Carsten Sievers obtained his Diplom and Dr. rer nat. degrees in Technical Chemistry at the Technical University of Munich, Germany. Under the guidance of Prof. Johannes A. Lercher he worked on heterogeneous catalysts for various processes in petroleum refining including hydrogenation of aromatics in Diesel fuel, alkylation, alkane activation, and catalytic cracking. Additional research projects included novel catalytic system, such as supported ionic liquids. In 2007, he moved to the Georgia Institute of Technology to work with Profs. Christopher W. Jones and Pradeep K. Agrawal as a postdoctoral fellow. His primary focus was the development of catalytic processes for biomass depolymerization and synthesis of biofuels. He joined the faculty at the Georgia Institute of Technology in 2009. His research group is developing catalytic processes for the sustainable production of fuels and chemicals. Specific foci are on the stability and reactivity of solid catalysts in aqueous phase, surface chemistry of oxygenates in water, applied spectroscopy, physicochemical characterization of solid materials, synthesis of well-defined catalysts, methane conversion, pyrolysis, and gasification. He is President of the Southeastern Catalysis Society and Program Chair of the ACS Division of Catalysis Science & Technology.

Development of Heterogeneous Catalysts for Removing Oxygen from Biomass-Derived Compounds

The conversion of biorenewable feedstocks to value-added chemicals and fuels is one of the great challenges in modern chemical engineering. Since biomass contains much more oxygen than most chemicals and fuels, it is critical to develop processes for removing oxygen containing functional groups. Catalysts will play a critical role in most of these processes because they are critical for providing the required selectivity to certain products. Specific reactions for oxygen removal include hydrodeoxygenation (HDO), dehydration, condensation, and ketonization. This talk will highlight two studies on the development of catalysts for such reactions.

HDO is a promising route for converting complex mixtures of oxygenates in bio-oils to biofuels. The process provides oils with reduced reactivity and corrosiveness and increases the energy density of the product. In HDO, oxygen-containing functional groups are replaced by hydrogen, and water is formed as a by-product. This process can be performed over sulfided NiMo or CoMo catalysts. However, co-feeding of toxic H2S is required to keep these catalysts in their active sulfide phase under HDO conditions. To avoid the use of H2S, our group developed reducible ceria-zirconia catalysts that are capable of promoting similar surface reactions. The active sites on these catalysts are oxygen defects, which are formed in the presence of H2 under typical reaction conditions (250 – 400 °C). The formation of oxygen defects and the availability of dissociatively adsorbed hydrogen are studied in detail to identify the most promising catalysts. These catalysts are used for HDO of guaiacol.

Selective dehydration can be used to produce specific chemicals from biorenewable feedstocks. The dehydration of glycerol to acrolein is a particularly promising process because large amounts of glycerol are produced as a by-product of bio-diesel. In this talk, dehydration of glycerol over niobia catalysts with different concentrations of Brønsted and Lewis acid sites will be described. Important surface species are identified by in-situ IR spectroscopy, and it is shown how different acid sites affect different dehydration paths and the formation of coke.