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Pilot-Scale Evaluation of a Multi-Promoters Modified V/Ti-Based SCR Catalyst for Medium-Low Temperature DeNOx in Coking Plant Flue Gas

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Significance and Relevance

We developed a novel multi-promoters modified V/Ti-based (MPV) SCR catalyst for effective denitrification (DeNOx) at medium-low temperatures (220–250°C), demonstrating good sulfur resistance. Plate-type MPV SCR catalysts were fabricated and tested for NH_3-SCR activity within the medium-low temperature range for coke oven flue gas. Results of pilot test showed that at 215°C, NO_x reduction exceeded 99%, with stable performance over a 72-hour test. This study confirms the catalyst's effectiveness and its potential for energy savings and carbon reduction in coke oven gas treatment applications.

Preferred and 2nd choice for the topic: *Automotive and stationary emission control or Air cleaning and combustion*

Preferred presentation**:** Oral preferred or Short Oral

Introduction and Motivations

The coke oven process is essential in ironmaking, providing both fuel and a reducing agent for the blast furnace. NH_3-SCR technology is widely used to control NO_x emissions from coke oven flue gas[1,2]. Recently, there has been a shift from high-temperature (300–400°C) to medium-low temperature (200–250°C) NH_3-SCR technology to save heating energy. In this study, we developed a multi-promoters modified V/Ti-based (MPV) SCR catalyst with good sulfur resistance. Pilot-scale testing was conducted on plate-type MPV SCR catalysts for coke oven flue gas, examining how variations in operating conditions, temperature, and flow rate impact DeNOx efficiency. These findings provide valuable technical insights for coke oven flue gas denitrification, with potential to drive progress in the field.

Results and Discussion

1. Catalyst activity and SO_2 resistance of the MPV SCR catalyst

A MPV SCR catalyst was synthesized by impregnating the active vanadium with three kinds of promoters onto an anatase (TiO_2) support, followed by calcination at 500°C for 4 hours. We further tested the DeNOx activity of the MPV SCR catalyst under simulated flue gas at various reaction temperatures. As shown in **Figure 1(a)**, the DeNOx efficiency of the catalyst was >90 % at 220–250°C. In the **Figure 1(b)**, we observed the long-term effects of high H_2O and high SO_2 environments on the DeNOx efficiency of the MPV SCR catalyst. The DeNOx efficiency of the catalyst decreased from 99.5% to 80% as exposure time to high H_2O and high SO_2 conditions is extended from 1 hour to 32 hours.

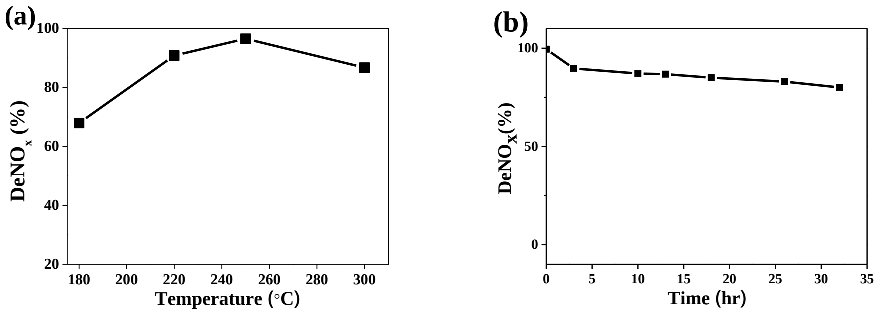

Figure 1. The activity tests of the granule-type MPV SCR catalyst in simulated flue gas; (a) effect of temperature on the DeNOx efficiency of the catalyst at 200 ppm NO, 3% O_2, NH_3/NO=1, GHSV: 27,751 h^{-1}. (b) long-term effects on the DeNOx efficiency of the catalyst at 200 ppm NO, 3% O_2, NH_3/NO=1, 14%H_2O, 1000 ppm SO_2, and GHSV of 27,751 h^{-1}.

2. Pilot-scale test and the evaluation of MPV SCR catalyst activity

A self-designed SCR pilot plant has been constructed and tested at CSC (China Steel Corporation). It is set up beside the #1 coke oven plant as shown in **Figure 2(a)**, which has dimensions of 2.3 × 2.2 × 3.05 m and was designed to a maximum gas flow of 240 m^3/h. The schematic diagram in **Figure 2(b)** illustrates the pilot-scale equipment composed of a heater, a catalyst bed, and a draught fan. A total of four plate-type SCR catalyst modules were filled in the catalyst bed, each measuring 15×15×15 cm and with a total volume of 0.0135 m^3. The SCR reaction utilized 10% ammonia-water solution as a reducing agent, which was mixed with the flue gas upstream. A portable flue gas analyzer (PG-300, Horiba, Japan) was used to analyze the composition of the flue gas both before and after the SCR reactor.

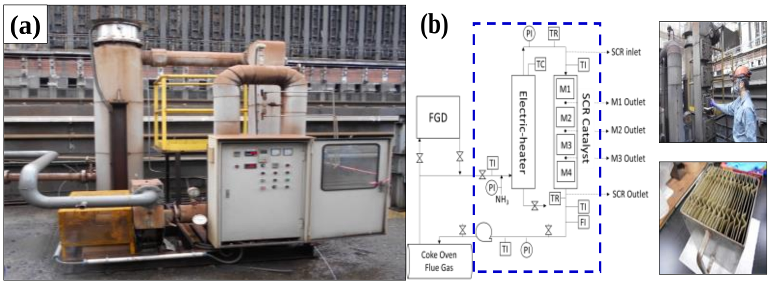

Figure 2. (a) Picture of the self-designed SCR pilot plant ; (b) schematic diagram of pilot-scale test for the plate-type MPV SCR catalyst ; dashed square referred to the SCR pilot.

As shown in Figure 3(a), the optimal temperature for the MPV SCR catalyst is between 210–268°C in pilot-scale test, achieving DeNOx efficiencies of over 95%, consistent with the laboratory-simulated flue gas DeNOx test results. Table 1 shows that under varying flue gas conditions (Coke Oven Gas: COG, Mixed Gas: MG) and operation periods (up to 72 hours), the MPV SCR catalyst achieved a DeNOx efficiency of over 97.5% at operating temperatures between 190–215°C.

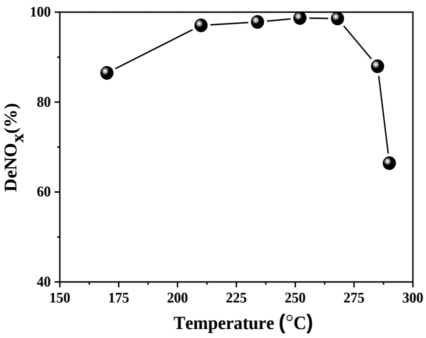

Figure 3. Effect of temperature on the DeNOx efficiency at the outlet of the MPV SCR catalyst module with a GHSV of 3,185-3,500 h^{-1}.

Table 1. The DeNOx efficiency at the outlet of SCR pilot reactor under different coke oven flue gas conditions.

Gas Type	Operation Time (hr)	GHSV (hr^{-1})	Temp (°C)	DeNO$_x$(%)
COG	1	4,500	207	97.5
MG	1	3000	190	99.8
MG	72	4,500	215	99.2

Here, we successfully fabricated plate-type MPV SCR catalysts and tested their NH_3-SCR catalytic activity in the medium-low temperature range of coke oven flue gas. The results showed that at an operating temperature of 215°C, the NO_x reduction exceeded 99%, maintaining stability over a 72-hour operating period. This study not only demonstrated the effectiveness of the catalyst, but also its successful application of medium-low temperature DeNOx catalyst technology for treating coke oven gas, with significant potential for energy savings and carbon reduction benefits.

References

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