her current project involves the use of microalgae to provide an alternate source of bulk chemicals, while at the same time utilising carbon dioxide from the atmosphere. She has also served as Secretariat of Singapore's Genetic Modification Advisory Committee and the Singapore Catalysis Society, and as the President of the International Researchers Club in Singapore.

Dr Calum Drummond

CSIRO
Materials Science and Engineering
Bag 33
Clayton Victoria 3169 AUSTRALIA
Email: calum.drummond@csiro.au

Abstract

Advanced materials for high performance energy storage devices

Energy storage devices are generally evaluated on two main requirements; power density and energy density.

In this presentation the focus will be on describing strategies that have been employed to improve the power density of carbon-based electrical double layer capacitors (supercapacitors) and lithium-ion batteries based on lithium iron phosphate cathodes.

High power density supercapacitors are desired for consumer electronic products. Advances in increasing the conductivity of the current collector, electrolyte, separator and electrode material have led to marked improvements in commercial supercapacitor performance.

Commercial lithium ion batteries are predominantly made with lithium-cobalt based oxide cathodes such as LiCo1/3Ni1/3Mn1/3O2. However there are problems associated with this material including its high cost due to the relative scarceness of cobalt, as well as it's environmental impact and toxicity. Lithium iron phosphate, LiFePO4, is a promising alternative cathode material due to its excellent electrochemical properties (theoretical capacity of 170 mAh/g), low cost and low toxicity. The major drawback for LiFePO4 is its poor conductivity, however this can be overcome through the addition of conductive carbon and incorporating nanostructured designs to improve the electrochemical performance.

Biography

Calum Drummond received a PhD in Physical Chemistry from The University of Melbourne in 1987. He is Chief of CSIRO Materials Science and Engineering and holds an Australian Research Council Federation Fellowship hosted by CSIRO Molecular and Health

Technologies. Prior to these current appointments, he was seconded from CSIRO to be the inaugural Vice President Research at CAP-XX. CAP-XX manufactures supercapacitors for consumer electronic products. The World Economic Forum designated CAP-XX as a 2005 global Technology Pioneer. CAP-XX was awarded the Frost & Sullivan 2006 Nanotechnology-enabled Energy Devices Technology Innovation of the Year Award. In April 2006 CAP-XX listed on the London AIM with a market capitalisation of AUS$ 110 million. Calum's research interests are in the area of advanced materials, including application to energy storage and biomedical products. He has been an author of over 170 publications including 4 invited book chapters, over 100 refereed ISI journal papers, 9 patents and 54 CSIRO reports for companies. The refereed journal papers have received more than 3000 citations, and his citation h-index is 32. Calum is a Fellow of the Australian Academy of Technological Sciences and Engineering (FTSE), a Fellow of the Australian Institute of Company Directors (FAICD) and a Fellow of the Royal Australian Chemical Institute (FRACI). Calum is a member of the Australian federal government's Future Manufacturing Industry Innovation Council.

Dr William Lilley

CSIRO
Energy Technology
10 Murray Dwyer Court
Mayfield West NSW 2304 AUSTRALIA
Email: william.lilley@csiro.au

Abstract

Intelligent energy distribution systems

In response to climate change Australia is developing a suite of options aimed at delivering more efficient and sustainable low emissions energy. One such solution is Distributed Energy (collectively demand side management, energy efficiency and distributed generation) which provides options near the point of use rather than at remote locations. The Low Emissions and Distributed Energy (LEDE) theme of CSIRO's Energy Transformed Flagship is developing local solutions through a range of initiatives. These include intelligent control and aggregation of appliances, optimisation of load and generation in minigrid systems, development of solar air conditioners, zero emission home technologies and construction of novel generation devices.

Wide scale deployment of Distributed Energy will require a revolution in engineering design, practice and regulation. To facilitate this change, CSIRO is investigating the economic, social, environmental and technical barriers and enablers for wide scale adoption. Outcomes of this research will enable change through increased awareness, and indentify critical steps to ensure Distributed Energy fulfils its promise as an early action solution for substantial greenhouse reductions.

Biography

Bill has worked for 10 years as a research scientist at the CSIRO Division of Energy Technology. In his current role he is responsible for managing the Intelligent Grid project which is investigating the economic, environmental, social and technical barriers and enablers for wide spread adoption in Australia. Bill received his PhD for the development of a near field chemically reactive dispersion model used to investigate the fate and health effects of motor vehicle emissions.

Professor Jianyi Lin

Institute of Chemical and Engineering Sciences, A*STAR
Department of Applied Catalysis
1 Pesek Road
Jurong Island 627833 SINGAPORE
Email: lin_jianyi@ices.a-star.edu.sg

Abstract

PEM Fuel cells, supercapacitors and H2 generators: An overview of the studies on energy storage devices at ICES

“Energy is the single most important challenge facing humanity today”, and “H2 & Fuel Cells” is one of the solutions. At the Institute of Chemical and Engineering Sciences (ICES), Singapore, we study H2 production, storage, PEM fuel cell, and supercapacitors”.

For PEM fuel cells our study has been focused on improving Pt/C catalysts in order to reduce its cost and enhance its stability. We invented a simple and effective citric-acid treatment, which can functionalize the carbon support, reduce the Pt loading, enhance electrode hydrophilicity, and improve the fuel cell output energy density by 30%. We can grow high quality vertically aligned carbon nanotubes (VACNT) on household Al foil by PECVD at 450oC. Using VACNT as support the Pt loading can be significantly reduced. Under identical conditions our 0.035mg/cm2 Pt/VACNT catalysts are comparable to 0.400mg/cm2 commercial E-TEK and JM catalysts. We also studied N-doped carbon nanospheres (NCN) which were derived from polypyroles and possessed very high surface area (1010m2/g), well-developed microporous (1.1nm) structure, high electronic and mass conductivities. Therefore the electrochemical performance of Pt/NCN is enhanced, superior over commercial ETEK for oxygen reduction reactions.

Supercapacitors have many advantages in the electrical energy storage, and would play an important role in energy conservation and future renewable energy technology. We have prepared and studied various types of novel nanostructured carbons and oxides, including tube-in-tube carbon nanotubes, linear-chain-carbon encapsulated single wall carbon nanotubes, high-surface microporous carbons, mesoporous carbons, hollow carbon spheres, MnO2 nanotube arrays etc. Many of them are promising electrode materials for supercapacitors due to their high specific capacitance (100-200 F/g) and high stability.

Future hydrogen economy needs on-site H2 production, which does not require a hydrogen delivery infrastructure. We have invented a microwave hydrogen generator which can release H2 from various types of metal hydrides, e.g. 7.6wt%H2 from MgH2 and 5.6wt%H2 from NaAlH4 within 2 minutes with 90% heating efficiency. With increasing demand on portable hydrogen source, we have found a new pathway which can instantaneously release hydrogen from chemical hydrogen carriers (water+solid fuels) at low temperatures with no CO emission, and hence is superior to methanol reforming.

Biography

Professor LIN Jianyi is currently a Principal Scientist at the Institute of Chemical and Engineering Sciences (ICES), A*STAR, Singapore, and an Adjunct Professor in the Department of Physics, National University of Singapore (NUS). He graduated from Xiamen University, China and received a PhD in Chemistry from Stanford University in 1991. His research and expertise areas lie in surface science and heterogeneous catalysis which include hydrogen production and storage, PEM fuel cell and supercapacitor applications.

Participants

Dr Sasi Nayar

South Australian Research and Development Institute
Department of Aquatic Services
2 Hamra Avenue
West Beach SA 5024 AUSTRALIA
Email: nayar.sasi@saugov.sa.gov.au

Abstract

A second generation microalgal biodiesel biorefinery for sustainable production of biofuels and value-added products

In the search for alternative fuels to replace petroleum-based fuels, one of the most exciting prospects is to produce fuel from algae. There is a significant research effort globally focusing on commercialising the technology of biofuel production from microalgae. The Algal Fuels ConsortiumTM, a collaborative alliance comprising the South Australian Research and Development Institute, Flinders University, CSIRO Energy Transformed Flagship, Flinders Partners and SANCON Recycling Pty Ltd, is in the forefront of these developments in Australia. The consortium is developing a pilot-scale biorefinery facility on Torrens Island in Adelaide, South Australia to demonstrate a commercially competitive and sustainable technology for production of biodiesel and high value co-products from microalgae, a second generation non-food biofuel feedstock. The 'Biorefinery approach' is the distinctive feature of this consortium that integrates high-value bioproducts and chemicals concurrently with biodiesel production. This will diversify and significantly improve revenue streams to provide a sustainable business model in achieving economic biofuel production. The technology addresses environmental sustainability by biofixation of carbon dioxide from power plant emissions and displacement of oil-based fossil fuels. Commercialisation will result in significant economic and environmental benefits for Australia. As an example, replacing 10% of Australia's mineral diesel needs with 1.6 billion litres of microalgal biodiesel, would require about 40,000 hectares of ponds (@ an output of 40,000L/ha/year), and result in a turnover of over $A1.6 billion, creating over 5,000 new jobs directly and a reduction of nearly 4 million tonnes of fossil CO2 emissions.

Biography

Dr Sasi Nayar leads the Algal Production Group at the South Australian Research and Development Institute. He has a PhD in Marine Ecology and Ecotoxicology from the National University of Singapore (2003) and a Masters Degree in Fisheries Science from the University of Agricultural Sciences, Bangalore (1998). He has significant experience of over 15 years in handling ecological research projects in mangroves, coral reefs, estuarine reefs, seagrass meadows, coastal and oceanic waters in the tropics and temperate environment. He has 25 publications in reputable peer reviewed international journals, 16 of them on phytoplankton biology and ecology. As a principal investigator, he has been successful in attracting > $13.6 million in grants from Federal and State governments, and industry for 9 projects, 6 on research and development of algal production systems for biofuel production in collaboration with biodiesel producers, universities and other agencies. He has played a key role in securing $5 million from state and federal governments to develop the NCRIS microalgal photobioreactor facility at SARDI, a unique state-of-the-art national facility. For his academic contributions, he has been awarded 10 awards.

Dr Jeffrey Obbard

Science and Engineering Research Council (SERC)
Institute of Chemical Engineering and Science, A*STAR
1 Pesek Road
Jurong Island 627833 SINGAPORE
Email: esejpo@nus.edu.sg

Abstract

Overview of the SERC Bioenergy Program

Jeff will be presenting an overview of the SERC Bioenergy Program and highlighting the opportunities that exist for collaboration with universities, polytechnics and research institutes in Singapore on projects related to the production of first and second generation biofuels, as well as production of sustainable biofuel feedstocks.

Biography

Jeff is an Associate Professor in the Division of Environmental Science & Engineering, and a Project Director (Bioenergy) at the Tropical Marine Science Institute at the National University of Singapore. He currently holds a joint appointment with the Science & Engineering Research Council (SERC), Agency for Science Technology & Research (A*STAR) as the Manager of its Bioenergy Programme. Jeff graduated from the Dept of Environmental Science at Lancaster University in the United Kingdom (BSc. Hons I), and this was followed by a PhD fully sponsored by the UK Water Research Centre. His doctorate investigated the impact of anthropogenic contaminants on the biogeochemical cycling of carbon and nitrogen. Jeff has worked extensively on the application of microbes and enzymes for the remediation of contaminated environmental media and, in more recent years, has become focused on the microbial production of biofuels, as funded by A*STAR. In 2005, he was a recipient of the United Nations Mondialogo Engineering Award (with special laureate recognition) for his work on sustainable development. He received the Outstanding Mentor Award from the Singapore Ministry of Education in 2005, and was also the recipient of the NUS University Teaching Excellence Award in 2007 & 2008.

Dr Deborah O'Connell

CSIRO
Sustainable Ecosystems
Bellenden Street
Crace ACT 2911 AUSTRALIA
Email: deborah.o'connell@csiro.au

Abstract

Sustainable production of biofuels and bioenergy in Australia (joint presentation with Tom Beer)

See page 15 for full details.

Biography

Dr Deborah O'Connell is a systems analyst at CSIRO Sustainable Ecosystems in Canberra, Australia. Her recent research has focused on developing and applying integrated assessment frameworks and systems analysis approaches in the domains of water and energy.

She is currently leading an interdisciplinary team of 14 scientists on a project entitled Sustainable Biomass Production for Biofuels and Bioenergy in Australia: Can biomass provide low emission fuel and energy without compromising food, water and biosecurity? http://www.csiro.au/science/Sustainable-Biomass-Production.html

Since 2005 Deborah has led the CSIRO team that produced a series of industry reports including the high profile report Biofuels in Australia – an overview of issues and prospects. These reports have set the agenda for biofuels and bioenergy research in Australia. This team has produced numerous journal and conference papers with many more in progress. Deborah has given many keynote and other high profile talks, had steady engagement with print, radio and TV media, and been on numerous Steering Committees, discussion panels and other industry forums.

ACADEMIC QUALIFICATIONS

• Bachelor of Agricultural Science with Honours at the University of Western Australia, Perth, Western Australia, 1988

• Doctor of Philosophy at the Centre for Resource and Environmental Studies, ANU and CSIRO Land and Water, Canberra, Australia, 1997.

Mrs Sylvia Tulloch

Dyesol Industries

3 Dominion Place

Queanbeyan NSW 2620 AUSTRALIA

Email: stulloch@dyesol.com

Abstract

Dye solar cell research and commercialisation at Dyesol

Dye Solar Cell technology draws together two very important scientific concepts – nanotechnology and biomimicracy. In the past decade there has been a growing realisation that there is a great deal to be learned from natural processes, and one of the first demonstrated successes is the DSC, which mimics the energy in light being absorbed by a leaf. Dyesol was established to commercialise the R&D undertaken by an Australian team in collaboration with Michael Graetzel at EPFL Switzerland. This paper discusses discuses Dyesol current projects and products, including its collaboration with Corus to develop solar steel roofing manufactured using the coil coating process; Dyesol programmes on the better relative performance of DSC in higher temperatures and at lower light levels, as well as at wider angels of incidence; and demonstration of efficiencies of over 12% and stabilities equivalent to over 20 years. A Roadmap to take Dyesol efficiencies over 20% will also be presented.

Biography

Sylvia Tulloch was the founding Managing Director of Dyesol, responsible for the business strategy and plan, and conceived the company name and logo for Dyesol. She was formally Executive Director of STI from 2001 to 2004, and Joint Managing Director of STA from 1994 to 2000. She is the named investor of several Dyesol's patents, including the key patents for the SureVolt flexible panel and the CEGS combined Energy Generation and Storage devices. She is Managing Director of Dyesol Industries Pty Ltd and is now especially focused on Dyesol strategy in the North American Region. Investor Relations is her personal responsibility. Sylvia is a materials scientist with over twenty five years experience in establishment and management of high technology business, and a particular interest in the commercialisation process. She holds a MSc degree from the University of NSW. She was formerly President of the Sustainable Energy Industries Association of Australia, Chair

of the Renewable Energy Action Agenda Implementation Group and on the committee guiding the Australian Renewable Energy Technology Roadmap, and a Director of the Australian Business Council for Sustainable Energy. She is currently a member of the Future Manufacturing Industries Innovation Council, which advises the Australian Minister for Industry.

Dr Louis Wibberley

CSIRO

Energy Technology

10 Murray Dwyer Circuit

Mayfield West NSW 2300 AUSTRALIA

Email: louis.wibberley@csiro.au

Abstract

Achieving a 60% reduction in CO2 from coal-based generation without capture

The focus of the current clean coal approach is to reduce the of next generation coal plants with CO2 capture and storage. The technology options being considered include advanced supercritical pf with post combustion capture, IGCC with capture, and oxy-pf with flue gas liquefaction. With capture, these technologies would give a delivered cost of electricity (including transmission and distribution penalties) of around $115/MWh, and with a fuel cycle thermal efficiency of only 29-30% for delivered electricity.

A proposed alterative pathway will be presented which focuses on achieving much higher efficiency from smaller, more flexible and adaptable coal-based plants, and using this system to underpin high penetration renewables.

Biography

Dr Wibberley has 30 years of experience in pyrometallurgy, combustion, and energy technology. This includes 5 years in CSIRO, 18 years in industrial research and 6 years of university experience in a consulting role to industry.

Currently, Dr Wibberley is principal technologist in CSIRO's Division of Energy Technology, and is responsible for developing major new research and development initiatives in energy technology. He has led the establishment of what is now a core program within CSIRO on post-combustion CO2 capture for storage, one of the more promising technological solutions for the near-term reduction of greenhouse emissions from fossil fuels. A major recent initiative is a technology strategy to provide a step change in the efficiency of coal use, through the use of coal fired diesel engines and direct carbon fuel cells. Higher efficiency, together with the ability to underpin the development of renewables, has the potential to achieve a 60% reduction in greenhouse gas emissions intensity, whilst being able to continue to exploit the advantages of coal - a significant, secure fuel source. Other work involves the development of new power cycles for solar thermal and geothermal energy for electricity generation.

Dr Gerry Wilson

CSIRO
Future Manufacturing Flagship
Bayview Avenue
Clayton Victoria 3168 AUSTRALIA
Email: gerry.wilson@csiro.au

Abstract

The Victorian Organic Solar Cell Consortium (VICOSC): A case study of organic photovoltaic research in Australia

It is becoming increasingly clear that energy generation from renewable resources will be an important part of the energy 'mix' as the world attempts to satisfy its future energy needs. In particular solar power would seem to satisfy many of the criteria for clean and 'green' energy. Organic photovoltaics (OPVs), whilst still in its nascent state, nonetheless enjoys many distinctive attributes as compared to the more established silicon technology. Australia has a rapidly growing OPV effort, particularly in the area of bulk heterojunction devices, with significant activity in Queensland, New South Wales and Victoria.
This presentation will summarize some of the work being done in the various groups and how it is being coordinated. It will use as an example the work currently being prosecuted under the Victorian Government's Organic Solar Cell Consortium (VICOSC) and will describe recent scientific and pre-production achievements.

Biography

Gerry Wilson received his BSc (Hons) from University College Dublin and a PhD from the Research School of Chemistry (ANU). His research experience includes steady-state and ultra-fast laser spectroscopy as applied to the photochemistry and photophysics of macromolecular and supramolecular systems. The aim of this work is to understand, and ultimately control, how photoinduced excited states dissipate their energy. This fundamental science underpins artificial photosynthetic systems, the emerging areas of organic and polymeric light-emitting diodes (OLEDS and PLEDS) and the complementary science of organic photovoltaics. The work also addresses issues such as polymer photodegradation. His spectroscopy background has also proved useful in developing both overt and covert features for use as security devices on things like currency and other valuable documents.

During his career in CSIRO he has managed at various times and combinations; the Water Group; the Biomaterials Group; the Surface and Colloid Group; Security Devices Group; the

Participants

Nanomaterials Group and The Polymer Group. He has participated in three CRCs, the CRC for Water Quality & Treatment, the CRC for Eye Research & Technology (later the Vision CRC), and the CRC for Polymers. He claims that despite his management all these groups have had an amazingly high degree of impact – eg extended wear contact lens, security features for polymer banknotes and for other valuable documents, spin outs and joint ventures (PolyNovo and DataTraceDNA), MIEX resin for water purification, major licencing deals with multinationals etc – a tribute he claims is entirely due to the teams of great scientists and business development staff. He is currently Theme Leader for Flexible Electronics – a group of talented and passionate scientists working to develop low-cost plastic solar cells and flexible displays.

Dr Pui Kwan Wong

Institute of Chemical and Engineering Sciences, A*STAR
1 Pesek Road
Jurong Island 627833 SINGAPORE
Email: pkwong@ices.a-star.edu.sg

Abstract

Catalysis for sustainable fuels and chemicals

The bulk of fuels and chemicals are produced from crude oil by the petrochemical industry. The industry faces two major challenges: supply of crude oil struggles to keep pace with rising demand; and environmental pressures, including climate change concerns, are increasing. To address these challenges, industry must develop sustainable (environmentally benign, safe, and cost competitive) options to replace crude oil with alternative feedstocks. Advanced processing technologies for alternative feedstock leading to lower cost and reduced green house gas emission can provide significant competitive advantages to major petrochemical hubs such as Singapore. An overview of next-generation catalytic process technologies for the production of sustainable fuels and chemicals from alternative fossil and renewable feedstocks will be presented.

Biography

PK Wong received his PhD from the University of Iowa under the supervision of Professor John Stille. He began his industrial career at Dow Chemicals in Midland, Michigan before joining Shell Chemicals in Houston in 1980. While at Shell, he has carried out a variety of exploratory research projects in homogeneous catalysis and polymers, and participated in several development projects including the commercialization of aliphatic polyketones. He joined ICES in 2003 as a principal scientist and program manager for the Applied Catalysis group. Currently he is deputy director responsible for the sustainable energy and chemicals program at ICES. He also manages the newly launched carbon capture and utilization program in A-STAR. He holds 70 issued US patents and 14 publications.

Dr John Wright

CSIRO

Energy Transformed Flagship Program

10 Murray Dwyer Circuit

Mayfield West NSW 2300 AUSTRALIA

Email: john.wright@csiro.au

Abstract

Australia's energy future: Meeting our future energy demand

This will be a scene-setting presentation that will introduce the workshop participants to the current Australian energy situation in terms of our major sources of energy and the environmental challenges that the energy industry will face in the future. A range of future energy scenarios will be considered that show the technology progressions appropriate to Australia that will be required to meet various targets, particularly Greenhouse gas reduction goals. It will be shown that to achieve our emission targets will require a whole of economy transformation in the way we generate and use energy. Finally some selected examples of CSIRO work on low emission energy technologies will be given to demonstrate how we are assisting the industry to prepare for the major transformation to come.

Biography

Dr John Wright has over 35 years experience in the minerals and energy sectors. Currently, he is an advisor to CSIRO's Sustainable Energy Partnerships working across CSIRO to develop major partnerships with industry, governments and the community. He was previously the Director of the CSIRO Energy Transformed Flagship, a position he held from 2002 to end 2008. Before that he was the Chief of CSIRO Energy Technology. His major interests are in the development of low emissions technologies involving energy futures modelling, electricity from fossil fuels and renewables, alternate transport fuels and distributed energy. Current Board memberships include the Centre for Low Emissions Technology, and the Priority Research Centre for Energy. He is a Member of the Implementation and Liaison Committee of the International Partnership for the Hydrogen Economy, the Executive Committee of the International Energy Agency's Hydrogen Implementation Agreement and the IEA Experts Group for Energy Science. He is a Conjoint Professor at the University of Newcastle and a member of the Facility of Engineering

Advisory Committee. He is a Fellow of the Australian Academy of Technological Sciences and Engineering, the Australasian Institute of Mining and Metallurgy, the Australian Institute of Energy and the Australian Institute of Company Directors.

Dr Jinchuan Wu

Institute of Chemical & Engineering Sciences, A*STAR
Department of Industrial Biotechnology
1 Pesek Road
Jurong Island 627833 SINGAPORE
Email: wu_jinchuan@ices.a-star.edu.sg

Abstract

Technical progresses in producing biodiesel, biogas and bioethanol from renewable resources

Biodiesel is commercially produced by 1-step transesterification of triglycerides with methanol using alkali catalysts such as KOH. The drawbacks of the conventional process are the requirement of purified triglycerides and generation of salt-containing glycerol. We developed a 2-step process for biodiesel production. Triglycerides are enzymatically hydrolyzed to fatty acids and glycerol followed by esterification of the free fatty acids with methanol catalyzed either by immobilized lipases or solid acids to produce biodiesel. This 2-step process allows the use of crude vegetable oils with any percentages of free fatty acids and water and directly produces salt-free glycerol. It is very suitable for handling waste cooking oil.

Glycerol and xylose are the byproducts from biodiesel and lignocellulosic bioethanol industries, respectively. Converting them into value-added products is favorable to improving the process economy. We developed an efficient method to convert xylose and glycerol into biogas by introducing exogenous microbes that are able to convert these “hard” substrates into easier ones for the methane-producing microorganisms to digest.

Inhibition of microbes by various inhibitors severely affects the productivity and efficiency of microbial fermentation processes. Improving microbial tolerance to various inhibitors is thus of great importance in developing cost-effective bio-refinery processes. We developed a novel method of genomic DNA shuffling, which has been successfully applied to improve the ethanol tolerance of a yeast strain for bioethanol production.

Biography

Dr. Jinchuan Wu is a Senior Scientist at the Institute of Chemical & Engineering Sciences (ICES) and Program Manager of the Industrial Biotechnology Group. He received his Bachelor (1986), Master (1989) and PhD (1994) from Tianjin University (China) and had once worked in Kanazawa University (Japan) as an Associate Professor from 1998-2000 and in Tianjin University as a Lecturer, Associate Professor and Professor before he joined ICES in 2002. He was a visiting scientist in Toyama Prefectural University (Japan) in 2007. His current research of interest includes biomass to fuels and chemicals, microbial screening and fermentation, enzyme modification and directed evolution, bio-catalysis in organic media and bioprocess engineering.

Dr Xiangdong Yao

University of Queensland
ARC Centre of Excellence for Functional Nanomaterials
St Lucia QLD 4072 AUSTRALIA
Email: x.yao@uq.edu.au

Abstract

Nanoporous carbon confined ammonia borane for hydrogen storage

Developing sustainable energy technologies has emerged in recent years as an economic and political imperative amid mounting concerns over environmental pollutions, climate change and high oil prices. While hydrogen is widely accepted as a promising solution to these crucial issues, the utilization of hydrogen presents many critical challenges. Numerous efforts have been devoted to develop hydrogen storage materials for practicle use, especially for on-board applications of fuel cells electrical vehicles.

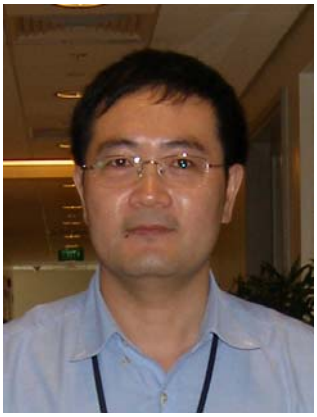
Ammonia borane (AB) has been attracting great attention recently due to its very high hydrogen capacity, e.g. 19.5 wt%. However, some critical issues have remained to hinder its real application for practical applications for hydrogen storage, e.g. slow kinetics, irreverserbility and possible release of NH3 and/or BH3. Our recent works on AB confined by nanoporous carbons, together with doping Li, presented very good characteristics of hydrogen storage in AB: hydrogen release from AB at below 80ºC with a moderate kinetics and without any NH3 and/or BH3. The improvement of hydrogen storage properties could be explained by the thermodynamic modification caused from the particle size effect and the confinement of nano-pores of the framework. However, the irreversibility is not improved and further research is highly desirable.

Biography

Dr Xiangdong Yao was originally from China where he finished his Primary, Senior and Tertiary education. He obtained his BEng at Northeastern University in 1989 and MEng at Northwestern Polytechnical University in 1992 respectively for Materials Science and Engineering. From 1992 to 2000, he was employed in the Institute of Metal Research, Chinese Academy of Sciences as Research Associate (1992), Assistant Professor (1995) and Associate Professor (1998). His research was mainly on the design and development of

new high-temperature materials, which lead to the innovation of three superalloys (three patents commercialized) and numerous scientific publications. In 2000, he came to The University of Queensland where he was granted the PhD degree in Materials Engineering in 2005, working on the computational modeling for microstructure formation in light metals. From November 2003, he joined the ARC Centre of Excellence for Functional Nanomaterials and focused on the research of non-equilibrium materials by both mechanical grinding and rapid solidification with nano-structural metallic materials, especially nanostructured light metal materials for clean and sustainable energy applications. His research on hydrogen storage materials resulted in 3 patents with high commercialization potential and several tens of journal publications. He is the recipient of the prestigious ARC Postdoctoral Fellowship (2006) and Australian Research Fellowship (2009).

Participants



Dr Yugen Zhang

Institute of Bioengineering and Nanotechnology, A*STAR
31 Biopolis Way
The Nanos 138669 SINGAPORE
Email: ygzhang@ibn.a-star.edu.sg

Abstract

N-Heterocyclic carbenes related catalytic systems in biomass conversion and CO2 fixation

The search for sustainable, alternative energy is of critical importance today. Biofuels is highly attractive as the only sustainable source of liquid fuels currently. However, the replacement of petroleum feedstock by biomass is limited by the lack of highly efficient methods to selectively convert carbohydrates to chemical compounds for the biofuel production. A new NHC-Cr/ionic liquid catalytic system has been developed for the selective conversion of sugars to HMF. This new system achieved excellent efficiency and the highest HMF yields reported thus far for both fructose and glucose feedstocks. A novel THF-BIMICl biphasic system with tungsten catalyst for fructose conversion to HMF under mild reaction conditions has been also developed. With the tungsten catalyst, HMF could be produced from fructose even at room temperature. Carbon dioxide is abundant in the atmosphere, and is known to be a greenhouse gas (GHG) that causes global warming. It would be very attractive to utilize carbon dioxide in the atmosphere to generate useful commodities or fine chemicals. However, carbon dioxide is a rather stable molecule, and has limited usage as a feedstock so far. The stable linear structure of carbon dioxide is typically activated by homogeneous and heterogeneous organometallic catalysts under fairly harsh reaction conditions. We present the first CO2 reduction reaction catalyzed by N-heterocyclic carbene (NHC) organocatalysts with silanes under ambient conditions. The catalytic reduction of CO2 by NHCs also provides for a highly selective methoxide end-product in excess of 90% hydrogen transferring yield with carbon dioxide gas or dry air as feedstock. It offers a very promising chemical CO2 fixation protocol, which can be applied towards the direct conversion of CO2 in air to methanol via the formation of polysiloxanes.

Biography

Yugen Zhang (born in Jiangsu, China in 1966) is the principal research scientist and team leader at the Institute of Bioengineering and Nanotechnology (IBN), Singapore. He graduated in Geochemistry at the University of Science and Technology of China (USTC), China, where he also received his PhD in Chemistry in1992. After that, he joined the same university as faculty, and was promoted to Professor in 1999. He worked at organometallic lab, Riken in 1996 – 1997 as visiting scientist and in 2000-2001 as Riken Fellow. Before he joined IBN, he worked in Harvard University as research associate for three years (2002-2004). His main research areas are catalysis, nano-structured materials and their application in sustainable technology.

Dr Jianying Zhou

Institute for Infocomm Research, A*STAR
1 Fusionopolis Way
#21-01 Connexis
South Tower 138632 SINGAPORE
Email: jyzhou@2r.a-star.edu.sg

Abstract

Intelligent energy distribution systems: Demands and challenges

Intelligent energy distribution systems will revolutionize the way we use energy by taking full advantage of the vast renewable resources like wind and solar power in a country. In this talk, I will discuss the demands and challenges in developing a smart, strong and secure electrical grid, which will help deliver reliable power more effectively with less impact on the environment to customers across a country. Such a need has been highlighted by the fact that the US government is planning to distribute nearly $4 billion grants in smart grid technology development. To enable the smart grid be a reality, one challenge is to establish the industry-wide standards to ensure that the technologies being developed are compatible within the new architecture. In addition, smart grid security should be thoroughly investigated to protect the multi-system network from hackers and natural disasters, given the potential direct impact on national security systems. A security framework must be set up to provide real-time and reliable monitoring, detection, alert, containment and recovery solutions in case of perturbations, vulnerabilities and attacks.

Biography

Dr. Jianying Zhou is a senior scientist at the Institute for Infocomm Research (I2R, A*STAR, Singapore), and heads the Network Security Group. He is also an adjunct professor at the University of Science and Technology of China and Shanghai Jiaotong University. He received his PhD in Information Security from the University of London in 1997. His research is focused on computer and network security. He has published over 100 referred papers at international conferences and journals, of which the top 10 publications received over 1000 citations. He has served over 100 times in international conference committees as general chair, program chair, publication chair, publicity chair and PC member. Before joining I2R, he was a security consultant at the headquarters of Oracle Corporation (USA). He also worked at the Chinese Academy of Sciences, and received the National Science and

Technology Progress Award in 1995. He is now leading an A*STAR research project "Security Architecture and Techniques for Communications, Control and Management of Energy Distribution Systems", to provide comprehensive protection for smart energy distribution systems. More info is available at icsd.i2r.a-star.edu.sg/staff/jianying/.

Dr Furong Zhu

Institute of Materials Research and Engineering, A*STAR
Photovoltaic Program
3 Research Link
Singapore 117602 SINGAPORE
Email: fr-zhu@imre.a-star.edu.sg

Abstract

Translucent polymer solar cells

Organic solar cells offer a potentially much cheaper alternative way to harness solar energy. Considerable enhancement in device efficiencies is needed if this technology is to become a viable option for large scale energy production. After a brief of IMRE's photovoltaic R&D activity in materials synthesis, materials process, device design and engineering, our recent research progress in developing translucent polymer solar cells will be discussed. The technology addresses the enhancement of translucent organic photovoltaic cells over the two competing performance indices: power conversion efficiency and transmittance, for stacking up or transparency. The translucent cathode plays a major role in determining the efficiency of translucent solar cells by controlling the intensity of incident light absorption at the photoactive layer of each cell. The results obtained from translucent polymeric solar cells, based on poly(3-hexylthiophene) (P3HT): 1-(3-methoxycarbonyl)-propyl-1-phenyl-(6,6)C61 (PCBM) blends will be presented.

Biography

Dr Furong Zhu is a Senior Scientist and the Program Manager at the Institute of Materials Research and Engineering - Singapore (IMRE) where he conducts R&D on experimental device physics and semiconducting materials-oriented research for application in organic electronics including organic light emitting diodes (OLEDs), organic photovoltaics, thin film transistors and sensors. Furong received his PhD from Charles Darwin University in Australia for rsearch in thin film amorphous silicon solar cells. He did his post-doctoral research in the Department of EEE at Kyoto University in Japan from 1993-1995, and was a Research Fellow with Department of Physics at Murdoch University in Australia from 1995-1997 working on silicon thin films derived from PECVD for device application. He joined IMRE in 1997 and is currently leading the OLED and photovoltaic R&D activity at IMRE. He

has authored/co-authored over 80 refereed journal/conference publications, and filed 6 patents in OLEDs and organic photovoltaics.