PLATINIZED TIN OXIDE: A LOW-TEMPERATURE OXIDATION CATALYST

ERIK J. KIELIN

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Advisor: Floyd Klavetter, Assistant Professor of Applied Science

Abstract

Some combinations of a noble metal with a reducible metal oxide, an NMRO catalyst, possess a synergistic level of activity for the catalytic oxidation of CO at lower temperatures and partial pressures of O_2 than can be obtained by either component alone. These properties make NMRO catalysts candidates for use in recycling of CO_2 laser gas, purification of breathing air in enclosed spaces, purification of compressed air and other oxygen-containing gases, CO removal from automobile emissions during cold start, personal safety masks, and selective chemical sensors. The activity for the reaction between CO and O_2 on a variety of noble metal-metal oxide combinations was measured. The most promising candidates, Au on MnO_2 and Pt on SnO_2, were investigated for the effects on activity of noble metal loading, of reductive pretreatment at elevated temperature, and of reaction gas mixture composition. Optimum activity was obtained at 28% Au/MnO_2 and 17% Pt/SnO_2. Both catalysts benefited from reductive CO pretreatment at 125øC while showing no change in activity from pretreatment in He or O_2 in He. Both catalysts showed enhanced activity when the reaction gas mixture contained excess O_2, and both were inhibited somewhat by excess CO. Au/MnO_2 was severely inhibited by CO_2 in the reaction gas mixture whereas Pt/SnO_2 showed no inhibition by CO_2. A method for coating Pt/SnO_2 onto various substrates was developed. The SnO_2 layer was applied to the substrate via thermal decomposition of tin (II) 2-ethylhexanoate, SnEH. The decomposition of SnEH was followed using DRIFTS. The effects of surface area and pore size distribution of both substrate and of the SnO_2 layer on the CO oxidation activity of the final catalyst coating were investigated. Low-surface area, high-pore diameter substrates provided the highest activity catalyst coatings. The activity also increased as the total SnO_2 loading and surface area were increased. Activity correlated with total Pt and SnO_2 surface areas. Small amounts of H_2O in the reaction gas mixture enhanced the low-temperature, CO-oxidation activity over Pt/SnO_2; large amounts eliminated the activity unless the catalyst was mildly heated. The activity-enhancing effect of water is due, in part, to the formation of surface hydroxyl groups. Hydroxyl groups may function in the dissociative adsorption of O_2 or as oxidizing agents themselves. Silylation of the hydroxyl groups of Pt/SnO_2 destroyed the CO-oxidation activity. Changes in the catalyst surface from silylation were analyzed using DRIFTS. In addition, molecular water enhances the activity by aiding in the breakdown of surface-bound CO_2 consistent with the creation of more acidic sites on SnO_2 with the addition of H_2O. The conversion of formaldehyde, acetaldehyde, and the C1 to C_3 alcohols over Pt/SnO_2 was investigated and compared to that over Pt. Differences in product mixtures were attributed to the presence of higher concentrations of surface oxygen provided by SnO_2. The oxidation of the C1 to C5 hydrocarbons to CO_2 and H_2O over Pt/SnO_2 was found to occur at significantly lower temperatures than reported for noble metal catalysts. The reduced temperature was attributed to the presence of SnO_2. Mechanisms are discussed.