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Experimental investigation of adsorption of NO and SO_2 on modified activated carbon sorbent from flue gases

J.L. Zhu [a], Y.H. Wang [a], J.C. Zhang [a,b,*], R.Y. Ma [a]

[a] *The Key Laboratory of Science and Technology of Controllable Chemical Reactions, Ministry of Education, Beijing University of Chemical Technology, Beijing 100029, PR China*
[b] *Department of Civil Engineering, National University of Singapore, Singapore 119260, Singapore*

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Abstract

It is indicated that modified carbon is a practical sorbent for removal of NO and SO_2 from waste gases by the adsorption method. The ideal compositions for the prepared sorbent were 4.0 wt.% and 2.5 wt.% Na_2CO_3 and KOH at the experimental conditions, respectively, shortened as $ACNaK_{2.5}$. Experimental investigation showed that the sorbent had a comparatively high breakthrough adsorption capacity of NO and SO_2, about 5.8 g (NO + SO_2)/100 g sorbent. It is indicated that a relatively high adsorption temperature would benefit the sorbent adsorption capacities on NO and SO_2 at a certain space velocity and pressure. Further study revealed that the $ACNaK_{2.5}$ sorbent had good regenerability at the experimental conditions, which implied that the $ACNaK_{2.5}$ sorbent would be a useful sorbent for simultaneous removal of NO and SO_2 from waste gases by adsorption.

Keywords: Activated carbon; Modification; Nitrogen oxides; Sulfur dioxide; Adsorption

* Corresponding author. Tel.: +65 687 46501; fax: +65 677 91635.
E-mail address: zhangic2005@yahoo.com.cn (J.C. Zhang).

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1. Introduction

Air pollution by nitrogen oxides (mainly NO) and sulfur compounds (mainly SO_2) in combustion waste gases, such as Diesel engine emissions and electric power factories that use coal as the main fuel, has become a serious environmental problem in recent years, especially in urban areas [1–4]. It appears that the selective catalytic reduction (SCR) of NO_x by various hydrocarbons is an effective method of removal of NO_x from exhaust gases [5,6]. The other interesting technique is using N-containing reactants as reducing agents, such as ammonia [7], which is considered the most promising technology to be used in commercial industries. Nevertheless, for practical application, the most important concern of those mentioned processes is the requirement that the catalyst has good stability in the presence of water steam and amounts of SO_2 as well as higher activity at the desired temperatures [8,9]. Usually, it is expected that the catalyst has higher activity at comparatively lower temperatures. A number of catalysts, such as metal doped zeolites and metal oxides, have been proposed as catalysts for removing NO_x from waste gases using the reduction method [10]. However, most zeolite based catalysts have instability at practical reaction conditions [11,12]. Although a wide range of metals and metal oxides, including Co, Cu, Ag and Pt, have been reported to have good activities of removal of NO_x from waste gases using the reduction method [13,14], some of the investigated results have shown that the catalyst's activities would be deactivated by the presence of water steam and sulfur compounds, mainly SO_2. Thus, particular efforts have been directly made to find a suitable method of simultaneous removal of NO_x and SO_2 [15]. The adsorption method is now considered to be the most attractive way to treat waste gases containing NO_x and SO_2. Recently, zeolites have been reported as possible NO_x adsorbents [16]. The investigated results conducted on zeolites indicated that the zeolite structure, the ratio of silica to alumina and the cation counters balancing the negative charges of the zeolite framework were important parameters on their NO_x removal performances [17]. Further investigation showed that the adsorption of NO on Cu-ZSM-5 zeolite was activated by the pre-adsorption of NO_2 in the presence of oxygen at room temperature [18]. It is believed that the sorbent performance on adsorption of NO_x, to some extent, is obviously predominated by its capacity for removal of NO. This is because NO_x in flue gases typically consists of more than 90% NO. Then, some researchers considered that the sorbent should have comparatively higher activity of oxidizing NO to NO_2 in order to make the sorbent have a higher capacity of adsorption of NO [17,18]. Thus, most of researches have been concentrated on sorbents' modification to improve their ability to capture NO [19]. Unfortunately, few works have been reported to remove NO and SO_2 simultaneously by the adsorption method. Therefore, it is necessary to prepare a kind of sorbent for removal of NO and SO_2 by the adsorption method. Moreover, this sorbent should be repeatedly regeneratable and reusable.

In this study, a kind of sorbent of activated carbon was prepared, which was modified by co-impregnation with sodium carbonate and potassium hydroxide as well as supporting small amounts of surfactants on the support of activated carbon. The effects of the sorbent compositions, temperature, space velocities and pressure on the sorbent performances were investigated in a fixed bed reactor. An investigation of sorbent stability was also performed in this experiment, lasting for 16 cycles. Finally, the fresh, reacted and regenerated sorbents were characterized by using The Brunauer–Emmett–Teller (BET) method, the inductively coupled plasma (ICP) technique and the scanning electron microscope (SEM). The mechanisms for this sorbent to simultaneous remove NO and SO_2 are still under investigation in our laboratory, which will be discussed