

# Influence of vanadia monolayer coverage on structure-functional relationships of powder and monolith SCR catalysts prepared on commercial titania supports

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## Introduction

For stationary applications,  $V_2O_5$ - $WO_3$ /TiO<sub>2</sub> is widely used as a catalyst for the selective catalytic reduction (SCR) of NO<sub>x</sub> using NH<sub>3</sub> as the reductant.<sup>1</sup> This catalyst is well known for its high SCR activity, thermal stability and resistance towards poisoning by SO<sub>2</sub>.<sup>1</sup> Much attention has been given to understanding the role of  $V_2O_5$  monolayer coverage on  $V_2O_5$ /TiO<sub>2</sub> catalyst using either P25 titania or in-house made anatase titania support<sup>3,5</sup>. On the other hand, less attention has been given to understand: 1) the effect of vanadia coverage on powder and monolith  $V_2O_5$ - $WO_3$ /TiO<sub>2</sub> catalysts using various types of commercially available titania, and 2) the relationship between surface properties (acidity and reducibility of vanadia species) and SCR activity of  $V_2O_5$ - $WO_3$ /TiO<sub>2</sub> at different  $V_2O_5$  coverages.

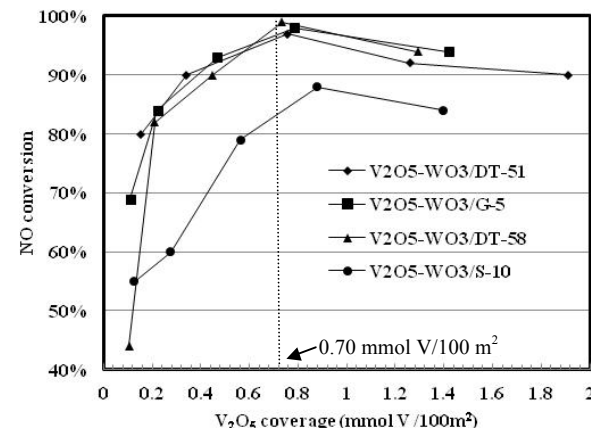
In this work, powder and monolith  $V_2O_5$ - $WO_3$ /TiO<sub>2</sub> catalysts with different  $V_2O_5$  loadings were prepared to achieve monolayer coverage on several types of commercial titania. The SCR activity of these catalysts was evaluated as a function of vanadium coverage. The catalysts were characterized by temperature programmed desorption of NH<sub>3</sub>, temperature programmed desorption of methanol, temperature programmed reduction by hydrogen, oxygen chemisorption, N<sub>2</sub> adsorption measurements and powder X-ray diffraction to describe the surface and structural properties. A good correlation between redox sites and SCR activity for powder and monolith V-W/TiO<sub>2</sub> catalysts was found.

## Materials and Methods

Powder and monolith  $V_2O_5$ - $WO_3$ /TiO<sub>2</sub> catalysts were prepared using Degussa P25, and Millennium DT-51, G-5, DT-58 and S-10. To achieve monolayer coverage on powder and monolith catalysts, a range of  $V_2O_5$  loadings from 1 to 8 %wt. was examined. The loading of WO<sub>3</sub> was 9 %wt. in all samples. Powder catalyst samples were prepared by co-impregnation using ammonium metavanadate and ammonium tungsten oxide hydrate dissolved in a solution of warm oxalic acid and deionized water. The samples were dried at room temperature overnight, then at 120 °C for 6 hr and subsequently calcined at 500 °C for 5 hr. Monolith samples were prepared by adding ammonium metavanadate and oxalic acid solution into titania, ammonium metatungstate hydrate, glass fiber, bentonite, K4M and Ucar. Material was then extruded into a monolith form. The resulting monolith dried overnight and subsequently calcined at 500 °C for 5 hr in air. The SCR activity screening was carried out in a fixed bed reactor at 350 °C at atmospheric pressure using GHSV= 85,700 h<sup>-1</sup>. The simulated flue gas containing NO=400 ppm, NH<sub>3</sub>=400 ppm, CO<sub>2</sub>=14 %v and O<sub>2</sub>=6 %v balance with N<sub>2</sub> was used for the activity screening. The total flow used for the test was 1 L.min<sup>-1</sup>.

## Results and Discussion

The activity screening of powder  $V_2O_5$ - $WO_3$ /TiO<sub>2</sub> catalysts was evaluated and the results are shown in **Figure 1**. NO conversion initially increased with  $V_2O_5$  coverage and reached a maximum approximately at 0.70 mmol V/100 m<sup>2</sup> vanadia coverage, decreasing at higher coverage. This information was used to investigate the effect of  $V_2O_5$  coverage of monolith  $V_2O_5$ - $WO_3$ /TiO<sub>2</sub> catalysts on the SCR activity. In the case of monolith catalysts, NO conversion initially increased with  $V_2O_5$  coverage and reached a maximum approximately at 0.47 mmol V/100 m<sup>2</sup> vanadia coverage, decreasing at higher coverage (not shown here). The decline in the SCR of monolith catalyst at higher vanadia coverage was similar to those powder catalysts. Spectroscopy data reveals that a decrease in SCR activity at higher vanadia coverage is due to a decrease of the reducibility and dispersion of vanadium species.



**Figure 1.** Effect of  $V_2O_5$  coverage on NO conversion of  $V_2O_5$ - $WO_3$ /TiO<sub>2</sub> powder catalysts

## Significance

This study reveals that rapid decrease in SCR activity at higher vanadia coverage is due to a decrease of the reducibility and dispersion of vanadium species. No correlation between acidity and activity was found.

## References

1. Busca, G.; Lietti, L.; Ramis, G.; Berti, F. *Applied Catalysis B-Environmental* **1998**, *18*, 1.
2. Went, G. T.; Leu, L. J.; Rosin, R. R.; Bell, A. T. *Journal of Catalysis* **1992**, *134*, 492.
3. Baiker, A.; Handy, B.; Nickl, J.; Schraml-Marth, M.; Wokaun, A. *Catalysis Letters* **1992**, *14*, 89.
4. Amiridis, M. D.; Wachs, I. E.; Deo, G.; Jehng, J. M.; Kim, D. S.; *Journal of Catalysis* **1996**, *161*, 247.
5. Fushun, T.; Ke, Z.; Fang, Y.; Lili, Y.; Bolian, X.; Jinheng, Q.; Yining, F.; *Chinese Journal of Catalysis* **2012**, *33*, 933.