

Synthesis, characterization, and the fundamental interrogation of novel catalytic materials for industrial and energy applications

Sheima J. Khatib

Department of Chemical Engineering, Virginia Tech

Abstract

Catalysts are substances that accelerate the rates of chemical transformations without themselves being consumed in the reactions, and thus represent an economical means of manufacturing products. They are used widely in the fuels, chemicals and pharmaceutical industries, as well as in environmental applications to reduce ambient contamination. One of the important roles of catalysis is related to energy. Catalysis makes processes more energy efficient, transforms energy sources into useful forms and reduces or eliminates harmful emissions from energy use. Catalysis is therefore key to achieving a cleaner world and a sustainable future.

One of the major challenges for catalysis science research is to understand the fundamental role that catalyst structures play on the catalytic activity and selectivity at the atomic level. Meeting this challenge allows the rational design of catalyst structures that control the selective activation of specific bonds in multifunctional reactants producing the desired products with minimal energy use. Various studies focused on understanding the structure-activity relationship in heterogeneous inorganic catalytic systems used in industrially relevant processes will be presented.

To produce real world catalysts that respond to the specific demands in industry, it is essential to combine the fundamental atomic-scale understanding of the catalytic processes with reactor engineering science. Membrane reactors are a particularly interesting system to use in catalytic processes. In a membrane reactor, chemical reaction and product purification by separation occur simultaneously by combining the reaction chamber with the selective membrane, thus combining separate processes into one stage. This results in compactness, cost reduction in equipment and maintenance, simplified separations and easier heat management. Results on the study of hydrogen separating palladium membranes will be presented and their potential application in membrane reactors for catalytic hydrogen production in future studies will be discussed.