SEMTE seminar

Sustainable Production of Electricity, Valuable Chemicals and Fuels from Biomass-Derived Compounds over Advanced Electrocatalysts

School for Engineering of Matter, Transport and Energy

Dr. Wenzhen Li

Department of Chemical Engineering
Michigan Technological University

abstract

Biomass resources are cheap, abundant, and annually renewable, thus they are expected to play a key role in our future energy landscape. The U.S. DOE has identified the top ten inexpensive, platform compounds or building blocks (i.e. glycerol, levulinlic acid, etc) from biomass. Currently the chief research challenge is to develop cost-effective, green and sustainable approaches to convert these primary building blocks to fuels, chemicals, and energy. My group's recent research on sustainable and efficient production of electrical energy, valuable chemicals and fuels from biorenewable glycerol and levulinic acid over advanced electrocatalysts will be presented. We developed a facile surfactant-free and low temperature process to prepare surface dealloyed PtCo nanoparticles supported on carbon nanotube (SD-PtCo/CNT). The direct crude glycerol (88%, directly from biodiesel manufacturing) anion-exchange membrane fuel cell using the SD-PtCo/CNT anode catalyst (0.5 mg_{Pt} cm^{-2}) achieved a world record peak power density of 268 mW cm^{-2} (at 80 °C and ambient pressure) and decent reaction stability and durability. We discovered that electrocatalytic oxidation of biorenewable polyols to valuable products with a tuneable degree of oxidation can be achieved by varying electric potential. The degree of glycerol oxidation on Au nanoparticles can be tuned with anode potential to produce tartronate (oxidizing two primary –OH, ≥ 0.35 V), mesoxalate (oxidizing three –OH, ≥ 0.45 V), or glycolate (breaking C-C bond, ≥ 0.9 V). This may open a new strategy for the targeted transformation of biomass compounds with poly-alcohol or multi-functional groups into valuable chemicals. We also explored new cost-effective electrocatalytic processes to renewable electricity storage in biofuels, and achieved selective electrocatalytic reduction ***(cont.)***

(abstract cont.) of levulinic acid to high energy-density biofuel intermediates: valeric acid (VA) or γ-valerolactone (gVL) on a non-precious Pb electrode in a single electrocatalytic (flow) cell reactor with high Faradaic efficiency (i.e. >86%) and electricity storage efficiency (i.e. >68%), and low electricity consumption (i.e. 1.1 kWh L_{VA}^{-1}). The applied potential and electrolyte pH have been found to control the reduction products. My future research direction in this area and teaching interest will also be briefly discussed.

biosketch

Dr. Li is a SFHI (strategy faculty hiring initiative) in Sustainability assistant professor in the Department of Chemical Engineering at Michigan Technological University. His research interests are in the areas of catalysis, electrochemical energy, and nanomaterials. Dr. Li has 54 peer-reviewed journal articles with 3600^{+} citations, 6 issued patents, and his h-index is 26. Dr. Li is one of the pioneer researchers who discovered that carbon nanotubes are a better fuel cell catalyst support than conventional carbon black. His current research efforts are to explore novel electrocatalytic processes and develop advanced nanostructured catalysts for sustainable production of electrical energy, valuable chemicals, and hydrocarbon fuels from biomass-derived platform compounds and greenhouse gas CO_2. Dr. Li got his Ph.D. with honors in Chinese Academy of Sciences, and has worked as postdoctoral researcher with Prof. Masahiro Watanabe in University of Yamanashi, and with Prof. Yushan Yan in University of California Riverside.

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