POLSKIE TOWARZYSTWO MINERALOGICZNE – PRACE SPECJALNE
MINERALOGICAL SOCIETY OF POLAND – SPECIAL PAPERS
Zeszyt 22, 2003; Volume 22, 2003

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SMECTITES AS CATALYSTS FOR REMOVAL OF AIR POLLUTANTS

INTRODUCTION

The most promising technologies designed for the removal of gaseous air contaminations are based on catalytic processes aimed at conversion of the hazardous pollutants to harmless or easily trappable products. The present work demonstrates that smectites can be successfully used for manufacturing of catalysts active in the abatement of toxic air pollutants.

EXPERIMENTAL

Ti-pillared montmorillonite was obtained by the method of Sterte (1986). Vanadium dopant was introduced by cation exchange. Selective catalytic reduction of NO with NH_3 was carried out in a flow microreactor, at 1000 ppm NO, 1000 ppm NH_3, 2% O_2 diluted with He. Details of the preparation procedure and catalytic testing are given in Bahranowski et al. (1997). Zr-pillared montmorillonite was obtained by the method of Yamanaka and Brindley (1979). Palladium was introduced by impregnation. Catalytic combustion of trichloroethylene (TCE) was carried out in a flow microreactor, at 2g/m^3 TCE in air. Details of the preparation procedure and catalytic testing are given in Bahranowski et al. (2003).

RESULTS AND DISCUSSION

The most widespread commercial catalyst used for removal of nitrogen oxides (deNOx) is based on mixed vanadia/titania system. In view of this, a deNOx catalyst based on titania-pillared montmorillonite doped with vanadium has been designed (Bahranowski et al., 1997). ESR investigation of the catalysts obtained in such a way demonstrated that V centres were anchored to the titania pillars (Bahranowski et al., 1993). In the selective catalytic reduction of NO by ammonia toxic gases become converted to harmless products:

$$NO,\ NH_3 \xrightarrow{O_2} N_2,\ H_2O$$

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Pillared catalysts proved very active in this reaction. To check on the quantum size effects of V deposition onto nanometer size pillars the activity of the best clay catalyst, containing 3.4 wt.% V, was compared with that of the material prepared by deposition of 1 monolayer of V on a conventional TiO_2 support (Fig. 1).

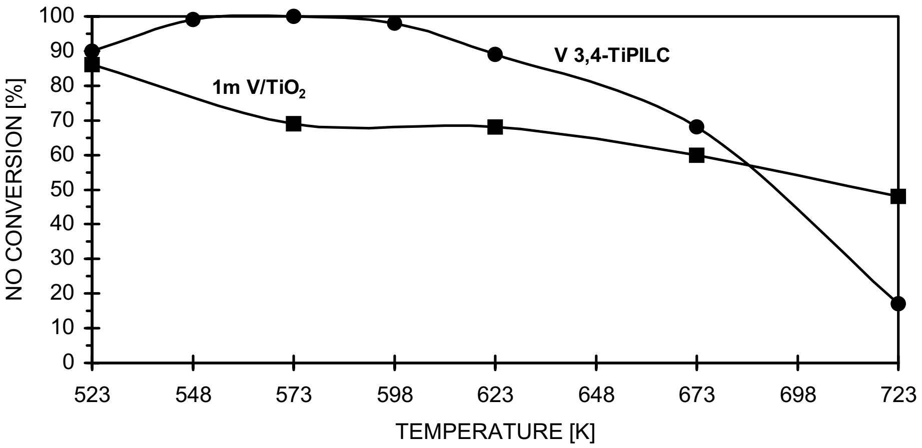

Fig. 1. Catalytic activity (%NO conversion) in NO SCR by ammonia of V-doped Ti-pillared clay catalyst (V3.4-TiPILC) and reference conventionally prepared sample (1m V/TiO_2)

It turned out that in a broad temperature range the pillared sample was more active than the reference material, reaching 100% of NO conversion unattainable with the other catalyst. The results showed clearly, that the deposition of vanadium on titania pillars led to novel systems of properties different from those of the reference material prepared by a conventional way.

Chlorinated volatile organics belong to the most frequently used industrial solvents, hence their significant contribution to the air pollution. Catalytic destruction of these contaminants consists in their combustion to carbon dioxide, water vapour and easily trappable hydrogen chloride. Thus, for trichloroethylene (TCE) the desired outcome of catalysis is:

$$C_2HCl_3 \xrightarrow{O_2} CO_2,\ H_2O,\ HCl$$

Frequently, however, unwanted products, such as chlorine, evolve as well. The reaction mechanism requires that the catalyst possesses both the acid and the redox centres. For this reason the clay catalyst has been designed, which combined the acidity of Zr-pillared montmorillonite with redox properties of the Pd dopant. Zirconia pillars were also considered stable enough to withstand exposure to HCl formed during the catalytic reaction. To assess the performance of the clay catalysts the catalytic results have been related to the performance of an industrial catalyst used for abatement of chlorinated organics (Fig. 2). The Pd0.4-ZrPILC catalyst (0.4 refers to the wt.% of Pd) turned out much better than the industrial reference. 100% of TCE combustion is reached at temperature by 100 degrees lower than on the reference sample, a factor of immense importance in terms of energy saving. Also, on clay catalyst HCl is the main Cl-containing product, while the industrial catalyst produces significant amounts of undesired chlorine.

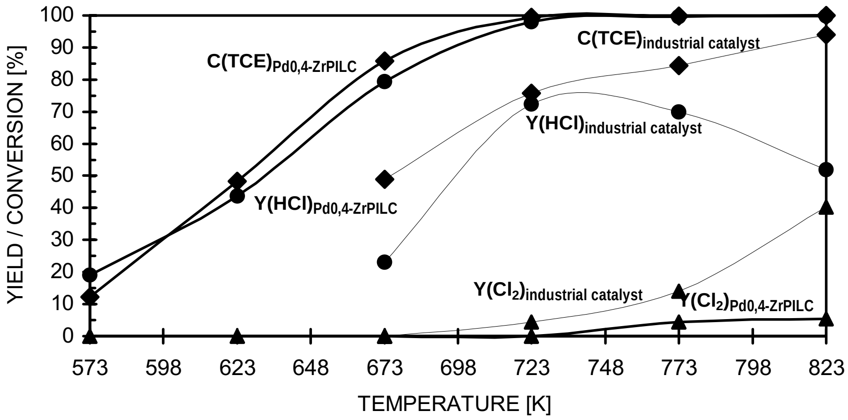

Fig. 2. Activity (C - %TCE conversion) and yield (Y) of HCl and Cl_2 in TCE combustion over Pd0.4-ZrPILC (thick lines) and industrial catalyst (thin lines).

CONCLUSIONS

Catalysts based on modified smectites show excellent properties in the catalytic removal of nitrogen oxides and chlorinated volatile organics.

Acknowledgement: This work was financed in part by the Polish Committee for Scientific Research within the research project No. 6 P04D 007 21.

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