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Recycle Sewage Sludge Char as Flue Gas De-NOx Catalyst within Low Temperature Ranges

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Abstract

Sewage sludge chars produced at four different pyrolysis temperatures (550, 650, 750 and 800°C) were investigated to check their CO and SO_2 emissions in a hot flue gas flow; and then their catalyst effect on De-NOx process with hydrazine hydrate as reductant was studied. It was found that the chars produced at 750 and 800 °C were highly temperature- and oxidant-resistant and their CO emissions were considerably inhibited in the temperature range of 100 to 400 °C with oxygen level of 5~10%, at the same time, De-NOx efficiencies were increased by 25% to 50%, suggesting those chars are proper De-NOx catalysts. Chars obtained at pyrolysis temperatures of 650, 750 and 800 °C were also checked their possibilities for absorbing NOx in flue gas, and it was found that they can achieve 20%~30% of De-NOx efficiency by adsorption within a temperature range of 100~250 °C at oxygen level around 8%. When hydrazine hydrate was used as a reducing agent together with char catalysts, the De-NOx efficiency was greatly affected by O_2 pressure and lower O_2 is benefit for the improving De-NOx efficiency. Moreover, it was found that char obtained at 750 °C had the best ability to remove NOx both as an absorbent and as a catalyst.

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Keywords: Sewage sludge; char; purolysis;De-NOx; catalyst

1. Introduction

Carbon materials are commonly adopted as catalysts [1], therefore chars from sewage sludge pyrolysis processes were investigated as catalysts for Selective Catalytic Reduction (SCR) De-NOx process; however few studies have been carried out on CO emission behaviours of these chars during De-NOx process, which can be a serious problem inhibiting its application. Generally when ammonia or urea is adopted as a reducing agent in a SCR De-NOx process, the reaction temperature is more than 350 °C, under this temperature intensive release of CO from the sewage sludge char could happen. In this study, sewage sludge chars were produced at four pyrolysis temperatures: 550, 650, 750 and 800°C. Those four sludge chars were tested as SCR catalysts in the De-NOx process with hydrazine hydrate as a reducing

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agent at lower temperature ranges. The De-NOx efficiencies and the CO emissions of these chars in hot flue gas were discussed.

2. Experimental Materials and Method

(1) Materials

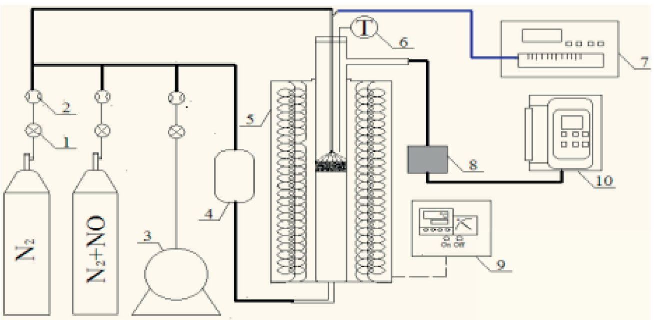
Sewage sludge samples were obtained from a sewage treatment plant in Shanghai, China, where municipal wastewater is treated using the standard activated sludge method. The wet sludge samples were dried in a 105 ºC oven for twenty four hours. Table 1 shows the approximate moisture, combustible component, and ash levels, as well as the ultimate analysis data of C, H O and N of the dried sludge. 100g of dried sewage sludge was pyrolyzed in a reactor for 30 minutes at four different temperatures: 550, 650, 750 and 800 ºC under a N_2 flow of 60mL/min. The obtained char samples were then sieved with a 150~200 mesh and then stored and sealed.

Table 1. Characteristics of dried sewage sludge

proximate analysis				ultimate analysis /%			
A /%	V /%	FC /wt.%	Q_{net}/kJ·kg^{-1}	[C]	[H]	[O]	[N]
27.28	63.60	9.12	15652	37.53	5.85	19.88	5.37

(2) Methods

The De-NOx experimental apparatus is composed of a gas distribution system, a quartz tubular reactor with an inner diameter of 40mm and a height of 900mm, a temperature control system and a gas analysis system. Figure 1 illustrates the setup. As 90% of NOx in the flue gas is composed of NO, NO was used instead of NOx in the simulated flue gas environment. The reductant hydrazine hydrate solution was controlled by a micro-injection pump. The vertical furnace temperature control system was provided with a surge reaction temperature mechanism.



1. Reducing valve; 2. Mass flowmeter; 3.Air compressor; 4.Gas mixer; 5. Tube furnace; 6. Thermal couple; 7. Micro injection pump; 8.Filter; 9. Temperature controller; 10. Flue gas analyzer

Figure 1. Schematic diagram of the laboratory- scale experimental system for De-NOx

NOx concentration in the outlet gas was analyzed by a flue gas analyzer (KM9106; Kane International Ltd). The NOx removal rate η was calculated as follows:

$$\eta(\%) = \frac{[NO_x]_{in} - [NO_x]_{out}}{[NO_x]_{in}} \times 100\%$$