

Monometallic and highly-diluted bimetallic catalysts based on Pt and Cu for the selective transformation of furfural

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ΠΕΡΙΛΗΨΗ

Introduction: The utilization of biomass for the co-production of sustainable fuels and chemicals has the power to transform global energy and materials markets. This necessitates the development of new catalytic processes capable of selectively transforming highly functionalized organic molecules into either alternative 'drop in' chemical intermediates and fuels, or entirely to products with novel properties. Here we investigate the selective hydrogenation of furfural to furfuryl alcohol under extremely mild reaction conditions over monodisperse Pt, Cu and Pt/Cu nanoparticles supported on a variety of solid oxide supports.[1] The results are compared with temperature programmed desorption (TPD) and scanning tunnelling microscopy (STM) studies of furfural in the presence of H₂ on a Pt(111) extended surface.[2] Finally we report recent results on the reactivity of furfural on highly diluted alloy nanoparticles and Single Atom Alloys (SAA)[3] based on Pt/Cu.

Findings: The platinum catalysed liquid phase hydrogenation of furfural was studied over five different oxide supports (SiO₂, ZnO, Al₂O₃, MgO and CeO₂) as a function of solvent and temperature. Furfural hydrogenation was found to be sensitive to Pt particle size, with those of approximately 4 nm being highly active and selective for the hydrogenation reaction in methanol, even at 50 °C, whereas smaller Pt nanoparticles promote decarbonylation to furan. Solvents such as ethanol favour the formation of undesired acetal side products through reaction with furfural at 70 °C.[1]

Our work on Pt(111) further demonstrated a coverage/adsorption geometry dependent reactivity of furfural. Clean Pt(111) leads to the decomposition and decarbonylation of furfural to produce surface carbon and furan respectively. However, pre-adsorbed H on Pt(111) minimizes the decomposition of furfural and the formation of furan while promoting the formation of furfuryl alcohol and methyl furan.[2] Hydrogenation reactions were also carried out on bimetallic PtCu/Al₂O₃ catalysts with varied metal ratios. Characterization of Pt/Cu materials shows the presence of a PtCu₃ mixed metal phase which has a pronounced effect in the catalytic activity of the metal nanoparticle. Dilution of Pt content with Cu leads to a synergistic effect which facilitates the hydrogenation reaction with high conversion and selectivity. Reactions on SAAs show that Pt content can be lowered to a critical point and exhibit high rates of reaction after a surface oxide reduction period.

Conclusions: 1. Furfural can be selectively hydrogenated under mild temperature and H₂ pressure on a variety Pt based catalysts. The reaction is sensitive on Pt particle size, temperature and solvent. 2. Work on Pt(111) shows that the reaction strongly depends on the adsorption geometry of the reactant molecule. 3. Highly diluted Pt/Cu alloys offer an effective alternative for the hydrogenation of furfural in terms of activity and selectivity towards furfuryl alcohol.

ΒΙΒΛΙΟΓΡΑΦΙΑ

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