PLATINIZED TIN OXIDE: A LOW-TEMPERATURE OXIDATION CATALYST

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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 O2 than can be obtained by either component alone. These properties make NMRO catalysts candidates for use in recycling of CO2 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 O2 on a variety of noble metal-metal oxide combinations was measured. The most promising candidates, Au on MnO2 and Pt on SnO2, 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/MnO2 and 17% Pt/SnO2. Both catalysts benefited from reductive CO pretreatment at 125°C while showing no change in activity from pretreatment in He or O2 in He. Both catalysts showed enhanced activity when the reaction gas mixture contained excess O2, and both were inhibited somewhat by excess CO. Au/MnO2 was severely inhibited by CO2 in the reaction gas mixture whereas Pt/SnO2 showed no inhibition by CO2. A method for coating Pt/SnO2 onto various substrates was developed. The SnO2 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 SnO2 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 SnO2 loading and surface area were increased. Activity correlated with total Pt and SnO2 surface areas. Small amounts of H2O in the reaction gas mixture enhanced the low-temperature, CO-oxidation activity over Pt/SnO2; 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 O2 or as oxidizing agents themselves. Silylation of the hydroxyl groups of Pt/SnO2 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 CO2 consistent with the creation of more acidic sites on SnO2 with the addition of H2O. The conversion of formaldehyde, acetaldehyde, and the C1 to C3 alcohols over Pt/SnO2 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 SnO2. The oxidation of the C1 to C5 hydrocarbons to CO2 and H2O over Pt/SnO2 was found to occur at significantly lower temperatures than reported for noble metal catalysts. The reduced temperature was attributed to the presence of SnO2. Mechanisms are discussed.