**SCR of NO with C$_3$H$_6$ over iron modified Ag/Al$_2$O$_3$ catalysts supported on honeycomb ceramic**

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**Abstract:** Ag/Al$_2$O$_3$ catalysts supported on honeycomb ceramic were prepared by sol-gel and impregnation methods and modified with Fe to promote the catalytic performance for SCR of NO with C$_3$H$_6$ and to improve the resistance to SO$_2$ and H$_2$O. The results showed that the NO reduction efficiency by 7.2Fe/1.9Ag/20Al$_2$O$_3$/CM with C$_3$H$_6$ was more than 90% and reached about 100% at 500 °C and 550°C respectively. Iron can effectively improve the ability of Ag/20Al$_2$O$_3$/CM catalysts to resist SO$_2$ and H$_2$O in flue gas.

**Keywords:** SCR of NO, Ag/Al$_2$O$_3$ catalysts, C$_3$H$_6$, Fe

1. **Introduction**

Ag supported on Al$_2$O$_3$ catalyst showed good activity in the SCR of NO by HC agents [1, 2]. The resistance of Ag/Al$_2$O$_3$ catalysts to H$_2$O and SO$_2$ is a problem. More et al. [3] used Mg to modify the Ag/Al$_2$O$_3$ catalyst and found that Mg can improve the resistance of Ag/Al$_2$O$_3$ to SO$_2$, but H$_2$O had a great influence on the reduction of NO by Ag/Mg/Al$_2$O$_3$, e.g., at 350°C, the addition of 9% H$_2$O reduced the conversion of NO by 40% and the conversion of reducing agent C$_3$H$_6$ by 10% respectively. The resistance of Ag based catalysts to SO$_2$ and H$_2$O remains to be further investigated for HC-SCR of NO.

Recent studies demonstrated that iron or iron oxides could effectively reduce NO above 850°C with HC fuels and has a good ability to resist SO$_2$ and H$_2$O [4]. Further study found that the iron-based supported catalysts can effectively reduce NO with HC at lower temperature, e.g., Fe/Al$_2$O$_3$/Cordierite with a 5.5% Fe loading (mass fraction) can achieve a NO reduction efficiency of up to 97% at 550°C and a better resistance to SO$_2$ and H$_2$O in the flue gas [5]. In this study, the Ag/Al$_2$O$_3$ catalyst was modified by Fe in order to improve its resistance to SO$_2$ and H$_2$O and cordierite honeycomb ceramic was used as the carrier. The C$_3$H$_6$-SCR of NO was tested in a flow reactor with simulated flue gas.

2. **Experimental**

Sol-gel and impregnation methods were used to prepare the catalysts. Raw cordierite honeycomb ceramics were first immersed into the Al$_2$O$_3$ sol for 3h followed by drying at 110 °C for 12 h and calcining at 500°C for 5 h to prepare the 20Al$_2$O$_3$/CM samples. Then the 20Al$_2$O$_3$/CM samples were immersed into the 1 mol/L AgNO$_3$ solution first for 10 hours, then dried at 110 °C for 12 h and calcined at 500°C for 5 h to obtain the Ag/20Al$_2$O$_3$/CM samples, which were then immersed into the 1mol/L Fe(NO$_3$)$_3$ solution to finally obtain the xFe-yAg/20Al$_2$O$_3$/CM catalysts, where $x$ and $y$ note the mass fraction of loaded Fe and Ag respectively based on the raw cordierite honeycomb ceramics mass. The physical-chemical properties were characterized by SEM, XRD, Nitrogen adsorption/absorption, H$_2$ temperature programmed reduction (H$_2$-TPR) and pyridine adsorption FTIR (Py-FTIR), etc.

The C$_3$H$_6$-SCR of NO evaluation were conducted in a one-dimensional electrically heated temperature programmed ceramic tubular reactor in simulated flue gas atmosphere (total flow rate 1.5L/min, 500ppm NO, 0.5% C$_3$H$_6$, 3% O$_2$, 8% H$_2$O, 200ppm SO$_2$, N$_2$ balanced) at 200-700 °C.

3. **Results and discussion**

Figure 1 presents the NO and C$_3$H$_6$ conversion. The NO conversion to N$_2$ over 7.2Fe/1.9Ag/20Al$_2$O$_3$/CM was about 100% at 550 °C and did not decrease as the temperature increased. However, the NO conversion over 2.0Ag/20Al$_2$O$_3$/CM decreased from about 90% at 550°C to about 60% as the temperature increased to
700 °C. Figure 2 presents the effect of SO$_2$ and H$_2$O in the flue gas on the NO conversion. The results showed that 7.2Fe/1.9Ag/20Al$_2$O$_3$/CM had a good resistance to SO$_2$ and H$_2$O, while 2.0Ag/20Al$_2$O$_3$/CM would lose its reactivity in the presence of SO$_2$ and H$_2$O.

Figure 3 presents the SEM images of the catalysts. The surface of 2Ag/20Al$_2$O$_3$/CM was relatively smooth and a layer of Ag$_2$O was formed on the surface of the carrier, 20Al$_2$O$_3$/CM. When iron was used to modify the 2Ag/20Al$_2$O$_3$/CM catalyst, e.g., 7.2Fe/1.9Ag/20Al$_2$O$_3$/CM, the catalyst surface became porous and needle-like and sheet-like crystals whose main phases were Fe$_3$O$_4$ and AgFeO$_2$ based on XRD patterns were formed. The other characterization was also conducted to investigate the influence of Fe on the physical and chemical properties of the catalysts. H$_2$-TPR results showed that 7.2Fe/1.9Ag/20Al$_2$O$_3$/CM has better reduction properties than Ag/20Al$_2$O$_3$/CM in a wider temperature range. Pyridine adsorption spectroscopy (Py-FTIR) results showed that Fe increased the Lewis acid sites on the catalyst surface.

4. Conclusions

Fe loading can effectively improve the resistance of Ag/Al$_2$O$_3$ catalysts to SO$_2$ and H$_2$O. NO conversion to N$_2$ was higher than 90% at 500 °C when there was 200 ppm SO$_2$ and/or 8% H$_2$O and reached about 100% at 550 °C when 7.2Fe/1.9Ag/20Al$_2$O$_3$/CM was used as the catalyst for C$_3$H$_8$-SCR of NO.

References