Abstract

The development of effective routes to clean energy production and air pollutant elimination is important for energy and environmental sustainability. Catalysis plays a central role in establishing such routes, but a major challenge is the design and preparation of active, robust and low-cost catalysts for the targeted catalytic reactions. In this dissertation work, recent findings in our investigations of the design, synthesis, and characterization of nanoalloy catalysts for several industry-important reactions will be discussed. One example involves probing the catalytic oxidation of carbon monoxide over Pd and Pt based multimetallic nanoalloy catalysts on different supports. This study aims at establishing the correlation among the nanoscale phase structures, the nanoparticle composition, the chemical nature of support, and the surface catalytic sites of the catalysts during the catalytic reactions such as CO oxidation and propane oxidation. In particular, we focus on detecting and monitoring the nanoscale evolution of surface catalytic sites by probing the chemical and intermediate species on the catalysts in correlation with the bimetallic composition and the alloying phase structure. Advanced and analytical techniques such as synchrotron high-energy X-ray diffraction coupled to atomic pair distribution function analysis and diffuse reflectance infrared Fourier transform spectroscopy are employed for in-situ characterizations of the nanocatalysts. The results, along with computational modeling, have provided new fundamental insights into the design and of highly-active and stable nanocatalysts for the targeted reactions towards achieving energy and environmental sustainability.