



PROJECT FACTS

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CLEAN FUELS & CHEMICALS

Ethanol Reforming for Producing Pure H₂ for Fuel Cell Applications

The light alcohol ethanol is an important candidate as a chemical carrier for hydrogen for use in mobile polymer electrolyte membrane (PEM) fuel cell applications. Not only is it less hazardous than methanol, but it can be produced by fermentation of a variety of biomass carbohydrate sources (e.g., sugar cane), and could conceivably lead to decreases in CO₂ emissions. However, the major drawback of ethanol relative to methanol is that, since it contains a C-C bond, this introduces additional elements of complexity when designing catalysts for reforming ethanol. Although the mechanisms of methanol and ethanol reforming contain certain similar features, replacing -H with -CH₃ presents a significant complication from the standpoint of catalyst stability. CAER and INT have examined several catalytic ethanol conversion reactions, including direct decomposition, steam reforming, partial oxidation, and oxidative steam reforming.

At the heart of catalytic reforming reactions is the surface mechanism. Over the past three years, CAER and INT has made good progress in developing understanding regarding surface reaction pathways, as well as harnessing the likely intermediates involved in the catalysis of metals, metal oxides, and most recently, novel bifunctional catalysts that rely on interfaces formed between a metal and an active oxide. CAER and INT are employing techniques such as temperature programmed desorption and infrared spectroscopy to shed light on these pathways, and have recently published a number of case studies to demonstrate the power of infrared spectroscopy for studying ethanol reforming catalysts, and show precisely what kinds of information can be gleaned using the technique.

While understanding of the fundamental mechanism is important, the greatest challenge facing catalyst developers today is improving catalyst stability. There are many different ways that carbon deposits may form during ethanol reforming and the nature of carbon depends on both the type of metal present (e.g., base metals like Co or noble metals like Pt) and the reaction conditions used (e.g., feed and temperature). CAER and INT have investigated strategies to either hinder carbon formation or react it from the surface once formed. These include not only modifications to the catalyst itself (e.g., adding active oxide components like ceria, zirconia, or mixed oxides to increase the surface fugacity of oxygen or alloying the metal component to hinder carbon formation by ensemble control), but also adjusting feed ratios to favor the removal of carbon from the surface (e.g., co-feeding O₂).