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Functionalized Mesoporous Silica Nanoparticles as Efficient Solid Catalysts for Biomass Conversion

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Seminar Room C, Sousei Hall, Hokkaido University

（創成科学研究棟4階セミナー室C）

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In this presentation, I will introduce the successful synthesis of multi-functionalized mesoporous silica nanoparticles (MSNs) as an effective, reliable, and re-usable solid catalysts for cellulosic and microalgae biomass conversion. For cellulosic biomass conversion, I will introduce our enzyme-assisted catalytic system by using Fe_3O_4 nanoparticle-embedded mesoporous silica nanoparticles as recyclable hosts for immobilization of various enzymes. For the first time, a carboxyl group functionalized mesoporous silica nanoparticles with large pore size of 40 nm were synthesized and used to chemically link cellulase. The proposed cellulase-assisted biocatalyst exhibits a high efficiency (over 80%) of cellulose-to-glucose conversion. In addition, we have demonstrated such enzyme-immobilized Fe_3O_4@MSNs can be used for multi-step cellulose-to-glucose-to-fructose sequent conversion in an aqueous solution. A high fructose yield up to 50%, which is the same yield when using free enzyme, could be achieved. For chemical-assisted catalytic system, we demonstrated the synthesis of MSNs with both acid and ionic liquid groups. Such bi-functionalized MSN solid catalysts have enhanced the production of HMF from fructose dehydration in mild condition using DMSO as solvent. The kinetics study has indicated that our bi-functionalized MSN could accelerate fructose dehydration by reducing activation energy. In addition, we also demonstrated the functionalization of MSN with acid, base, and both acid and base groups. The functionalized MSN-based catalysts have showed enhanced catalytic efficacy toward cellulosic conversion including fructose-to-HMF dehydration, glucose-to-fructose isomerization, and cellobiose-to-glucose hydrolysis. The bi-functionalized MSN enhanced the yields of glucose and HMF directed converted from cellulose, indicating the cooperative catalytic ability. Through the combination of enzyme-assisted and chemical-assisted catalytic systems, various functionalized MSNs were used for a sequent reaction of cellulose-to-glucose-to-fructose-to-HMF with the aim of achieving highest yield of final product. Finally, I will also introduce the application of functionalized MSNs in the production of biodiesel converted from microalgae.

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Kevin Wu received his PhD from The University of Tokyo, Japan, in 2005. From April 2005 to September 2006, he worked on the orientational control of 2D hexagonal mesoporous thin films with Prof. Kazuyuki Kuroda (Waseda University, Japan) as a post-doc. From October 2006 to July 2008, he was in Prof. Victor S.-Y. Lin's group (Iowa State University, U.S.A.) as a post-doc. He was appointed as Assistant Professor at the Department of Chemical Engineering, National Taiwan University, in August 2008. He was promoted as Associate Professor in August 2012. His current research interest is the synthesis of functionalized porous inorganic nanoparticles for biomedical and energy-related applications.