Efficient removal of elemental mercury by magnetic chlorinated biochars derived from co-pyrolysis of Fe(NO$_3$)$_3$-laden wood and polyvinyl chloride waste

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Keywords:
Biochar
Mercury
Magnetism
Flue gas
Municipal solid waste

Abstract

Chlorinated biochars (Cl/biochars) prepared by co-pyrolysis of biomass and polyvinyl chloride (PVC) waste were demonstrated as cost-effective sorbents for elemental mercury (Hg$^0$) removal in our previous study. But the decrease in specific surface area of Cl/biochars caused by PVC melting inhibits the further increase of Hg$^0$ removal performance. Moreover, the difficulty in separating the used Cl/biochars from fly ash restricts the utilization of fly ash as a cement additive. To solve these problems, magnetic chlorinated biochars (Fe-Cl/biochars) are synthesized through one-step pyrolysis of Fe(NO$_3$)$_3$-laden wood/PVC mixtures in this study. The sample characterization showed that magnetic Fe$_3$O$_4$ was introduced into the Fe-Cl/biochars. Besides the magnetism, both increased specific surface area and more C=O groups were obtained under Fe catalysis. The Fe-Cl/biochars showed far better Hg$^0$ removal performance compared to the Cl/biochars over a broad reaction temperature range (25–220 °C). O$_2$, HCl and NO promoted Hg$^0$ removal whereas SO$_2$ had little effect on Hg$^0$ removal. H$_2$O slightly suppressed Hg$^0$ removal. Compared to the commercial activated carbon manufactured specifically for Hg$^0$ removal, Fe-Cl/biochars was superior in both Hg$^0$ adsorption capacity and adsorption rate at 140 °C. The mechanism of Hg$^0$ removal over Fe-Cl/biochars was chemisorption reaction, where Fe$_3$O$_4$, C–Cl and C=O provided active sites for Hg$^0$ removal.

1. Introduction

Mercury has received widespread attention due to its toxicity, bioaccumulation and persistence in the ecosystem [1,2]. Among various human activities, coal-fired utility boilers are deemed as one of the largest anthropogenic source of mercury emissions. The world has