



BIOFUELS & ENVIRONMENTAL CATALYSIS

PROJECT FACTS

UNIVERSITY OF KENTUCKY
CENTER FOR APPLIED ENERGY RESEARCH

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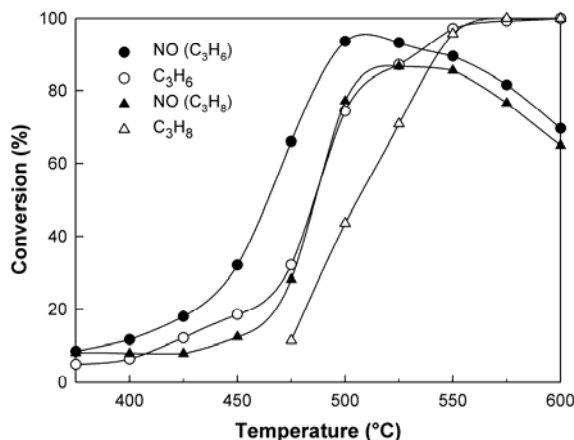
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Development of New Catalysts for NO_x Emission Control Based on Bismuth Oxide

Although Selective Catalytic Reduction (SCR) using ammonia has proven to be highly effective for NO_x removal from stationary emission sources, safety and distribution issues surrounding the use of ammonia for mobile applications have led to major efforts to develop SCR catalysts capable of utilizing organic reductants such as hydrocarbons. Ideally, this would enable the use of on-board diesel fuel as the NO_x reductant.

Prior to this study, there were no reports concerning the properties of bismuth oxide in NO_x reduction. We reasoned that the mild oxidizing characteristics of bismuth oxide might be beneficial in hydrocarbon SCR, favoring NO_x reduction over total oxidation of the hydrocarbon reductant. Indeed, we find that bismuth oxide supported on alumina shows significant NO_x reduction activity using propene or propane as the reductant, albeit that relatively high temperatures are required (~450-600 °C; see figure). Optimum SCR activity is observed for sol-gel catalysts at bismuth loadings of 3-7 wt%, XRD and XPS measurements showing that the bismuth oxide in these catalysts exists as a highly dispersed phase. This suggests that highly dispersed BiO_x species are able to use hydrocarbons efficiently for NO reduction, in contrast to larger bismuth oxide clusters that display increased activity for hydrocarbon combustion. In this respect the behavior of Bi₂O₃/Al₂O₃ parallels that of other metal oxide catalysts such as In₂O₃/Al₂O₃ and Ga₂O₃/Al₂O₃.



Comparison of NO reduction over Bi₂O₃/Al₂O₃ (Bi = 5 wt%) using propene and propane as reductants (C₃H₆/NO = 2.63, C₃H₈/NO = 2.53)

For Bi₂O₃/Al₂O₃ catalysts, *in situ* DRIFTS studies indicate the existence of surface acetate, nitrate and nitrite species under SCR conditions (using propene as reductant). DRIFTS data also suggest the intermediacy of organo-nitrite and/or organo-nitrate species in the NO_x reduction process, as well as isocyanate. The formation of organo-nitrite intermediates is further supported by reactor data showing increased levels of NO₂ formation at low temperatures (relative to that expected from NO oxidation alone), consistent with the decomposition of an organo-nitrite species. Overall, these observations support a reaction scheme in which adsorbed NO_x reacts with propene oxidation products (e.g., acetate), to form organo-nitrogen compounds which undergo progressive reduction to N₂.