Single and Bi-metallic Silver Modified ZSM-5 for HC-SCR

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The emission of nitrogen oxides (NO_x) from internal combustion engines is one of the biggest environmental problems nowadays. The waste gases from traditional gasoline engines can be purified successfully by three-way catalysts, which operate under stoichiometric conditions. However, the more efficient diesel and lean-burn engines emit gases with a large excess of oxygen, which so far cannot be purified effectively from NO_x.

The selective catalytic reduction by hydrocarbons (HC-SCR) is an elegant technique for the abatement of NO_x emissions from lean-burn vehicles. In this method the unburned hydrocarbons in combination with added ones are used to reduce NO_x in the exhaust gases over a suitable catalyst. A catalytic system on the basis of silver supported on alumina, shows extremely high NO_x into N_2 conversion (maximum conversion of 90% at 450^{o}C) in large excess of oxygen (6 vol.%) and water (12 vol.%), i.e. under real lean-burn conditions with low sulphur containing diesel fuel. However, a drawback of the Ag/alumina catalyst is its poor catalytic activity at low temperatures (below 300^{o}C) and the strong CO formation during the conversion of NO_x with a maximum value at 450^{o}C. A combination of Ag/alumina with commercial platinum oxidation catalyst for CO removal at a 33 mm distance resulted in a decrease of NO_x conversion by about 20% at 450^{o}C. For that reason single and bi-metallic silver modified ZSM-5 catalysts, which has both oxidation and reduction activity were synthesized using three different methods of preparation, characterized by several techniques and tested in simulated diesel conditions. Additionally the catalytic behavior of the most active catalyst, containing 5 wt.% Ag and prepared by impregnation (5Ag(Imp)-H-ZSM-5), was studied over a broad temperature range with two reducing agents (octane and propene). To correlate the catalytic activity of the prepared catalysts with preparation parameters the materials were characterized by XRD, SEM, N_2-physisorption, octane/propene-TPD, EPR and ICP techniques. A dual bed system consisting of Ag/alumina and the most active zeolitic material (5Ag(Imp)-H-ZSM-5) was shown not only to substantially enhance the activity of Ag/alumina in the low temperature region (below 300^{o}C), but also to completely oxidize the produced CO and unburned hydrocarbons. These two important features of the zeolite catalyst suggest it as a competitive candidate to replace the expensive noble metal based oxidation catalysts, which only oxidizes the produced CO and unburned hydrocarbons and decreases the high NO_x reduction activity of the Ag/alumina.