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Electronic Effect of Platinum Alloy Catalysts on Olefin Hydrogenation Kinetics

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ABSTRACT

Dehydrogenation of alkanes is the first step in transforming light hydrocarbons into liquid fuels and chemicals. This process has traditionally used platinum alloys as catalysts. Alloys are used industrially because they have a greater selectivity than monometallic platinum. Alloying platinum with an inactive promoter modifies the crystalline structure of the surface (geometric effect), and the 5d electrons in platinum responsible for chemistry (electronic effect); both have been suggested to be primarily responsible for dehydrogenation selectivity in platinum alloys. Alloy catalysts have been synthesized using early 3d transition metal promoters with the same Pt_3M crystal structure. X-Ray Absorption Spectroscopy (XAS) was used to quantify the electronic changes between the different catalysts and platinum. Reaction orders and activation energies for the hydrogenation of ethylene were collected to quantify how the electronic effect modifies the kinetics of a structure insensitive reaction. Comparing the results of platinum and the alloys, we found that these promoters' electronic effect had a significant effect on the apparent kinetics of the reaction. The implications of these results on selectivity of platinum alloys for dehydrogenation are discussed.

KEYWORDS

Energy, catalysis, shale gas, alkane transformation, paraffin, olefin, hydrogenation, dehydrogenation