

A effect of H₂-H₂O pre-treatment over Pd catalyst for VOCs removal

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Introduction

Volatile Organic Compounds (VOCs) in industrial gas represent a serious environmental problem. Catalytic oxidation is an effective solution for reducing the emissions of VOCs. In this way, two kinds of catalysts are usually applied: (i) noble metal based solids which possess high activity but are expensive and (ii) metal oxides based samples which are cheaper but less active [1-2]. Supported noble metals as Pt and Pd are well established as efficient catalysts for the oxidation of different VOCs [3-4]. Moreover, among the noble metals, ‘‘Pd’’ is often more active than ‘‘Pt’’ for oxidation [5].

In this study, the promotion of Pd/ γ -Al₂O₃, Pd/TiO₂ catalysts for the oxidation characterization of VOCs using Ru and Ir promoter with H₂ and H₂O treatment was used.

Materials and Methods

Monometallic Pd and bimetallic Pd-Ir, Pd-Ru were supported to γ -Al₂O₃, TiO₂. In order to distribute metals uniformly, H₂ and H₂O treatment technique was used. Toluene, Xylene and MEK were used as reactants. The monometallic and the bimetallic catalysts were prepared by the excess wetness impregnation method and characterized by XPS, BET, XRD, and TEM analysis.

The conventional catalyst had low activity below 200 °C; precisely the desired operating condition. The H₂ and H₂O treated catalyst had much higher activity and selectivity from room temperature all the way to 200 °C. This has been repeated many times with the only difference in the catalysts being the addition of water (to incipient wetness) during the reduction step. We have since found that the H₂ and H₂O treated catalyst has much smaller (~2 nm) and more stable Pd particles on the surface of the titania with higher H₂ spillover related to the higher selective CO oxidation activity. In addition, the H₂ and H₂O pre-treatment can redisperse successfully the sintered Pd particles with activity.

The catalytic oxidations were carried out using a conventional fixed bed flow reactor. The catalytic reactor consisted of a vertical tubular of 1/2 inch diameter in an electrical heating system controlled by a proportional integral derivative (PID) controller. To get the accurate measurement of the catalyst temperature, a K type thermocouple was positioned in the catalyst bed. For accurate and stable controlling the gas flow rates, mass flow controllers (Bronkhost Co, Netherland) were used. The concentration of reactants was 2000 ppm, controlled by the temperature of the saturator and mixed with another gas stream. The catalytic activities of the selected samples were examined in the temperature range of 150–300 °C with an interval of 30 °C. Experimental data was collected after a steady state. The concentration of inlet and exit gas stream was measured using a gas detector ppbRAE plus model (RAE systems, USA) and GC-17A model (Shimadzu), simultaneously.

Results and Discussion

As a result, Pd-Ir, Pd-Ru bimetallic catalysts showed higher conversion than Pd monometallic ones. Pd-Ru bimetallic catalyst showed highest conversion on the TiO₂ supporter. After H₂ and H₂O treatment, the VOCs conversion of catalysts were higher than that of non-

treated ones on the γ -Al₂O₃, TiO₂ supporter. Pd-Ir, Pd-Ru bimetallic catalyst showed higher activation and conversion by 95% at low temperature(210 °C) on the γ -Al₂O₃ supporter.

The peak of Pd3d_{5/2} shifted negative on non-treated catalysts. The important role of H₂ and H₂O treatment was prevent from agglomeration of noble metal and transformation to metallic site. H₂ and H₂O treatment effected on of Pd particles with uniform distribution.

In the kinetics, VOCs oxidation was appeared on the apparent first order reaction. The activation energy of H₂ and H₂O treatment catalysts were a little lower than that of non-treated ones on the γ -Al₂O₃, TiO₂ supporter.

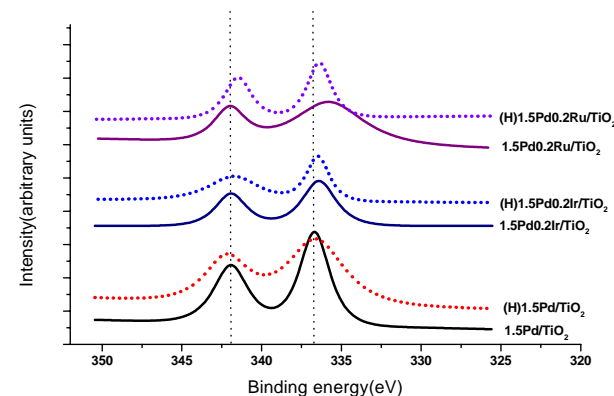


Figure 1. XPS spectra of Pd3d from the aged catalysts. (H: H₂ and H₂O treatment catalysts)

Significance

In this study, Pd-Ir, Pd-Ru bimetallic catalysts promoted oxidation conversion of VOCs. In addition to, the catalyst on the γ -Al₂O₃, TiO₂ supporters with H₂ and H₂O treatment promoted oxidation conversion of VOCs. The important role of H₂ and H₂O treatment was preventing from agglomeration of noble metal and transformation to metallic site.

References

1. P. Ge'lin, M. Primet, *Appl. Catal. B* 39, 1 (2002)
2. T. Maillot, C. Solleau, J. Barbier, D. Duprez, *Appl. Catal. B* 14, 85 (1997).
3. P. De'ge', L. Pinard, P. Magnoux, M. Guisnet, *Appl. Catal. B* 27, 17 (2000)
4. J. Carpentier, J.-F. Lamonier, S. Siffert, E.A. Zhilinskaya, A. Aboukai'rs, *Appl. Catal. A* 234, 91 (2002)
5. J.R. Gonzalez-Velasco, A. Aranzabal, J.I. Gutie'rrez, R. Lopez-Fonseca, M.A. Gutie'rrez-Ortiz, *Appl. Catal. B* 19, 189 (1998)
6. I. H. Son., A. M. Lane., *Catal letters*, 76, 3-4 (2001)