Selective Catalytic Reduction of NO by NH_3 over V_2O_5-WO_3/TiO_2 Catalysts

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Introduction

Nitrogen oxides (NO_x) are produced by combustion of fossil fuels and are emitted from automobiles and stationary sources such as oil- and coal-fired power plants, and waste incinerators. Reduction of NO_x can be achieved by adapting various combustion techniques (e.g. low NO_x burner or flue gas recirculation) or by treatment of flue gas. The most effective and common technique to remove NO_x in the exhaust gas from stationary sources is selective catalytic reduction (SCR) of NO_x to N_2 using ammonia as a reductant [1].

The widely-used industrial catalyst for the SCR process is based on V_2O_5-WO_3 supported on anatase TiO_2.The amount of vanadium oxide in the catalyst formulation is generally small (< 1 wt%). Vanadium oxide brings about the high activity of the catalyst in the reduction of NO_x but it also enhances the undesired oxidation of SO_2 to SO_3 in the case of sulfur-containing fuels [1-2]. Tungsten oxide is added to provide thermal stability of the V_2O_5-WO_3/TiO_2 system [3].

Materials and Methods

To prepare TiO_2, titanium tetraisopropoxide ($Ti(OC_3H_8)_4$) underwent controlled hydrolysis under acidic condition, following by dialysis in cellulose membranes. The resulting TiO_2 sol was then dried and calcined at 350 °C for two hours so as to obtain TiO_2 powder.

To deposit V_2O_5 and WO_3 on TiO_2 support, the desired amount of support was soaked under continuous stirring, in an excess solution of ammonium metavanadate (NH_4VO_3) and ammonium metatungstate ($H_{26}N_6O_{40}W_{12}$), respectively. After the impregnation, the supported catalyst was calcined at 550 °C for two hours.

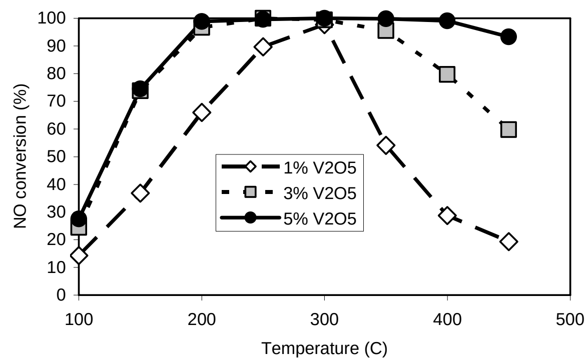
Approximately, 0.2 g of V_2O_5-WO_3/TiO_2 catalyst was placed in a tubular reactor. A heating coil was employed to raise the temperature of the reaction to the desired temperature in the range of 150 – 450 °C. The feed gas contained 500 ppm of NO, 500 ppm of NH_3, 3% of O_2, and balance N_2. GHSV for each experiment was set at 40,000 hr^{-1}. The concentration of NO leaving the reactor was monitored continuously by NO_x analyzer (Shimadzu NOA-7000).

Results and Discussion

According to XRD result, TiO_2 support consisted of primarily anatase phase with some rutile and brookite phases present. The specific surface area of TiO_2 support is 91 m^2/g. After the impregnation of V_2O_5 and WO_3, the specific surface area of the catalyst decreased to a value in the range of 58 – 72 m^2/g, probably due to the second calcinations at 550 °C.

The activity of V_2O_5-WO_3/TiO_2 catalyst for SCR of NO was determined by conversion of NO. Our preliminary results indicated that as the amount of V_2O_5 loading increased, the NO conversion reached an optimum around 300 °C (See Figure 1). Furthermore, at 5 wt% V_2O_5 the NO conversion remained high (>90%) beyond 300 °C. When the amount of WO_3 loading was varied, complete conversion of NO was still achieved around reaction temperatures of 250 – 300 °C. Nevertheless, the influence of WO_3 loading on the NO conversion beyond 300 °C was still inconclusive. Further experiments were planned in order to elaborate on that.

Figure 1. Conversion of NO as a function of temperature for V_2O_5-WO_3/TiO_2 catalysts containing 8 wt% WO_3 and 1-5 wt% V_2O_5



Significance

Increasing the amount of V_2O_5 loading in V_2O_5-WO_3/TiO_2 catalyst can increase the thermal stability of the catalyst during SCR of NO by NH_3.

References

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