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Deep study on effects of activated carbon's oxygen functional groups for elemental mercury adsorption using temperature programmed desorption method

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HIGHLIGHTS

- Ester group captures mercury prior to carbonyl group.
- Oxgen groups are more important than surface area above 130 °C.
- Ester group dominates mercury adsorption at 210 °C.
- Physisorption only occurs in the range from room temperature to 130 °C.

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ABSTRACT

Oxygen functional groups play an important role in elemental mercury adsorption by activated carbon (AC). However, the adsorption mechanism of oxygen functional groups is unclear. This study investigated the effects of oxygen functional groups on elemental mercury adsorption using temperature programmed desorption method. Nitric acid treatment, non-thermal plasma treatment, and heat treatment in nitrogen or carbon dioxide were used to modify AC's oxygen functional groups and pore structures. Base–acid titration experiments were conducted to calculate the amount of oxygen functional groups of samples. Mercury removal efficiency tests and temperature programmed desorption experiments of AC were carried out in a bench-scale quartz reactor. The results suggested that the mercury removal performance of AC was determined by the comprehensive effects of surface area, carbonyl group and ester group, and each of them had different influences on mercury adsorption at different temperatures. Physisorption which related with surface area only occurred in the temperature range from 30 °C to 130 °C, and it was inhibited by increasing temperature; while carbonyl group and ester group could capture mercury in the temperature range from 30 °C to 210 °C. However, increasing temperature could inhibit the mercury adsorption by carbonyl group in the temperature range of 130–210 °C, and the ester group dominated mercury adsorption at 210 °C. In addition, carbonyl group and ester group had different priority levels for mercury adsorption, active sites related with ester group had the highest priority of capturing mercury, and active sites in correlation with carbonyl group was the second, while active sites corresponding with physisorption was the last one.

1. Introduction

In recent years, mercury emissions have attracted wide attentions due to its potential risks to human health, particularly long term exposure to methyl mercury [1,2]. It is reported that coal fired power plants are one of the major anthropogenic mercury emission sources because of large amount of coal consumption [3]. The high-temperature boiler transforms most of the mercury compounds in the coal into elemental mercury (Hg^0) in the flue gas. When the flue gas passes through the purification system, some of the elemental mercury is oxidized to oxidized mercury (Hg^{2+}) by the $DeNO_x$ equipment, which is easily removed by the wet flue gas desulfurization (WFGD) because of its high solubility in water. Some of the elemental mercury is captured by fly ash and then removed by the dust removal device [4,5]. However, the remaining Hg^0 in flue gas is very difficult to be removed by

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