63g Adsorption Microcalorimetry Investigation of Nanocrystalline Mixed Metal Oxides

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Nanocrystalline oxides are potential catalysts that are higher in surface area than oxides prepared from more traditional techniques, where a larger portion of this increased surface area is external to the particle, rather than internal as for porous catalysts. In addition to an increased surface area, a higher concentration of surface defect sites results in stronger adsorption sites that can be active for reactions requiring strong surface acidity and/or basicity. A majority of these advantages come from the fact that the smaller particle size significantly affects the local structure, and therefore the surface chemistry, of the oxide material.

We have prepared pure oxides of MgO and Al_2O_3, and binary mixtures thereof containing various Mg:Al ratios, in order to investigate the adsorption properties of carbon dioxide and ammonia to probe the surface basicity and acidity, respectively. On a per-mass basis, the nanocrystalline prepared materials were found to have up to four times the number of adsorption sites compared to oxides of similar composition prepared using more traditional co-precipitation techniques. In addition, the nanocrystalline catalysts exhibited stronger adsorption sites for both CO_2 and NH_3, indicating the presence of stronger acid and base sites on the nanocrystalline surface. The surface of the nanocrystalline mixed metal oxides were further modified via the deposition of various acetylacetonates (such as sodium, potassium, copper, and aluminum) in order to produce catalysts containing supported surface oxides. The decomposition of 2-propanol and cycloaddition of CO_2 to propylene oxide were used as probe reactions in order to determine the effect of catalyst composition on surface acidity and basicity. The relationships between reactivity and acido-basic character of the catalyst surface will be discussed.