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PROJECT FACTS

UNIVERSITY OF KENTUCKY CENTER FOR APPLIED ENERGY RESEARCH

AUTOMOTIVE-RELATED RESEARCH

Catalysis for Automotive Emission Control

Ongoing work in the Biofuels Group is focused on reducing emissions of nitrogen oxides (NO_x) present in lean exhaust gas, such as that emitted by diesel engines. Several catalytic approaches are under investigation, based on NO_x storage catalysts (NSCs), as well as hybrid systems combining NSCs with ammonia SCR catalysts (SCR = Selective Catalytic Reduction). In addition to the synthesis of novel catalysts, studies are conducted to probe catalyst structure, mode of action and deactivation mechanisms. Research ranges from *in situ* spectroscopic studies to catalyst testing on automated bench reactors and engine dynamometers.

Electrochemical Power Sources

The electrochemistry group is engaged in research and development related to batteries, low-temperature fuel cells and electrochemical capacitors for energy storage and conversion applications. Current research is focused on materials and device development for electro-chemical capacitors and microbatteries. Low-cost, eco-friendly processing routes to prepare energy dense nanoporous carbons for electrochemical capacitors are under development and are being used to build novel asymmetric devices with improved electrochemical performance. Present applications for the asymmetric capacitors are targeted for portable communications and electronics for the US military and energy storage for electric utility grids. Micro-lithium ion battery development is also underway for MEMS (microelectromechanical systems) where template processing is used to fabricate nanostructured materials and novel three-dimensional electrode structures.

Membrane-Electrode-Assemblies for Hydrogen Fuel Cells

The Clean Fuels and Chemicals group at CAER focuses on the development of a new class of electro-catalysts to be used in membrane-electrode-assemblies (MEAs) of a fuel cell stack. Platinum is the most efficient electro-catalyst for accelerating chemical reactions in fuel cells for electric vehicles, yet it is also the most costly part of the fuel cell. For hydrogen fuel cells to become competitive and power the automotives of the future, catalysts in electrodes at CAER are designed to become significantly more active and appreciably more affordable. Our research provides novel mechanisms for catalyst nanoparticle formation and placement. Ongoing studies are conducted to understand the effects of nanostructures on catalyst performance including enhanced surface alloy formation that allows reduction of precious metal use and nanoparticle characteristics that improve oxygen-reducing activity, which can be enhanced based on shape and size dependence at the mole-cular level. The electrodes are tested by our automotive sponsor.

On-Board Hydrogen Production

The Clean Fuels and Chemicals group at CAER works on the refinement of the Water-Gas-Shift (WGS) catalyst system to aid the production of CO-free hydrogen for fuel cell applications. Due to the difficulties associated with hydrogen storage, this clean fuel will likely be generated in the near term on an as-needed basis by re-forming fossil fuels (natural gas, methanol, etc). Reforming hydrocarbons to hydrogen requires numerous steps and several catalyst systems. Our focus is on precious metal ceria catalyst systems for the low-temperature WGS reaction that is employed to reduce CO levels to < 1%. At CAER the formation mechanisms are studied using DRIFTS and XANES to probe the dynamics of the adsorbed species and also explore the redox-properties of the nano-sized ceria. Several platinum and gold on ceria systems, including doped catalysts, are studied and their nano-scale characteristics are determined using high resolution electron microscopy applications.

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