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EDITORIAL

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A Current Perspective on Catalysis for New Energy Technologies

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There is an increasing concern about global climate change and the decreasing availability of fossil fuels. Research is being conducted worldwide to develop new technologies for the generation of energy from renewable resources, such as biomass and solar photons, and to increase energy efficiency and lower emissions in the conversion of fossil fuels. Catalysis will be a key discipline and play a critical role in developing these new energy technologies. This Special Issue about catalysis for new energy technologies presents the current progresses in this exciting field, based on the Symposium on New Energy Technologies as a part of the 240th National Meeting of the American Chemical Society held in Boston, USA on August 22–26, 2010. It contains invited papers from leading researchers in a wide range of important topics related to new energy that address the scientific aspects including photocatalysis, catalysis for biomass conversion, hydrogen production from both fossil fuels and biomass, and the conversion of H_2 in fuel cells.

Solar energy is an abundant source of renewable energy, but the low energy efficiency of harvesting solar energy and the high cost are the hurdles for effective utilization of solar energy. Fundamental studies are necessary to enable the technological breakthroughs needed. The collection of papers in this field deals with artificial photosynthesis inspired by natural photosynthesis, nanocrystalline catalysts for photocatalytic steam reforming of ethanol and glycerol, and homogeneous photocalalytic oxidation of hydrocarbons.

Fan and coworkers has reviewed some successful prototypes from natural systems that can be used for the biomimetic design of artificial leaves, and the major advances in constructing artificial leaves by mimicking photosynthesis to capture solar energy. The recent progresses in catalytically production of hydrogen from water and various environmentally clean fuels from carbon dioxide by the artificial leaves are highlight-

ed. Y. Amao has reviewed the recent progress in solar fuel production based on the artificial photosynthesis system. Although the efficiency values of artificial photosynthesis are still too low for practical application, they illustrate that solar fuel production inspired by natural photosynthesis is achievable in the laboratory. More research will be necessary to explore the potential artificial photosynthetic systems. Fornasiero and coworkers reported the active and cheap Cu/TiO_2 nanocomposites for hydrogen production by means of the photocatalytic reforming of ethanol and glycerol. The highly dispersed Cu nanoparticles on TiO_2 were successfully produced by the photodeposition of Cu on the surface of multiphase TiO_2. Zhao and coworkers have presented ruthenium complexes as a new photocatalytic homogeneous system for the oxidation of hydrocarbons. They confirmed the light-induced formation of Ru^{IV}=O species during the photocatalytic oxygenation process. More detailed mechanistic studies are expected to provide guidelines towards the design of better photocatalytic systems for the oxidation of water and organic substances.

It has recently been stated that biomass is the only practical source of renewable liquid fuel. In the Energy and Climate Package and the related Renewable Energy Roadmap published on January 10, 2007, the European Commission proposed that in the European Union at least 10% of our transportation fuels should be biofuel by 2020. One work, collected in this Special Issue, reflects the progress in the application of the heterogeneous acidic catalysts for the production of biodiesel from waste oils. However, the second-generation biofuels made from plant wastes, or from crops specially grown for the purpose on land, which are not suitable for food production, offer greater promise than the first generation of biofuels being produced today. Lignocellulose (or cellulose) is the cheapest and most abundant source of biomass. The production of liquid fuels from lignocellulosic biomass involves removal of some oxygen, as CO_2 or H_2O, and conversion into a higher-density liquid fuel. It would also be desirable to have a biomass conversion process that is able to convert all the energy in the biomass to a transportation fuel that could easily be fit into existing infrastructure and without air pollution. However, selective activation of C–C, C–O, C–H bonds in biomass molecules remains a great challenge. Zheng et al. reported a combined experimental and DFT investigation of the selective activation of C–O bonds by using acetone and acetaldehyde as probe molecules. C=O bond hydrogenation has been considered as an important initial step in catalytic conversion of cellulose biomass. Unlike their corresponding monometallic catalysts, Co–Pt bimetallic catalysts exhibit significantly higher C=O hydrogenation activity, which was correlated to the weak binding energy of the reactants on the bimetallic surfaces predicted by DFT. Exploring the DFT investigation on the correlation between the binding energies of the carbonyl compounds and the hydrogenation activity could improve the capability of rational catalysts design for the selective hydrogenation of molecules. Chen and He also demonstrated the importance of selective activation of C–C bonds of biomass derived molecules in the steam reforming and gasification for hydrogen production. A general relationship between C binding energies and hydrogen selectivities was illustrated in their review of H_2 from biomass.

De Chen was born in Shanghai, China in 1962. He studied applied catalysis at the Norwegian University of Science and Technology (1994-1998) and received his PhD in 1998. In the same year he joined the Department of Chemical Engineering of the same university as an associate professor. In 2001 he became a full professor at the same department. His current research interests are heterogeneous catalysis and nanomaterials for new energy, which covers catalysts for hydrogen production and biomass conversion, sorbents of CO_2 capture, and nanocarbon materials as electrodes of fuel cells, supercapacitors and batteries.

Chang-jun Liu is a Professor at Tianjin University. He was the recipient of the NSFC's Distinguished Young Scholar award (2003) and he was the Changjiang Scholar (2004). He received his B.S. and M.S. in Chemical Engineering from the Dalian University of Technology, and his Ph.D. in Chemical Technology from Tianjin University. His research interests include catalyst preparation using cold plasmas, catalyst characterization, CO_2 utilization, and molecular modeling. He has been the organizer of several international conferences or symposia. He served as the 2010 Program Chair of Fuel Chemistry Division of the American Chemical Society. He is an advisory board member for the International CO_2 Forum and for Greenhouse Gases: Science and Technology, a new Wiley journal.

Fischer–Tropsch (FT) synthesis represents a promising process to produce clean liquid fuels from abundant natural gas, coal, and biomass, after first being converted to synthesis gas. The Minireview by Goodman, Liu and co-workers describes the state-of-the-art surface science studies on cobalt FT catalysts on both a single crystal and supported catalysts. The surface science results suggested that FT synthesis is structure insensitive in general and that there is no intrinsic particle-size effect. Rather small Co nanoparticles (2.5 nm) are easily oxidized by water vapor, which results in poor catalytic performance. No excessive carbon build-up is detected below reaction temperature of 550 K and graphite begins to form at higher temperatures. A Minireview about FT synthesis over molecular-sieve-supported catalysts was presented by Tao et al.

H_2 has been proposed as a clean energy carrier in the future. Sustainable hydrogen production is a key target in the development of future alternative energy systems for providing a

clean and affordable energy supply. Chen and He presented a comprehensive Review of sustainable H_2 production from biomass by means of three platforms; synthesis gas from biomass gasification, sugars from hydrolysis of biomass and bio-oils from biomass pyrolysis. One-stage efficient hydrogen production with a purity larger than 99% can be realized by sorption enhanced reactions including steam reforming and gasification of biomass derived molecules. General principles of rational design of catalysts with high activity and coking resistance were discussed. A comprehensive Review of catalysis for hydrogen production from logistic fuels was given by Yerga et al. The challenges and progress in steam reforming, partial oxidation, and autothermal reforming of heavy hydrocarbons were discussed. The low durability of the catalysts, attributed to carbon and sulfur poisoning, is the hurdle for any practical application. A Minireview by Liu and his coworkers has summarized the very recent progresses in the design, synthesis, and characterization of coke resistant Ni catalysts for steam and CO_2 reforming of methane. They critically reviewed the effects of identities of metals, promoters, and supports, as well as the preparation methods on carbon formation during methane steam and dry reforming. In the area of hydrogen conversion using fuel cells, an investigation is presented on the structural and compositional changes of catalysts. A trimetallic PtVFe/C catalyst was used for oxygen reduction in a fuel cell for research aimed at a better understanding of factors controlling electrocatalytic activity and stability of carbon-supported multimetallic catalysts.

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