

**Synthesis, Characterization of Vanadia/titania-based Catalysts and their
Performance in Ammonia Remediation**

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Abstract:

Malodor is an important class of air pollution that poses a serious threat to personal health and quality of life. Ammonia gas is a major cause of malodor complaints and is produced by microbial decompositions of organic wastes. A catalyst capable of attaining better than 99 % conversion of 50 ppm NH₃ in air at room temperature was successfully prepared. The E_A of the reaction is dramatically decreased by using the catalysts when the ratio of VO_x/TiO_x increases. The NH₃ was oxidized to nitrogen and water during the reaction without producing NO_x. The catalyst was characterized by BET, micro-Raman and X-ray photoelectron spectroscopy to identify the active sites to be monomeric VO_x on TiO_x.

Introduction:

Indoor air quality has captured much attention of many researchers recently because of its effect on human health. Ammonia is one of the most odor origin gases in the world that can be easily emitted in wash room, fish markets, meat treatment industries, piggery, landfill and agricultural activities. They have a sharp pungent smell which can be detected by human nose at even several ppm levels. The damages caused by Ammonia mainly role in eye, respiratory and skin.^[1] Selective catalytic

oxidation gives a new way to remove ammonia in oxygen or air in the recent years, ammonia reacts with air can produce nitrogen, nitrous oxide and nitrogen monoxide. This technology has reported in literature that different kinds of catalysts have been used for selective catalytic oxidation of ammonia into nitrogen, such as noble metals (Pt, Rh and Pd) iron exchanged into zeolite ZEM-5^[2] or supported on gamma alumina^[3], Ni oxides^[4], copper oxides and Ag oxides supported on γ -Al₂O₃^[5], V₂O₅/TiO₂ and CuO/TiO₂^[6], Fe exchanged ZSM-5^[7], Fe₂O₃/TiO₂.^[8]

Experimental:

2.5g Ammonia Vanadate Meta (NH₄VO₃, 98%, Nacalai Tesque INC) is dissolved in 500 ml DDI water, then 38.87g UV100 (TiO₂, Sachtleben) is added into 100 ml the above solution to prepare 1wt% of V₂O₅/TiO₂ catalyst. The mixed suspension is dried via rotary evaporator under 65°C with 120 r/min. After drying, the powder is put inside oven and further dried at 115°C for 24 hours. The obtained powder is then calcined at 200°C for 4 hours. A serial of 0.1wt%, 5wt% and 15wt% catalysts are also prepared with this method.

Results and Discussion:

The catalysts used in the experiments in this report are 1wt%, 5wt% and 15wt% V₂O₅/TiO₂ which are calcined in air at 200°C for 4 hours. To obtain the morphology of catalyst, SEM is measured. Figure 1 shows SEM images of 15wt% V₂O₅-TiO₂ catalyst. Figure 2 shows the Micro-Raman Spectra of 1wt%, 5wt% and 15wt% V₂O₅/TiO₂. The four main peaks of 160cm⁻¹, 390cm⁻¹, 520cm⁻¹ and 640cm⁻¹ are assigned to anatase phase of TiO₂. The intensity of peaks at 810cm⁻¹ and 940cm⁻¹ increase as the V₂O₅/TiO₂ loading increases from 1wt% to 5wt% which are associated to polymeric form of V₂O₅, when the loading increases to 15wt%, the peak of 940cm⁻¹ shifts to 1020cm⁻¹, which is associated to monomeric form of surface of V₂O₅. In the four catalysts, the peak of crystal V₂O₅ isn't seen in the Micro-Raman spectra at 995cm⁻¹. We can run the experiments at different temperature, to observe the relation between T and conversion shown in Figure 3. To design the experiment condition, the reaction flow rate is 400 SCCM containing 10 SCCM 8.73% NH₃ in N₂ and 390 SCCM N₂, so the concentration of the inlet NH₃ is 2175ppm. The reaction temperature is ranging from 25°C to 250°C. Then the Arrhenius equations of three V₂O₅-TiO₂ catalysts are obtained, shown in Table 1. It is found that 15wt% one has the lowest E_a, that means the reaction barrier decreases a lot as the V₂O₅/TiO₂ ratio increases.

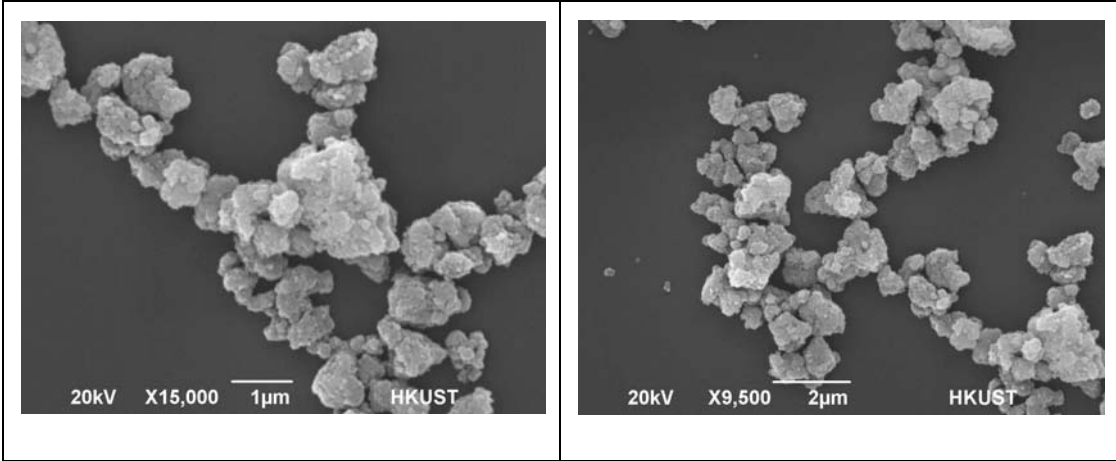


Figure 1 SEM images of 15wt% V_2O_5/TiO_2

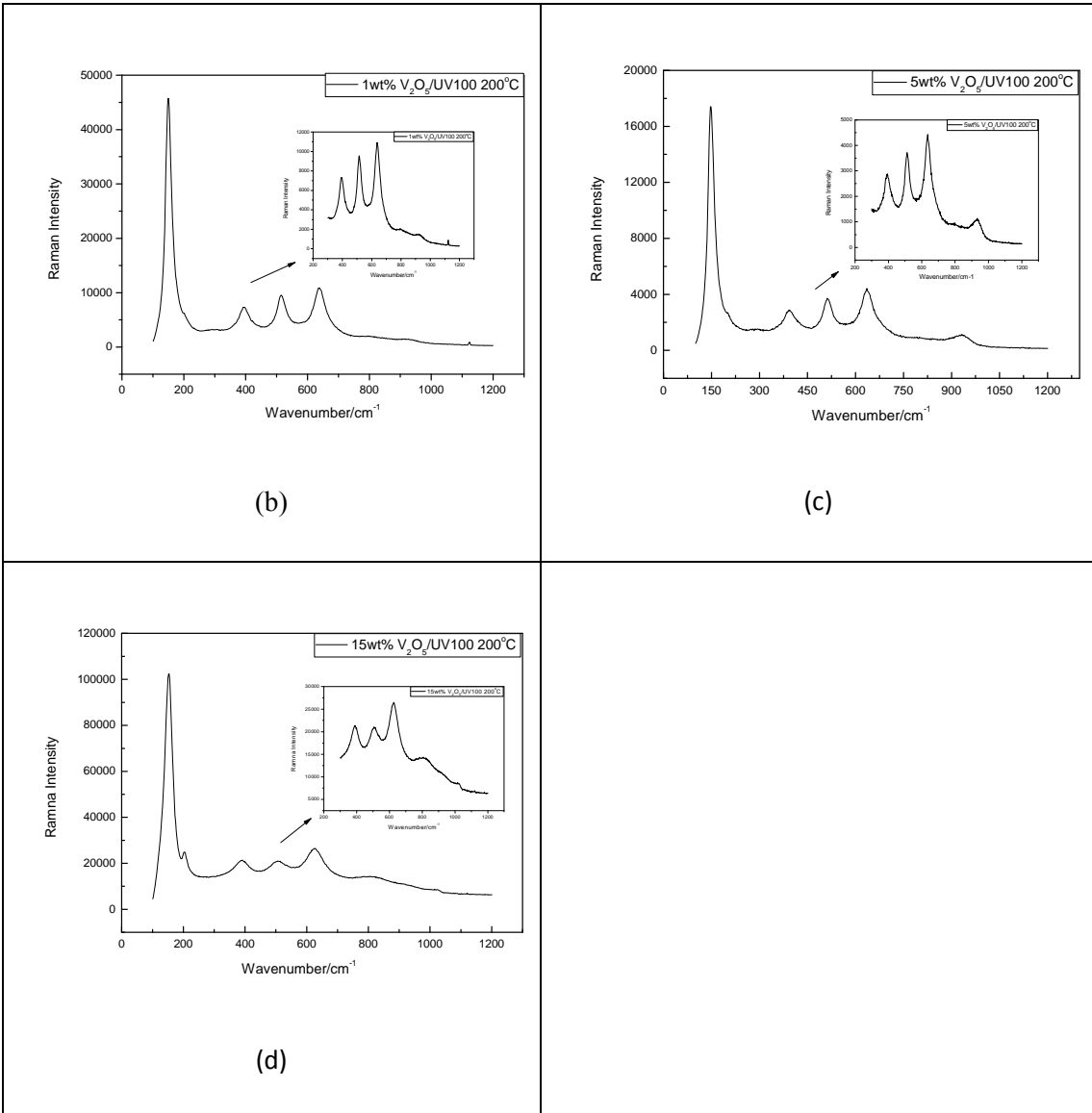


Figure 2 Micro-Raman Spectra of 1wt%, 5wt% and 15wt% V₂O₅/TiO₂.

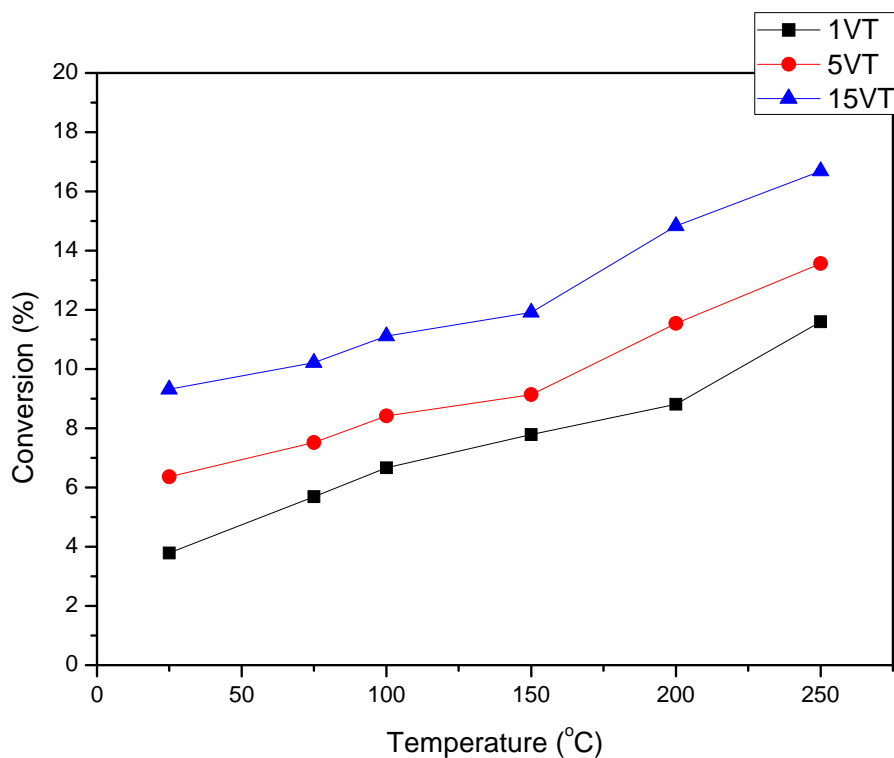


Figure 3. Figure 5 NH₃ conversion using 1wt%, 5wt% and 15wt% V₂O₅-TiO₂ catalyst

Table 1. Arrhenius equations and Ea of 1wt%, 5wt% and 15wt% V₂O₅-TiO₂

Catalyst	Arrhenius equation	Ea/kJ*mol ⁻¹
V ₂ O ₅ -TiO ₂ -1wt%	$\ln k = -1.081 - 722/T$	6.00
V ₂ O ₅ -TiO ₂ -5wt%	$\ln k = -1.087 - 513/T$	4.27
V ₂ O ₅ -TiO ₂ -15wt%	$\ln k = -0.827 - 406/T$	3.37

Conclusion:

The obtained V₂O₅-TiO₂ catalysts dramatically decrease the reaction barrier of NH₃ oxidation, where the catalysts achieve a 99% conversion for 50ppm NH₃ gas in air at room temperature.

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