



Full Length Article

Chlorine-Char composite synthesized by co-pyrolysis of biomass wastes and polyvinyl chloride for elemental mercury removal



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HIGHLIGHTS

- Effects of pyrolysis temperature, mixing ratio and heating mode were investigated.
- Hg⁰ removal by Cl-Char was much higher than that by raw char (2.5–5 times).
- The mechanism of Hg⁰ adsorption was studied by XPS and TPD analysis.
- A novel method was proposed to synthesize Cl-Char composite for Hg⁰ removal.
- Biomass/PVC wastes are adaptive materials for synthesizing Hg⁰ removal sorbents.

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ABSTRACT

A novel method using the co-pyrolysis of polyvinyl chloride (PVC) and biomass wastes (wood and paper) was adopted to synthesize chlorine on the surface of the char, and the synthesized Cl-Char composite was tested for removal of elemental mercury as a sorbent. The mercury removal efficiency of Cl-Char was much higher than that of raw char (2.5–5 times) and reached nearly 90% at 140 °C. Brunauer-Emmett-Teller (BET) measurements, X-ray photoelectron spectroscopy (XPS) and ion chromatography (IC) were used to characterize the sorbents derived from wastes. The introduction of PVC could increase the yield of sorbents, but it decreased the specific surface area of the sorbents because melted PVC adhered to the paper (or wood) molecules and blocked the development of the porous structure. The IC and XPS analysis results indicated that a synergistic effect occurred during the co-pyrolysis process and Cl released from PVC was partly fixed into the pyrolyzed chars to form C-Cl functional groups. This was the primary effective component for the mercury capture via chemical adsorption in contrast to simple physical adsorption on the chlorine-free char. The data also suggested that the existing forms of mercury on the used sorbent were HgCl_x via a temperature-programmed decomposition (TPD) experiment because the chemisorbed mercury species could be completely released from 200 to 400 °C. The elemental mercury removal efficiency increased as a function of temperature from 20 °C to 140 °C and then decreased at 170 °C. The presence of O₂ enhanced Hg⁰ removal whereas SO₂ inhibited Hg⁰ removal; NO had little influence on Hg⁰ removal.

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1. Introduction

Mercury, a heavy metal, is a concern because of its toxicity, volatility, persistence, bioaccumulation and worldwide migration into the environment [1,2]. All species of mercury are harmful to human beings and can be easily absorbed by human beings and

damage our nervous system [3,4]. The average content of mercury in Chinese coal is 0.22 mg/kg and 0.09–0.126 mg/kg in the United States [5]. Coal combustion is the largest anthropogenic source of mercury emission because of the large quantity of coal that is consumed worldwide. In 2011, the Emission Standard of Air Pollutants for Thermal Power Plants (GB13223-2011) stated that the emission concentration of mercury and its compounds in the stack flue gas should not exceed 0.03 mg/m³.

During combustion, mercury is released in three forms: oxidized forms (Hg²⁺), particle-bound (Hg^p) and elemental mercury (Hg⁰) [6,7]. Hg²⁺ and Hg^p can be removed efficiently by wet flue

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