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Fate of heavy metals during molten salts thermal treatment of municipal solid waste incineration fly ashes

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ABSTRACT

Thermal treatment could effectively realize the detoxification of heavy metals in municipal solid waste incineration (MSWI) fly ash through the approach of removal or stabilization process. To lower the operating temperature and suppress the evaporation of heavy metals, a molten salts ($NaCl$-$CaCl_2$) thermal treatment method was proposed for the detoxification of heavy metals from MSWI fly ash at a relatively mild condition (600/800 °C). The fate of heavy metals during the heating process and their stabilization properties in the remained ash slag after molten salts thermal treatment were investigated. The results showed that, compared with the traditional thermal treatment, heavy metals were more easily chlorinated by the means of molten salts thermal treatment. The well distributed chloride in molten salts facilitated the direct chlorination of PbO/CdO. Furthermore, Al_2O_3 in ash enhanced the indirect chlorination of CuO/PbO/CdO, except for ZnO. In contrast, SiO_2 showed better performance in promoting the indirect chlorination of heavy metal oxides. Meanwhile, some Zn^{2+} was precipitated from molten salts as Si/Al-Zn composite oxides through the interactions with ash containing Si/Al oxides. On the other hand, the dissolved heavy metals in molten salts showed a good thermal stability during the thermal treatment. The volatilization fractions of all detected heavy metals were less than 5%. After the molten salts thermal treatment, heavy metals in the ash slag were well stabilized and the amount of heavy metals leached was significantly lower than that from the raw fly ash.

1. Introduction

In the past decades, incineration technology has been rapidly developed and widely applied to the treatment of municipal solid waste (MSW) in China, leading to the production of large amounts of fly ash (Shen et al., 2018). Due to the toxic dioxins and high contents of heavy metals, MSW incineration fly ash has been classified as hazardous solid wastes in many countries (Sun et al., 2011; Jiao et al., 2016). Recently, solidification/stabilization technique, stabilizing heavy metals in cement-based materials, has been widely used for the disposal of fly ash (Dell'Orso et al, 2012). However, some researchers argued that dioxins and heavy metals in the solids may have a potential risk to environment in a long term period (Jin et al, 2013; Tang et al., 2013; Zhao et al., 2018). Granulation of fly ash at room temperature also had been tested and the mechanical properties were investigated (Medici et al, 2000). By comparison, thermal treatment has recently drawn much attention for the treatment of MSW incineration fly ash, which can quickly realize the detoxification of fly ash through the decomposition of dioxins and the stabilization of heavy metals (Hu et al., 2013; Yu et al., 2016). Subsequently, the treated ash could be utilized for cement and ceramic manufacturing (De Casa et al., 2007; Shi et al., 2009).

In particular, the dioxins are mostly thermally unstable and begin to decompose at 300 °C (Lundin and Marklund, 2005; Lundin et al., 2011). The stabilization of heavy metals should be realized at higher temperatures (Luan et al., 2016). In the heating process, less volatilized Cr and Ni tended to remain in the residues while volatile heavy metals, such as Pb, Cd, Zn and Cu, may evaporate from MSW incineration fly ash mainly in the form of chlorides (Wang et al., 2009; Arena and Gregorio, 2013;Nowak et al., 2013; Hu et al., 2018). Nevertheless, the high operating costs and the serious pollution as a result of the evaporation of heavy metals, suppressed the wide application of the traditional thermal treatment technique (Lindberg et al., 2015).

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