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Activated coke impregnated with cerium chloride used for elemental mercury removal from simulated flue gas

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HIGHLIGHTS

- AICC was developed for effective Hg^0 removal from simulated flue gas.
- The AICC samples possessed a joint oxidation effect on Hg^0 removal.
- The Hg species adsorbed on AICC samples were identified mainly as HgO and $HgCl_2$.
- The roles of O_2, NO, SO_2 and H_2O (g) in Hg^0 oxidation by AICC were explored.

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ABSTRACT

Gas-phase elemental mercury (Hg^0) removal by activated coke impregnated with cerium chloride (AICC) was studied under simulated flue gas conditions. Brunauer–Emmett–Teller (BET), X-ray diffractogram (XRD), scanning electron microscopy with energy dispersive X-ray spectrometry (SEM-EDX) and X-ray photoelectron spectroscopy (XPS) analyses were used to characterize the samples. The effects of $CeCl_3$ loading values, reaction temperatures and individual flue gas components including O_2, NO, SO_2 and H_2O (g) on Hg^0 removal efficiency of AICC samples were investigated. Results showed that Hg^0 removal efficiency of AC was significantly enhanced by $CeCl_3$. The optimal $CeCl_3$ loading value and reaction temperature was around 6% and 170 °C, respectively. Additionally, the experiment results of effects of flue gas components on Hg^0 removal efficiencies showed that when O_2 was present in the flue gas, NO and SO_2 were observed to promote Hg^0 oxidation. However, in the absence of O_2, SO_2 showed an insignificant inhibition on Hg^0 removal. Furthermore, when H_2O was added into the flue gas, the Hg^0 removal capacity had a slight declination. The analyses of XRD and XPS showed that Ce_xO_y and C–Cl were generated on the surface of AICC and those active elements had remarkably positive effects on the Hg^0 removal. The reaction mechanism indicated that Hg^0 oxidation was achieved through two pathways: one was that Hg^0 bond with CeO_2 and was converted by the catalytic oxidation of valence variable cerium; the other was that Hg^0 reacted with C–Cl on the sample and was oxidized favored by chloride presence. And according to Hg 4f XPS analysis, the mercury on the surface of AICC was mainly in the form of mercuric oxide (HgO) and mercuric chloride ($HgCl_2$).

1. Introduction

Mercury emitted from coal-fired utility boilers has become a significant environmental issue because of its volatility, persistence, bioaccumulation and high toxicity [1–3]. On April 19, 2012, the US Environment Protection Agency (EPA) issued the national standard *Final Mercury and Air Toxics Standards* for the control of mercury, acid gases, and other toxic pollution from coal-fired power plants [4]. In addition, the State Environmental Protection Administration of China (SEPA) also initiated the *Emission Standard of Air Pollution for Thermal Power Plants* (GB13223-2011), in which the limit of mercury emission from coal-fired power plants is 0.03 mg/m^3 [5]. Therefore, it is required to develop effective technologies to govern mercury emission from coal-fired utility [6].

Mercury removal in coal-fired utilities greatly depends on its speciation in the post-combustion flue gases [7]. Mercury in coal-fired flue gas is often present as elemental mercury (Hg^0), oxidized mercury (Hg^{2+}), and particle-bound mercury (Hg^P). Thereinto, Hg^P

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