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2022-2023 中日高层次科学家研讨交流活动
（煤燃烧与低碳利用）
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2022-2023 China-Japan High-level Expert Symposium on Coal Combustion and Low Carbon Utilization

Introduction

2022-2023 China-Japan High-level Expert Symposium on Coal Combustion and Low Carbon Utilization will focus on coal combustion, low carbon utilization, and Carbon Capture, Utilization and Storage (CCUS). Top scientists and experts from China, Japan and other countries are invited for presentations and dialogues on cutting-edge research and practice of Coal Combustion and Low Carbon Utilization, and explore the best way to achieve carbon neutrality. It is fully expected that this symposium will provide a consultation and reference for the policymaking and industrial development in China, Japan, and other countries as well.

Chairs

Xu Minghou
Director, the International Joint Research Center for Clean Coal Utilization

Naruse Ichiro
Director, Professor, Institute of Materials and Systems for Sustainability, Nagoya University, Tokai National Higher Education and Research System

Hosts

Department of Foreign Expert Services, Ministry of Science and Technology of the People's Republic of China

Sakura Science Program Headquarters, Japan Science and Technology Agency

Organizers

Foreign Talent Research Center, Ministry of Science and Technology of the People's Republic of China

Huazhong University of Science and Technology

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Foreign Talent Research Center, MOST

The Foreign Talent Research Center, Ministry of Science and Technology of the People's Republic of China, a public institution directly affiliated to China's Ministry of Science and Technology, is mainly responsible for: carrying out research on the development of foreign talent and the theories, strategies, policies, and development status of scientific and technological innovation; developing foreign talent think-tanks and promoting networks of theoretical achievements during overseas expertise introduction; undertaking the construction, operation, maintenance and development of foreign talent resource pools; providing resources, platforms and other services for the overseas expertise introduction; editing and publishing professional media articles for the overseas expertise introduction, and undertaking the publicity work entrusted by the Ministry; organizing professional meetings and major events for overseas expertise introduction as well as scientific and technological exchanges; providing services including evaluation, consultation, introduction, information, and training for foreign talent; managing the China Society for Research on International Exchange and Personnel Development; and undertaking other tasks assigned by the CPC Leading Group, MOST and leaders of the Ministry and tasks entrusted by relevant departments and bureaus.

Sakura Science Program Headquarters, JST

Japan Science and Technology Agency (JST) plays a central role in Japan's Science and Technology Basic Plan. Based on science and technology targets issued by the government, we fund strategic basic research, academia-industry collaboration and technology transfer. In recent years, we promote international joint research and the fostering of next generation human resources. JST also provides information services to support R & D activities. Our comprehensive contribution stimulates substantive progress in science and technology and helps tackle a variety of social issues.

JST continues to strengthen our close relationship with universities, research institutes and industry in and outside Japan, create collaborative science and technology innovation and ensure sustainable development of our society.

Sakura Science Program invites talented young people from other countries and regions to Japan in a form of industry-academia-government collaboration, to introduce and offer experience in science and technology. Beginning in 2014, over 33,000 young people have visited Japan through this program.

By exchanging ideas in the field of science and technology among the participants of Sakura Science Program, we:

-Support the development of talented people overseas who have the potential to contribute to the innovation in science and technology; and support continuous interaction between Japan and other countries and regions.

-Promote globalization of Japanese educational and research institutes.

-Strengthen good relationship between Japan and other countries and regions and ultimately pursue the development of science and technology in Japan and worldwide.

Huazhong University of Science and Technology (HUST)

HUST is a comprehensive research university located in Wuhan, China under the direct supervision of the Ministry of Education of the People's Republic of China. It is a participant university of the former "985" Project in China, and also one of the first universities approved under the national "Double First-Class" Initiative, China's "Excellence Initiative" for institutions of higher education.

HUST has consistently ranked among the top 10 universities in China in the major domestic and international rankings, including the Shanghai Ranking's Academic Ranking of World Universities and US News and World Report Best Global Universities Ranking.

Situated in the city of Wuhan, the capital of Hubei Province, HUST lies near the central banks of the Yangtze River. With a population of over eleven million, Wuhan is the foremost cultural, educational, transportation and economic city in Central China, playing a leading role in the Yangtze River Economic Zone and now emerging as a global megacity with enormous business opportunities.

HUST is comprised of its main campus close by picturesque East Lake and a satellite medical campus located in the central business district of Hankou across the Yangtze River. Today the university has more than 3,400 full-time teachers, including over 1,200 professors, serving approximately 55,000 full-time students. Complementing this rich academic environment is

HUST's remarkable greenscape – covering 72% of the campus, its rich canopy of trees explains why many people now refer to it as the "university in the forest".
HUST boasts a full range of academic disciplines, comprising 10 major categories that range from engineering and medicine - HUST's two most notable pillars of strength - to its fast-growing science and distinctive liberal arts disciplines. Guided by its sense of mission to contribute to social progress and the greater global community, the university continues to explore the frontiers of science, and is the only university in China that includes four national research facilities. International cooperation also lies at the core of HUST development strategy.

School of Energy and Power Engineering (EPE), HUST

EPE was one of the schools founded by Huazhong Institute of Technology (HIT), one of the predecessors of HUST. Power Engineering and Engineering Thermophysics of EPE, as the first batch of First-level National Key Disciplines, is one of the three "Double-First Class" disciplines in China. EPE has 6 secondary disciplines, including Engineering Thermophysics, Thermal Engineering, Power Machinery and Engineering, Fluid Machinery and Engineering, Refrigeration and Cryogenic Engineering, and New Energy Science and Engineering. Additionally, Energy and Power Engineering, Nuclear Engineering and Technology, and New Energy Science and Engineering are national first-class undergraduate programs. EPE boasts of a discipline system supported by State Key Laboratory of Coal Combustion, National Energy Clean Coal Low Carbon Generation Technology R & D (Test) Center, Energy Saving and Emission Reduction of Energy & Power Devices Engineering Research Center, MOE, and 9 national engineering practice centers.
The school carries out scientific research and talent training centered on low-carbon, efficient and safe use of fossil energy, deep and joint removal of pollutants, optimization of energy terminal utilization and energy saving, renewable energy, and advanced power plants. Since 2012, remarkable achievements have been made in scientific research, as the number of state-level projects like the National Natural Science Foundation of China, ranks the top in the discipline of Engineering Thermophysics and Power Engineering. Furthermore, our international cooperation has yielded major results with nearly 200 million yuan of the international cooperation fund.
Under the guidance of the educational philosophy of leading in application, breakthrough in basic subjects, and responsibility in action, the school will strive to cultivate students, carry out in-depth scientific research, maintain the comprehensive strength of the disciplines at the leading position in China, and develop our key and characteristic disciplines into international first-level disciplines.

Agenda **Japanese Standard Time (JST)**

July 28 th, 2023	
Opening Ceremony	
Moderator: Xu Minghou	
9:30-10:00	**Opening Address** ● Jiang Dehua, Level II Bureau Rank Official, Department of Foreign Expert Services, Ministry of Science and Technology of the People's Republic of China ● Kishi Teruo, Director General, Sakura Science Program Headquarters, Japan Science and Technology Agency ● Gao Liang, Vice President, Huazhong University of Science and Technology ● Naruse Ichiro, Director, Professor, Institute of Materials and Systems for Sustainability, Nagoya University, Tokai National Higher Education and Research System **Group Photo**
Session I **Coal Combustion and Low Carbon Utilization**	
Moderator: Yao Hong	
10:00-10:20	**Keynote Speech 1:** Control of Ash Deposition in Pulverized Coal Combustion Boilers ● Naruse Ichiro
10:20-10:40	**Keynote Speech 2:** Advantages, Disadvantages, Opportunities and Challenges of Chemical Looping Combustion ● Zhao Haibo
10:40-11:00	**Keynote Speech 3:** A Deep-Learned Approach for the Classification of Fly Ash Particles in Coal Combustion ● Ninomiya Yoshihiko
11:00-11:20	**Keynote Speech 4:** Building Carbon Neutral and Reliable Energy System on Basis of CCUS ● Gao Lin
11:20-11:40	**Keynote Speech 5:** Inorganic Nanomaterials to Achieve Efficient Hydrogenation Reactions ● Yamauchi Miho
11:40-12:00	**Break**
12:00-12:20	**Keynote Speech 6:** CO_2 Mineralization Curing Technology for Coal Based Industrial Solid Wastes ● Wang Tao

12:20-12:40	**Keynote Speech 7:** Development of Novel Highly Efficient Conversion Methods of Low-Rank Coals and Biomass Waste into Electricity or Useful Products ● Ashida Ryuichi
12:40-13:00	**Keynote Speech 8:** Research Progress on Low Carbon Emission Technologies: Gas and Liquid Ammonia Combustion ● Li Jun
13:00-15:00	**Lunch**
Session II Carbon Capture, Utilization and Storage	
Moderator: Yamauchi Miho	
15:00-15:20	**Keynote Speech 9:** Low Temperature Catalytic Oxidation of Short-Chain Alkanes ● Guo Yanbing
15:20-15:40	**Keynote Speech 10:** Adsorption of CO_2 onto Biomass-derived Activated Carbons ● Saha Bidyut Baran
15:40-16:00	**Keynote Speech 11:** Micro CT and SEM Characterization of CO_2-induced Wellbore Cement Alteration under Geologic CO_2 Storage Conditions ● Zhang Liwei
16:00-16:20	**Keynote Speech 12:** New Concepts toward Low-cost and Safe CO_2 Storage ● Tsuji Takeshi
16:20-16:40	**Break**
16:40-17:00	**Keynote Speech 13:** High Temperature Combined Functional Materials for Integrated CO_2 Capture and Utilization ● Wu Chunfei
17:00-17:20	**Keynote Speech 14:** CO_2 Hydrogenation Selectivity Shift over In-Co Binary Oxides Catalysts ● Guo Limin
17:20-17:40	**Keynote Speech 15:** Carbon-negative and Resource-integrative Biomass Conversion Based on Pyrolysis, Carbonization and Gasification ● Hayashi Jun-ichiro
Virtual Research	
Moderator: Zhao Yongchun	
17:40-18:00	**Chinese Pioneer Case Research:** Opportunities and Challenges of CCUS in China and Engineering Practice of China Energy ● Xu Dong

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● Yamauchi Miho
● Li Xian
● Paula Blanco-Sanchez
● Yu Dunxi
● Antonio Oliveira</td></tr>
<tr><th colspan="2">Closing Ceremony</th></tr>
<tr><td colspan="2">Moderator: Saha Bidyut Baran</td></tr>
<tr><td>19:00-19:20</td><td>Closing Address
● Xu Minghou, Director, the International Joint Research Center for Clean Coal Utilization
● Naruse Ichiro, Director, Professor, Institute of Materials and Systems for Sustainability, Nagoya University, Tokai National Higher Education and Research System</td></tr>
</table>

Chairs

Xu Minghou

Director, the International Joint Research Center for Clean Coal Utilization

Xu Minghou is the "Cheung Kong" Chair Professor of the Ministry of Education of the People's Republic of China, the Fellow of The Combustion Institute, and the Associate Editor of the American Chemical Society Publications journal *Energy & Fuels*. He was the Visiting Scientist at Instituto Superior Técnico in Technical, University of Lisbon from 1997 to 2000, and the Visiting Scholar at the University of Sydney, Australia in 1999. His main research interests are efficient and clean coal combustion theory and technology, CCUS, efficient biomass conversion and utilization, and solid waste utilization. He has coordinated a broad range of projects related to energy and environment. He was awarded the Second Prize of Natural Science Achievement Award (2003), and several Provincial or Ministerial Science and Technology awards of different ranks. He has published more than 200 SCI papers, and founded a series of international conferences on the advanced utilization of coal and biomass between China and Australia, and served as the Chairman of the Chinese side.

Naruse Ichiro

Director, Professor, Institute of Materials and Systems for Sustainability, Nagoya University, Tokai National Higher Education and Research System

Naruse Ichiro received his Ph.D. degree in Engineering from the Department of Chemical Engineering, Nagoya University in 1989. In 1989, he joined Department of Energy Engineering, Toyohashi University of Technology, as the Research Associate. In 1994, he became the Associate Professor in the Department of Ecological Engineering. Between 1997-1998, he served as the Visiting Researcher in the Department of Chemical and Environmental Engineering, University of Arizona. In 2006, he was appointed as the Professor at the International Cooperation Center for Engineering Education Development, Toyobashi University of Technology. He was appointed as the Professor of Mechanical Science and Engineering, Nagoya University in 2007 and the Professor of EcoTopia Science Institute, Nagoya University in 2012. In 2015, he was appointed as the Professor at the Institute of Materials and Systems Sustainability, Nagoya University, and in 2020, he was appointed as the Director of the Institute of Materials and Systems Sustainability, Nagoya University. His areas of expertise are energy and environmental engineering, coal utilization, biomass and waste management, and energy conversion engineering.

Moderators

Xu Minghou

Director, the International Joint Research Center for Clean Coal Utilization

Xu Minghou is the "Cheung Kong" Chair Professor of the Ministry of Education of the People's Republic of China, the Fellow of The Combustion Institute, and the Associate Editor of the American Chemical Society Publications journal *Energy & Fuels*. He was the Visiting Scientist at Instituto Superior Técnico in Technical, University of Lisbon from 1997 to 2000, and the Visiting Scholar at the University of Sydney, Australia in 1999. His main research interests are efficient and clean coal combustion theory and technology, CCUS, efficient biomass conversion and utilization, and solid waste utilization. He has coordinated a broad range of projects related to energy and environment. He was awarded the Second Prize of Natural Science Achievement Award (2003), and several Provincial or Ministerial Science and Technology awards of different ranks. He has published more than 200 SCI papers, and founded a series of international conferences on the advanced utilization of coal and biomass between China and Australia, and served as the Chairman of the Chinese side.

Yao Hong

Director, State Key Laboratory of Coal Combustion, HUST

Yao Hong obtained his Doctoral Degree from Toyohashi University of Technology, and worked as the Researcher of Japan Society for the Promotion of Science (JSPS) and Center of Excellence Program (COE) in Japan for 7 years. After returning to China, he continued to carry out a number of China-Japan cooperation projects, e.g. NSFC-JST. He collaborated with teams from Nagoya University, Tokyo Institute of Technology, Tohoku University, and Idemitsu Kosan Co., Ltd. in Japan to conduct research on oxy-fuel combustion and thermal conversion of carbon-neutral fuels such as solid waste. Up to now, he has published over 300 papers, given 40 presentations at international conferences, obtained over 40 granted patents, and received the Distinguished Paper Award from the Combustion Society of Japan and International Combustion Institute.

Yamauchi Miho

Professor, Institute for Materials Chemistry and Engineering, Kyushu University

Yamauchi Miho received her Ph.D. degree under the guidance of Professor Ikeda Ryuichi from University of Tsukuba in 2001 and started research work as a technical staff there. She moved to Kyushu University as the Assistant Professor in 2003, and to Catalysis Research Center, Hokkaido University as the Associate Professor in 2008. In 2012, she joined International Institute for Carbon-Neutral Energy Research as the PI and moved to Institute for Materials Chemistry and Engineering, Kyushu University as the Professor in 2022. Her research interests involve hydrogen related properties of metal nanoparticles, selective catalysis on the structure controlled nanocatalysts, and electrocatalysis for sustainable material production.

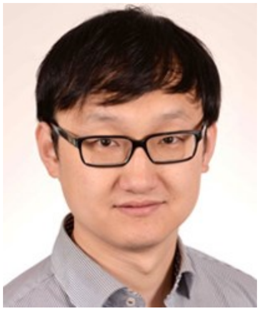
Zhao Yongchun

Professor, Huazhong University of Science and Technology
Vice Director, State Key Laboratory of Coal Combustion, HUST

Zhao Yongchun obtained his Ph.D. degree from Huazhong University of Science and Technology in 2008. From 2007 to 2008, he studied at National Institute of Coal, Spain, as a visiting Ph.D. student. Following postdoctoral work at HUST, he joined the faculty at State Key Laboratory of Coal Combustion of HUST. He is also the Director of the National Environmental Protection Engineering Technology Center for Trace Elements Pollution Control and Low Carbon Utilization of Coal (TE & CC). His research interests focus on trace element (Hg, As, etc.) partition, release, retention, and its potential as a resource, CO_2 monitoring and resource utilization, clean and low-carbon energy utilization, etc. He is the Chief Scientist of National Key R&D Program of China, the Principal Investigator of more than 20 projects supported by National Natural Science Foundation of China (NSFC) and large energy enterprises. He has published more than 140 peer reviewed international journal papers, and given more than 30 keynote presentations and invited talks. He has been served as the Associate Editor of *Clean Coal Technology*, the Guest Editor of *International Journal of Coal Geology* and *Journal of Fuel Chemistry and Technology*, and the Session Chair or Committee Member of many international conferences.

Yang Yang

Professor, State Key Laboratory of Coal Combustion, HUST



Yang Yang is the Chartered Engineer (UK), and the Member of Institution of Chemical Engineers (IChemE) and Royal Society of Chemistry (RSC). His research focuses on low carbon energy technology development with particular interest in industrial carbon reduction, CO_2 conversion and biomass thermochemical conversion for biofuels, and hydrogen and carbon materials. He is the investigator for a range of international research grants including National Key R&D Program of China, EU Horizon 2020 RISE project, Royal Society International Grant, Newton Fund Institutional Link, etc. He has over 60 academic publications in the field of energy and chemical engineering. He holds NSFC Overseas Excellent Young Scientists Award and EU Marie Curie ESR Fellowship.

Saha Bidyut Baran

Professor, Principal Investigator, International Institute for Carbon-Neutral Energy Research (WPI-I2CNER), Kyushu University
Professor, Mechanical Engineering Department, Kyushu University

Saha Bidyut Baran received his Ph.D. degree in 1997 from Tokyo University of Agriculture and Technology, Japan. He is the Founding Editor-in-Chief of *Evergreen Journal* and the Associate Editor of *Thermal Science and Engineering Progress*. He also served as the Managing Guest Editor of *Applied Thermal Engineering*, *Heat Transfer Engineering*, and *International Journal of Refrigeration*, and the Specialty Chief Editor of *Frontiers in Thermal Engineering*. He has been working as the Foreign PI of the Scheme for Promotion of Academic and Research Collaboration (SPARC) Project, Ministry of Education of the People's Republic of China, and Government of India and World Class Professor (WCP), Ministry of Research, Technology, and Higher Education, Republic of Indonesia, to develop research and cooperation programs with Universitas Indonesia. He is one of the top peer reviewers (within 1% Web of Science, Researcher ID: C-5828-2012) in research fields: energy generation, conversion and storage engineering. He was the first Bose Fellow of the Bose Center for Advanced Study in Natural Sciences, Bangladesh. His research interests include thermally powered adsorption cooling, refrigeration and desalination systems, heat and mass transfer analysis, energy efficiency assessment and energy policy. He has published more than 400 articles in peer-reviewed journals, edited 10 books, and holds 31 patents. His Scopus Citations are above 13,000 times with an H-index of 64.

Speakers

Naruse Ichiro

Director, Professor, Institute of Materials and Systems for Sustainability, Nagoya University, Tokai National Higher Education and Research System

Naruse Ichiro received his Ph.D. degree in Engineering from the Department of Chemical Engineering, Nagoya University in 1989. In 1989, he joined Department of Energy Engineering, Toyohashi University of Technology, as the Research Associate. In 1994, he became the Associate Professor in the Department of Ecological Engineering. In 1997-1998, he served as the Visiting Researcher in the Department of Chemical and Environmental Engineering, University of Arizona. In 2006, he was appointed as the Professor at the International Cooperation Center for Engineering Education Development, Toyobashi University of Technology. He was appointed as the Professor of Mechanical Science and Engineering, Nagoya University in 2007 and the Professor of EcoTopia Science Institute, Nagoya University in 2012. In 2015, he was appointed as the Professor at the Institute of Materials and Systems Sustainability, Nagoya University, and in 2020, he was appointed as the Director of the Institute of Materials and Systems Sustainability, Nagoya University. His areas of expertise are energy and environmental engineering, coal utilization, biomass and waste management, and energy conversion engineering.

Title: Control of Ash Deposition in Pulverized Coal Combustion Boilers

Abstract

This study proposed reduction technology of ash deposition on the heat exchanger tube in pulverized coal (PC) combustion boilers. Thermal spraying technique was adopted to change the surface properties of tube to control the ash deposition. Four types of coal ash with different melting points were tested as the samples for the ash deposition experiments. The long-term ash adhesion experiments were also carried out, using a precise tension tester at high temperature. As the theoretical approaches, the compositions of each ash particle depositing on the tube surface were analyzed by a computer-controlled scanning electron microscope (CCSEM) with electron dispersive spectroscopy (EDS) detector, thereby the interfacial reactions between the ash deposition layer and the heat exchanger tube were discussed. Those results obtained were also compared to the results obtained by the thermal equilibrium calculations. As a result, even for the ash particles with lower melting point, Ni alloy as a thermal spraying material played an effective role to control the deposition. The reason why the Ni alloy can reduce the ash deposition is to control the formation of molten slag even at high temperature. The effectiveness of the Ni alloy was also proved even after the long-term contact between the ash pellet and the rod thermally sprayed Ni alloy at high temperature. This was because the Ni alloy could control the diffusion of Fe compounds from the tube rod to the ash deposition layer.

Zhao Haibo

Vice Director, State Key Laboratory of Coal Combustion, HUST

Zhao Haibo received his Ph.D. degree in Thermal Engineering from Huazhong University of Science and Technology in 2007. His research area is low-carbon combustion and high-value utilization of fossil fuels (chemical looping combustion), as well as combustion synthesis of functional nanoparticles. He has won the National Excellent Youth Fund, Alexander von Humboldt Foundation Fellowship and the Fellow of The Combustion Institute. He has published over 200 international journal papers, published 3 first author monographs, and obtained more than 20 invention patents to China and the United States. His research work has won awards such as the Outstanding Paper Award of the International Combustion Institute, the Best Paper Award of the International Chemical Looping Conference, the First Prize in Natural Science of Hubei Province, and the First Prize in Natural Science of the Ministry of Education of the People's Republic of China.

Title: Advantages, Disadvantages, Opportunities and Challenges of Chemical Looping Combustion

Abstract

Chemical looping combustion (CLC), as a new generation of combustion technology, has the advantages of inherent CO_2 separation and cascade energy utilization, and is widely regarded as one of the most promising low-energy CO_2 capture technologies. After over 20 years of fundamental research and development, it has entered the industrial demonstration stage. However, it still faces several technical challenges, such as low combustion efficiency and CO_2 capture efficiency. In this presentation, the basic principles and development history of CLC are presented, and the inherent technical advantages, potential disadvantages, development opportunities, and key technical challenges are systematically analyzed. The opportunities for CLC include low energy consumption in carbon capture, fast improvement in technology maturity, and potential benefits beyond the low-carbon combustion of fossil fuels. The challenges it faces include the positive correlation between oxygen carrier performance and economical cost, which needs to develop the theory of high performance and low-cost oxygen carrier design and scale preparation methods; the dependence on empirical design methods for scaling up, which needs to develop the theory of reactor numerical design and optimization manipulation methods; and the difficulty of stable operation of the device, which needs to develop the method of synergistic regulation of heat and mass transfer between the fuel reactor and air reactor. Finally, this presentation provides an outlook on the technological maturity and industrial application of CLC.

Ninomiya Yoshihiko

Professor, Department of Applied Chemistry, Chubu University

Ninomiya Yoshihiko works on the reduction of CO_2 emissions from coal combustion and the prediction of ash deposits on heat transfer tubes using AI imaging technology, carbon reduction using methanation catalysts to reduce CO_2 emissions, and the use of renewable resources such as wood biomass for thermal energy. The focus is on the use of inorganic materials in fuels. The research is mainly conducted from the viewpoint of high temperature thermophysical properties of inorganic materials (ash) contained in fuels.

Title: A Deep-Learned Approach for the Classification of Fly Ash Particles in Coal Combustion

Abstract

The use of fuels produced by blending coal with biomass or other materials is being promoted to reduce CO_2 emissions from pulverized coal-fired power plants. It is necessary to understand the characteristics of inorganic materials due to the change in fuel properties and to develop an ash-free co-firing technology. We conducted combustion experiments using a drop tube furnace (DTF) to investigate the characteristics of PM formation during combustion of fuels such as coal, coal blends, and coal/woody biomass blends. CCSEM was used to measure the physical and chemical properties of coal minerals, and FactSage/ChemApp calculations were used to evaluate the melting characteristics of individual inorganic particles in coal and fly ash. This presentation is about the results of classifying the shapes of particles formed under different combustion conditions using a deep learning analysis method. The experiment was conducted in a laboratory-scale drop tube furnace to investigate the fly ash behavior of several fuel combinations at two temperatures, 1,350°C and 1,450°C. Ash samples were collected from a water-cooling probe and characterized by CCSEM. In addition, the particle shape of the fly ash was photographed for 200,000 to 500,000 particles using the automatic imaging function of the scanning electron microscope (SEM). Conventional image binarization methods can determine particle area and particle shape coefficients from projected cross-sectional images of particles, but cannot make categorical classification judgments such as spherical, agglomerated, or unmelted particles. Deep learning image classification directly determines the SEM image of particles using a convolutional neural network (CNN) method. Therefore, by selecting good quality teacher images, it is possible to classify the shape of fly ash particles by category. The information provided in this work is more useful to provide a practical approach to elucidate the mineral transformation behavior during the combustion of a wide range of solid fuels.

Gao Lin

Professor, Beijing Huairou Laboratory

Gao Lin specializes in the integration of pre- and post-combustion carbon capture systems, research and development of carbon capture processes, optimization and integration of energy systems, and strategic development of energy technologies. In 2009, his team were awarded the Second Prize of National Natural Science for their contributions to the comprehensive cascading utilization of energy and CO_2 control principles and methods in energy power systems. In 2015, he led the formulation of the *Roadmap for Carbon Capture and Storage Demonstration and Deployment in the People's Republic of China* and issued it at the 15th meeting of the Conference of the Parties (COP15) in Paris. He has published over 100 related papers in prestigious domestic and international academic journals, with more than 60 papers indexed in Science Citation Index (SCI). He had been involved in more than 10 national-level projects, including National Basic Research Program of China, National High-tech R & D Program, and the National Natural Science Foundation of China. He had also participated in over 10 international cooperative projects, including the EU Framework Program, and government cooperation projects between China and UK, Italy, and Sweden.

Title: Building Carbon Neutral and Reliable Energy System on Basis of CCUS

Abstract

In the context of addressing climate change and sustainable development, human energy technology is undergoing an unprecedented transformation. This transformation is characterized by a shift in the energy structure from primarily relying on fossil fuels to a complementary mix of fossil fuels, renewable energy, and other forms of energy. Furthermore, the energy utilization methods are transitioning from predominantly thermodynamic cycles to non-cyclic and multi-directional conversion approaches, such as photovoltaics and fuel cells. The pursued objectives are evolving from emphasizing efficiency to pursuing multiple compatible goals, including cleanliness, low carbon emissions, safety, and high efficiency.

Constructing a carbon-neutral energy system requires the complementary use of multiple energy sources and the synergy of various technologies. Both traditional fossil fuels and renewable energy sources must confront challenges and find their roles in future energy systems through technological innovations.

Fossil fuels like coal and natural gas offer advantages in terms of security and reliability, but their high carbon emissions are a fatal flaw. Carbon Capture, Utilization, and Storage (CCUS) technologies can respectively compensate for the aforementioned deficiencies, making it crucial pivot technology for future carbon-neutral energy systems. This report will discuss the current development status and issues of CCUS technology, identify the challenges it needs to address, and propose future directions and breakthroughs for its technological advancement.

Yamauchi Miho

Professor, Institute for Materials Chemistry & Engineering, Kyushu University

Yamauchi Miho received her Ph.D. degree under the guidance of Professor Ikeda Ryuichi from University of Tsukuba in 2001 and started research work as a technical staff there. She moved to Kyushu University as the Assistant Professor in 2003, and to Catalysis Research Center, Hokkaido University as the Associate Professor in 2008. In 2012, she joined International Institute for Carbon-Neutral Energy Research as the PI and moved to Institute for Materials Chemistry and Engineering, Kyushu University as the Professor in 2022. Her research interests involve hydrogen related properties of metal nanoparticles, selective catalysis on the structure controlled nanocatalysts, and electrocatalysis for sustainable material production.

Title: Inorganic Nanomaterials to Achieve Efficient Hydrogenation Reactions

Abstract

Hydrogenation reactions using green hydrogen are indispensable for the energy storage and material synthesis without a great deal of CO_2 emission. Electrochemical CO_2 hydrogenation (eCO_2H) attracts much attention as a technology for carbon circulation on the earth, and the selective eCO_2H into high value-added chemicals is increasingly demanded. We demonstrated variable selectivity using Hydroxide-derived copper (OH/Cu) electrodes having a controlled OH amount. Furthermore, CuPd nanocatalysts were found to exhibit unique selectivities depending on the mixing pattern of the alloy [Figure 1].

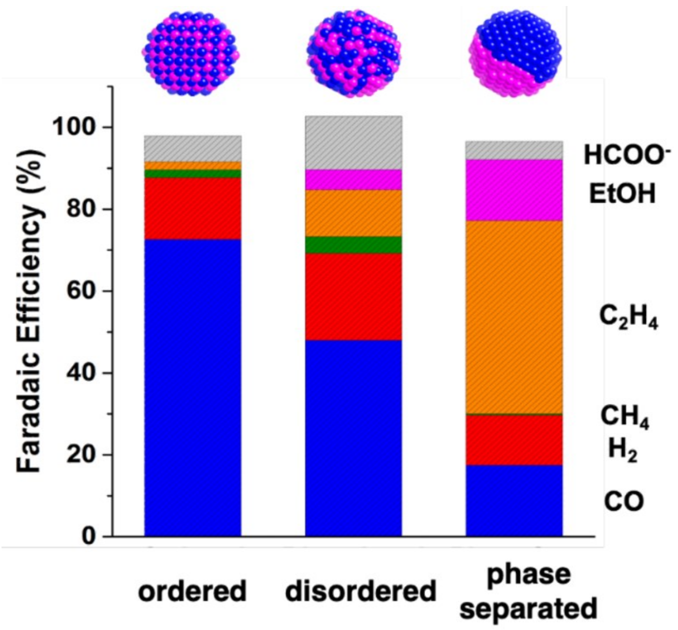
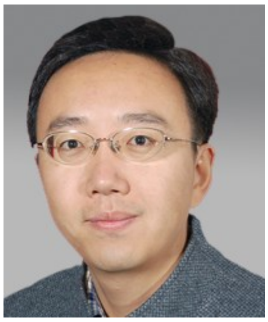


Figure 1 eCO2H on CuPd.

Wang Tao

Professor, College of Energy Engineering, Zhejiang University



Wang Tao received his doctoral degree from Zhejiang University in 2008. He was a postdoctoral fellow at Columbia University. He is active in the R & D of CCUS. In China, his team is leading the Jinjie 150 kilo-ton/yr CO_2 flue gas capture demonstration and the Jiaozuo 10 kilo-ton/yr CO_2 concrete curing demonstration. He serves as the Chinese Expert of Clean Energy Ministerial CCUS Initiative, the Member of CCUS committee of Chinese Society for Sustainable Development, and the Committee Member of International Association for Carbon Capture.

Title: CO_2 Mineralization Curing Technology for Coal Based Industrial Solid Wastes

Abstract

In recent years, China has the requirements of a rapid peak in CO_2 emissions and a need for neutralization. To address this, CO_2 mineralization combined with industrial solid waste resource utilization technology has been proposed as a potential solution. Pilot projects have been conducted to demonstrate the technical feasibility of this approach, and early deployment has been shown to have economic benefits due to the long asset life and high degree of marketization of products. Further research is needed to assess the efficacy of this approach in reducing China's carbon emissions and solid waste production.

The team at Zhejiang University has proposed a novel CO_2 mineralization curing technology for building materials, which involves a technical system comprising of kinetics improvement, inert material doping, and mild environmental activation. Through the research, it has revealed the progressive product layer diffusion-controlled kinetics in the process of CO_2 mineralization curing, constructed the CO_2 mineralization curing system under the doping of inert metastable materials, and developed a new method of rehydration for mild CO_2 mineralization activation. This helps to establish a systematic CO_2 mineralization curing process and form an industrial solid waste-based low-carbon cementitious material, offering both environmental and economic benefits.

Based on the fundamental research and technical progress, a 10,000 ton-CO_2/y mineralization curing (CMC) process was demonstrated in Jiaozuo city, China, by retrofitting a traditional autoclaved curing plant. An industrial concrete formula was developed using local solid wastes resources, including fly ash, furnace blaster slag, steel slag, and carbide slag, with approximately 90% of the raw materials coming from coal-based industries. A step pressure-equalizing procedure was developed to achieve a rapid carbonation rate, a high CO_2 conversion ratio of >98%, and efficient carbonation exotherm recycling. According to the global warming potential life cycle analysis, CMC showed significantly decreased the emission of 182 kg CO_2-Eq/m^3-product, with direct CO_2 sequestration accounting for 65% of the reduction.

Ashida Ryuichi

Junior Associate Professor, Department of Chemical Engineering, Kyoto University

Ashida Ryuichi received his Ph.D. degree in Chemical Engineering from Department of Chemical Engineering, Kyoto University in 2004. Following postdoctoral work at the Energy Institute of Pennsylvania State University, he served as the Assistant Professor in the Department of Chemical Engineering at Kyoto University in 2005, and became the Junior Associate Professor in 2016. He has received many awards, such as the Award for Encouraging Young Researcher from Japan Institute of Energy in 2009, the Award for Encouraging Young Researcher from Iron and Steel Institute of Japan in 2011, the Progress Award from Japan Institute of Energy in 2016, etc. His recent research focuses on the production of clean coal through the extraction of coal at elevated temperature, the fractionation of coal by the extraction of coal at elevated temperature and pressure, the development of upgrading techniques of unused carbonaceous resources such as low-rank coals, heavy oils, etc., the production of porous carbons and metal/carbon catalysts from coal or various resins and so on.

Title: Development of Novel Highly Efficient Conversion Methods of Low-Rank Coals and Biomass Waste into Electricity or Useful Products

Abstract

Based on an understanding of the physicochemical properties and chemical reactions of low-rank coals and biomass, the methods for effective utilization of low-rank coals and biomass were developed. In this presentation, two of these methods will be introduced: one is the method for highly efficient conversion of low-rank coals and biomass into electricity, and the other is the method for highly efficient conversion into useful materials. In the conversion to electric power, the aim is to achieve a significant increase in efficiency by using chemical energy conversion instead of a conversion to thermal energy, as is conventionally done in thermal power generation. In the conversion to useful substances, the aim is to produce some of the substances currently produced from petroleum and high-rank coals from low-rank coals and biomass by using decomposition reactions in which solvents are used as the reaction field.

Li Jun

Vice Director, Guangzhou Institute of Energy Conversion, Chinese Academy of Sciences

Li Jun was selected into the Talents Program of the Chinese Academy of Sciences, the Chinese Academy of Sciences Youth Team Program in the Field of Stable Support for Basic Research, and the Talents Program of Jiangxi Province. He mainly engaged in basic theoretical research and engineering technology development for the combustion and utilization of low-carbon/carbon free fuels. Focusing on efficient and clean combustion of low-carbon/carbon free fuels, theoretical and experimental research has been conducted on the combustion characteristics, combustion reaction mechanisms, pollutant generation and control mechanisms of low-carbon/carbon free fuels. Key technologies and equipment for the utilization of low-carbon/carbon free fuels have been developed. In the past 3 years, he has presided over and participated in 7 ministerial and provincial projects such as the talent project of the Chinese Academy of Sciences, the key research and development project of Guangdong Province, and the science and technology innovation project of Jiangxi Province. He has published more than 40 SCI papers, and applied for 18 Chinese invention patents (8 authorized). He also holds 1 Japanese patent.

Title: Research Progress on Low Carbon Emission Technologies: Gas and Liquid Ammonia Combustion

Abstract

Under the background of "carbon peaking & carbon neutrality", ammonia as a carbon-free fuel is considered as a sustainable energy choice, which can reduce the consumption of fossil fuels and the emission of CO_2, soot and hydrocarbon pollutants. Renewable ammonia can be used as fuel in much energy equipment such as engines to provide power for vehicles and marine ship, and heating for industry furnace. However, the main challenges of ammonia combustion are the difficulty of stable combustion and NOx emissions. The lack of understanding of ammonia fuel combustion characteristics, methods of combustion enhancement, and optimization of NOx formation limits its utilization as a fuel. In response to the above problems, this report aims to discuss the basic combustion characteristics of gas and liquid ammonia combustion as a fuel, enhanced combustion technology, engine application and heat recovery technology. On the basis of discussing the combustion characteristics of ammonia, the factors affecting stable combustion are analyzed, and the combustion mechanism of ammonia fuel is discussed in detail, including ammonia oxidation and NOx formation pathways. The swirl combustion technology is used to achieve stable combustion, and the influence of different burner design parameters on the stable combustion range and NOx emission is investigated. For the background of marine engine application, the atomization characteristics of liquid ammonia spray in the engine conditions are studied, and the laminar combustion velocity of n-dodecane/ammonia mixed fuel is measured.

Guo Yanbing

Associate Dean, Professor, College of Chemistry, Central China Normal University

Guo Yanbing serves as the Director of Engineering Research Center of Photoenergy Utilization for Pollution Control and Carbon Reduction, Ministry of Education of the People's Republic of China, and the Vice President of Wuhan Institute of Photochemistry and Technology. He received his Ph.D. degree from the Institute of Chemistry, Chinese Academy of Sciences in 2010. He has lead more than 10 projects, including the General Program of the National Natural Science Foundation of China, and Distinguished Young Project of Hubei Province. He has published more than 80 papers in *Nat Commun*, *J. Am. Chem Soc.*, *Angew. Chem. Int. Ed.*, *Environ. Sci. Technol.*, *ACS Catal.*, and other renown journals with over 4,500 citations and H-index of 32 (2 Essential Science Indicators highly cited paper). He has applied for 71 patents（22 authorized）. In addition, he also serves as the Editorial Board Member of *AIMS Environmental Science* and *Chinese Chemical Letter*, the Member of the youth chemical workers committee of the Chinese Chemical Society, and the Member of the standing committee of volatile organic pollution control committee of Chinese Society for Environmental Sciences.

Title: Low Temperature Catalytic Oxidation of Short-Chain Alkanes

Abstract

The abatement of volatile organic compounds (VOCs) is of great significance for environmental sustainability and human health. VOCs mainly emitted from transportation vehicles and industrial processes such as petroleum refining and petrochemical processing. With high ozone formation potential, short-chain alkanes need to be well controlled. Among various strategies, catalytic oxidation technology is one of the most effective method for short-chain alkane degradation. As typical catalysts for VOCs combustion, noble metal catalysts have been widely applied. However, further improving the low-temperature efficiency and reducing the usage of noble metal catalysts are still challenges calling for better solution. Herein, interface engineering for the activation of surface lattice oxygen, surface defect engineering for the activation of molecular oxygen, and single atom catalyst design for surface lattice oxygen and molecular oxygen dual activation strategies are developed as effective approaches for low-temperature elimination of short chain alkanes in the atmosphere, which shed light on the rational design of novel catalysts for energy and environmental applications.

Saha Bidyut Baran

Professor, Principal Investigator, International Institute for Carbon-Neutral Energy Research (WPI-I2CNER), Kyushu University
Professor, Mechanical Engineering Department, Kyushu University

Saha Bidyut Baran received his Ph.D. degree in 1997 from Tokyo University of Agriculture and Technology, Japan. He is the Founding Editor-in-Chief of *Evergreen Journal* and the Associate Editor of *Thermal Science and Engineering Progress*. He also served as the Managing Guest Editor of *Applied Thermal Engineering*, *Heat Transfer Engineering*, and *International Journal of Refrigeration*, and the Specialty Chief Editor of *Frontiers in Thermal Engineering*. He has been working as the Foreign PI of the Scheme for Promotion of Academic and Research Collaboration (SPARC) Project, Ministry of Education of the People's Republic of China, and Government of India and World Class Professor (WCP), Ministry of Research, Technology, and Higher Education, Republic of Indonesia, to develop research and cooperation programs with Universitas Indonesia. He is one of the top peer reviewers (within 1% Web of Science, Researcher ID: C-5828-2012) in research fields: energy generation, conversion and storage engineering. He was the first Bose Fellow of the Bose Center for Advanced Study in Natural Sciences, Bangladesh. His research interests include thermally powered adsorption cooling, refrigeration and desalination systems, heat and mass transfer analysis, energy efficiency assessment and energy policy. He has published more than 400 articles in peer-reviewed journals, edited 10 books, and holds 31 patents. His Scopus Citations are above 13,000 times with an H-index of 64.

Title: Adsorption of CO_2 onto Biomass-derived Activated Carbons

Abstract

Highly porous activated carbon can be used to substantially reduce carbon emissions and advance sustainability by facilitating several technologies and processes that do so. Utilizing low-carbon fuels can be impacted by high-quality activated carbon, including Carbon Capture and Storage (CCS), air and water purification, renewable energy production, and energy storage applications. For adsorbing CO_2 emissions from manufacturing processes and power plants, highly porous activated carbon can be effectively utilized. CO_2 can be successfully trapped and kept from escaping into the atmosphere thanks to the porous structure of activated carbon, which offers a huge surface area for adsorption. CCS, a technology, aids in lowering greenhouse gas emissions and the carbon footprint of various concerns. In this presentation, the synthesis techniques of highly microporous activated carbons (ACs) from waste biomass were introduced. The main objective of the present study is to provide our recent research and development activities on the synthesis and characterization of biomass-driven activated carbons toward achieving a carbon-neutral energy society.

Zhang Liwei

Researcher, Professor, Institute of Rock and Soil Mechanics, Chinese Academy of Sciences

Zhang Liwei got his Ph.D. degree from Carnegie Mellon University in 2013. His research has been focused on risk management of wellbore leakage under geologic CO_2 storage conditions, cement additives, and subsurface mineral dissolution/precipitation processes. Specific research areas include carbonation of cement and concrete, development of corrosion-resisting cement additives, subsurface mineral dissolution and precipitation in pores and fractures, etc. His research activities have resulted in 2 books (as the Editor), 5 book chapters, 19 patents and more than 120 journal articles and conference proceedings. He serves as the Steering Committee Member of International Energy Agency Greenhouse Gas R & D Programme (IEAGHG) Risk Management Network, and the Committee Member of the Energy and Environment Division of China Energy Society and the Climate Change Division of Chinese Society for Environmental Sciences.

Title: Micro CT and SEM Characterization of CO_2-induced Wellbore Cement Alteration under Geologic CO_2 Storage Conditions

Abstract

An aqueous CO_2-cement interaction experiment along with X-ray computed micro-tomography (micro CT) characterization of pre- and post-exposure cement samples was carried out to investigate the cement structure evolution under geologic CO_2 storage conditions. An image processing framework was proposed for mapping mineral dissolution and precipitation, and for characterization of carbonate shell morphology. By applying this framework, the 3D mineral precipitation and dissolution (or local mineral content change) map and the internal and external carbonate shells were visualised. The spatial distribution of the shell area, thickness, penetration depth and pore/calcite/portlandite content changes along the height of the sample was revealed as well. Structural evolution of individual pores in each reaction zone was further revealed by nano-scale SEM. This study shows the feasibility to use micro CT and nano-scale SEM to evaluate the alteration level of cement by high pressure and high concentration CO_2.

Tsuji Takeshi

Professor, Department of Systems Innovation, School of Engineering, the University of Tokyo

Tsuji Takeshi received his Ph.D. degree from the University of Tokyo in 2007. He then moved to Kyoto University as the Assistant Professor. He stayed at the Rock Physics Department of Stanford University from 2010 to 2011. He served as the Assistant Professor of International Institute for Carbon-Neutral Energy Research (I2CNER), Kyushu University from 2012 to 2016, the Professor of the Department of Earth Resources Engineering, Kyushu University from 2017 to 2021, and he joined the University of Tokyo in 2017. His research includes geophysics, seismology, hydrology, geodesy and planetary science. He has published more than 180 peer-reviewed papers. He won awards from the Seismological Society of Japan, the Geological Society of Japan, and the International Union of Geodesy and Geophysics (IUGG). He also received the Young Scientists' Prize from the Ministry of Education of the People's Republic of China, Ministry of Education, Culture, Sports, Science and Technology of Japan, and the Western Japan Cultural Award.

Title: New Concepts toward Low-cost and Safe CO_2 Storage

Abstract

It has been estimated that CCS and CCUS have the potential to contribute 15% of the cumulative reduction in emissions. Given the urgent need to mitigate atmospheric CO_2 levels, it is imperative that we explore all viable approaches for CO_2 reduction. When we evaluate these approaches, we need to consider three main factors: the amount by which CO_2 can be reduced, the rate at which CO_2 can be feasibly reduced, and the cost of CO_2 reduction. In terms of these three factors, CCS can be considered one of technically realistic CO_2 reduction approaches. At the worldwide level, the estimated potentials of CO_2 storage are as much as 10,000 Gt CO_2. The technology for CO_2 storage has been mostly developed based on the oil/gas exploitation technologies. However, its cost is still high. Safety is another key factor for CCS projects. CO_2 leakage and injection-induced earthquakes should be carefully evaluated. This presentation aims to address these concerns by exploring the potential of low-purity CO_2 storage to reduce the overall cost of CCS, and advocating for continuous monitoring strategies to ensure the safe storage of CO_2.

Wu Chunfei

Reader, School of Chemistry and Chemical Engineering, Queen's University Belfast (QUB)

Wu Chunfei is the Chemical Engineering Programme Lead at QUB. He serves as the Managing Editor of *Biomass & Bioenergy*, and the Founding Editor-in-Chief of *Carbon Capture Science & Technology*. He is the PI of a EU RISE international exchange programme in relation to biomass gasification and carbon capture and utilization, coordinating 15 research groups. He is the Co-I of a EU H2020-MSCA-RISE-2014 Flexi-PyroCAT project focusing on the co-processing of waste plastics and biomass, and the Co-I of EU H2020-MSCA-RISE-2019 for Advanced Zeolite Catalysis for Sustainable Biorefinery towards Value-added Chemicals. He has also been involved in several Engineering and Physical Sciences Research Council (EPSRC), Innovate UK, Royal Society and other EU projects. He has worked in the areas of converting renewable and waste resources to energy, fuel, and chemicals through catalytic thermochemical routes for more than 15 years. He has published more than 180 peer-reviewed journal papers with >10,000 citations (H-index of 61) in the areas of catalytic thermo-chemical conversion of wastes.

Title: High Temperature Combined Functional Materials for Integrated CO_2 Capture and Utilization

Abstract

CO_2 Capture and Utilization (CCU) is a sustainable process that can partially close the carbon cycle. It is attractive to store the excess and uncertain supply of energy from renewable sources to stable chemical energy. Increasing studies have been carried out on Integrated CO_2 Capture and Utilization (ICCU) to reduce the cost of the overall process by eliminating transportation and storage of the CO_2. ICCU could achieve in-situ CO_2 adsorption, separation and conversion using dual-function catalysts (DFMs), consisting of CO_2 adsorbents and catalysts. ICCU avoids temperature swing sorbent regeneration, which is considered an energy-intensive process. Integrating ICCU via reverse water-gas shift reaction (ICCU-RWGS) is particularly attractive due to the important industrial value of syngas. Furthermore, the in-situ CO_2 utilization can outperform conventional RWGS in relation to CO_2 conversion and CO selectivity. Herein, we achieved very promising ICCU-RWGS performance by CaO-alone and functionalizing CaO using active transition metals, e.g. Ni and Fe. Excellent CO_2 adsorption and extremely efficient CO_2 conversion can be achieved with simple materials, outperforming traditional separated CO_2 capture and catalytic conversion processes.

Guo Limin

Professor, School of Environmental Science & Engineering, HUST

Guo Limin is the Adjunct Professor of China-Europe Union Institute for Clean and Renewable Energy, HUST, and the Visiting Professor of WPI-I2CNER, Kyushu University. He received his Ph.D. degree from Shanghai Institute of Ceramics, Chinese Academy of Sciences in 2010. Before joining HUST in 2016, he has worked at two leading universities (Tohoku University and Kyushu University) in Japan as the Research Fellow for 6 years. Now, his research focuses on CO_2 catalytic hydrogenation, VOCs adsorption/catalytic combustion elimination, and proton exchange membrane cell for water electrolysis. Up to now, he has undertaken more than 30 governmental and industrial projects, published more than 100 journal papers, and obtained 19 patents.

Title: CO_2 Hydrogenation Selectivity Shift over In-Co Binary Oxides Catalysts

Abstract

The hydrogenation of CO_2 into methanol by renewable H_2 has attracted much attention due to its mitigation of overall CO_2 emissions and the simultaneous production of valuable chemical products. In_2O_3 is a promising catalyst for CO_2 to methanol. Introducing metal elements into In_2O_3 (M/In_2O_3) is one of the main strategies to improve its catalytic performance. However, the mechanism and active sites of the M/In_2O_3 catalytic system remain unclear and need to be further elucidated.

In this report, the noble-metal-free In_x-Co_y binary oxides catalysts were prepared for CO_2 hydrogenation to methanol. Much-improved performance and obvious product selectivity shift were observed. The optimized catalyst (In_1-Co_4) showed five times methanol yields than pure In_2O_3. And the cobalt-catalyzed CO_2 methanation activity was significantly suppressed, although cobalt was the majority of the metal element. To unravel the reason for this selectivity shift, detailed catalysts performance evaluation, together with several *in-situ* and *ex-situ* characterizations, were employed on cobalt and In-Co for comparative study. The results indicated CO_2 hydrogenation on cobalt and In-Co catalyst both followed the formate pathway, and In-Co reconstructed and generated a surface In_2O_3-enriched core-shell-like structure under a reductive atmosphere. The enriched In_2O_3 at the surface significantly enhanced CO_2 adsorption capacity and well stabilized the intermediates of CO_2 hydrogenation. CO_2 and carbon-containing intermediates adsorbed much stronger on In-Co than cobalt led to a feasible surface C/H ratio, thus allowing the $^*CH_3O$ to desorb to produce CH_3OH instead of being over-hydrogenated to CH_4.

Hayashi Jun-ichiro

Professor, Institute for Materials Chemistry and Engineering, Kyushu University
Director, Trans-disciplinary Research and Education Center of Green Technology, Kyushu University

Hayashi Jun-ichiro has been working in academic areas of chemical engineering mainly focusing on conversion of carbon resources ranging from coal to biomass and CO_2 and processes over a range of non-catalytic and catalytic conversion such as hydrothermal treatment, torrefaction, pyrolysis, carbonization, gasification, electrochemical oxidation and combustion. He has published more than 300 original academic papers mainly on carbon resources conversion. His most recognizable works are in finding, understanding and appreciation of "chemical interaction between volatiles and char from the pyrolysis" and also in physical, chemical and catalytic behavior of alkali and alkaline-earth metallic species in the pyrolysis and gasification. He is also the researcher who first produced high-strength metallurgical cokes from biomass alone without binder/additive.

Title: Carbon-negative and Resource-integrative Biomass Conversion Based on Pyrolysis, Carbonization and Gasification

Abstract

Chemicals/materials production systems starting from C5/C6 sugars, lignins and others (as "platforms") are expected to play most important roles in the future biomass-based industries, which have a fundamental problem of difficulty in recycling wastes to platforms. Such problems will be solved by introducing gasification of wastes (or that together with biomass) because it can integrate miscellaneous wastes and biomass resources into syngas (CO/H_2) that is the platform of C1 chemistry/biochemistry, without processes of component separation. The gasification is thus a key process that enables biomass-based production systems carbon negative. The carbon efficiency of the gasification is maximized by maximizing total CO/H_2 yield (in other words, Chemical Energy Recovery, CER). Recent research efforts are achieving catalytic steam/O_2 gasification of biomass with CER even over 95% and also complete tar removal. Use of CO_2/O_2 instead of steam/O_2 further improves the CO yield to a level of $\approx$ 100% on the biomass carbon basis.
The R & D of biomass pyrolysis/carbonization are also in progress. A sequence of low-temperature catalytic pyrolysis (torrefaction), pulverization/washing of torrefied biomass, briquetting and carbonization successfully produces anhydrosugars. Biomass-derived coke may be a key material in the future sustainable industries.
The pyrolysis, carbonization and gasification are endothermic processes and therefore have potentials of chemical and electric energies integration by means of supplying the latter (i.e., renewable electric energy) as is it is or as joule heat. Gasification biochar or coke with CO_2 plus joule heat can integrate carbon and CO_2 into CO. Combination of water electrolysis and gasification is thus interesting as co-production of H_2 and CO.

Xu Dong

Director, Carbon Neutrality Center, China Energy New Energy Research Institute

Xu Dong is the Member of the Expert Committee of Asia-Pacific Economic Cooperation (APEC) Sustainable Energy Center. He also worked in the secondment programme of the International Energy Agency (IEA) CCUS Unit between 2019-2020. His research focuses on development and demonstration of technologies along the CCUS industrial chain. He takes the lead in a number of key national and provincial R & D Programs on carbon capture and utilization as resource and energy source. In the meantime, he is also leading the successful on-going demonstration of China Energy's 150 kt/a CO_2 capture project in Jinjie Power Plant, as well as China Energy's 500 kt/a CO_2 capture demonstration project in Taizhou Power Plant, with the largest scale in Asia. He has so far applied for over 40 patents and published more than 50 research papers.

Opportunities and Challenges of CCUS in China and Engineering Practice of China Energy

The report is going to introduce the current development status, engineering cases and bottlenecks of CCUS in China under the carbon neutrality initiative. The opportunities and challenges for the future development of CCUS in China will be predicted. The report will also share the CCUS engineering practice of China Energy, as well as the 150,000 tons/year thermal power carbon capture demonstration project that has been put into operation at Jinjie Power Plant, as well as the Asia largest 500,000 tons/year thermal power carbon capture demonstration project in Taizhou Power Plant.

Roundtable Discussion Attendees

Yamauchi Miho

Professor, Institute for Materials Chemistry & Engineering, Kyushu University

Yamauchi Miho received her Ph.D. degree under the guidance of Professor Ikeda Ryuichi from University of Tsukuba in 2001 and started research work as a technical staff there. She moved to Kyushu University as the Assistant Professor in 2003, and to Catalysis Research Center, Hokkaido University as the Associate Professor in 2008. In 2012, she joined International Institute for Carbon-Neutral Energy Research as the PI and moved to Institute for Materials Chemistry and Engineering, Kyushu University as the Professor in 2022. Her research interests involve hydrogen related properties of metal nanoparticles, selective catalysis on the structure controlled nanocatalysts, and electrocatalysis for sustainable material production.

Li Xian

Professor, State Key Laboratory of Coal Combustion, HUST

Li Xian got his Ph.D. degree from Dalian University of Technology in 2008, and worked as the Postdoctor in Max-Planck-Institut for coal research (Germany) from 2008 to 2009, the Global-COE Researcher in Kyoto University from 2009 to 2010, and the Assistant Professor in Kyoto University from 2010 to 2013. He returned to China in 2013 to work at HUST as the Associate Professor, and became the Full Professor in 2020. His research interest is related to upgrading, thermal conversion, and utilization of the low grade carbonaceous energy resources. He got Excellent Achievement Award of Colleges and Universities from Ministry of Education of the People's Republic of China, Chutian Scholar Program Award from Department of Education of Hubei province, and Annual Award from Fuel Society of Japan. He is the Principal Investigator of more than 20 projects which are supported by Ministry of Science and Technology of the People's Republic of China, National Natural Science Foundation of China, and industries. He published more than 70 papers and has 15 patents.

Paula Blanco-Sanchez

Associate Professor, Chemical Engineering & Applied Chemistry Department, Aston University

Paula Blanco-Sanchez received her Ph.D. degree in Chemical Engineering from the University of Leeds. Her research focuses on biomass conversion and biorefineries, which is carried out at the Energy & Bioproducts Research Institute (EBRI). She is interested in working on the research areas of biomass conversion, biomass products upgrading into high-value fuels and chemicals, catalysis development and use, process optimisation, hydrogen production, and Bio-Energy with Carbon Capture and Storage (BECCS). She currently leads a project to develop CO_2 measurement guidelines, funded by the Industrial Decarbonisation Research and Innovation Centre (IDRIC), and in joint with Progressive Energy and the Energy Institute. She also works on the implementation of the Wolfson Centre for Low Carbon Hydrogen based on biomass gasification.

Yu Dunxi

Vice Director, State Key Laboratory of Coal Combustion, HUST

Yu Dunxi has been mainly engaged in the research of clean and efficient utilization theory and technology of carbon-containing energy such as coal/biomass and hydrogen-rich energy such as hydrogen/ammonia. In recent years, in order to reduce CO_2 emissions from power sector, he has been working on the replacement of high-carbon fuels with low-carbon ones. He discovered a new formation mechanism of combustion particulate matter (PM), and developed a novel PM control technology based on modified additives which successfully demonstrated and applied in large-scale coal-fired units.

Antonio Oliveira

Director, Department of Environmental Industrial Processes, Institute for Energy Technology, Norway (IFE)

Antonio Oliveira currently co-leads the CCU Forum of the CCUS Norway Association. He has an extensive research portfolio in bioeconomy, circularity, CCUS, H_2 production, and bio-refineries. At IFE, his primary responsibilities encompass innovative process conceptualization, technical feasibility studies, laboratory and bench-scale verification, and process modelling and simulation. He has played a crucial role in developing Sorption-Enhanced Reforming and Calcium-Looping technologies, including the creation of calcium-based solid sorbents for high-temperature CO_2 capture. Prior to IFE, he was the Senior Advisor of the Centre of Strategic Studies and Management in Science and Technology Policy in Brasilia, where he led studies that supported the establishment of research platforms in energy and bioeconomy.