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Full Length Article

Improved sodium adsorption by modified kaolinite at high temperature using intercalation-exfoliation method

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HIGHLIGHTS

- Intercalation-exfoliation method is applied to modify kaolin in this study.
- Kaolin modified with KAc served the best one to capture NaCl at high temperature.
- The pore structure of kaolin was significantly developed during modification process.
- Modification provides additional adsorption sites on kaolin for sodium fixation.
- Nepheline is proved to form when the sodium is chemically fixed by modified kaolin.

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ABSTRACT

Kaolin is one of the most widely used additives to alleviate fouling and slagging problems, which often occurred on the boilers burning coal with high sodium content. In order to improve the adsorption capacity in this condition, the intercalation-exfoliation method in material field was applied to modify kaolin. Six representative intercalation agents were selected to prepare samples, including hydrazine, urea, potassium acetate, formamide, methylformamide and dimethyl sulfoxide. Experimental results showed that both of pore volume and pore diameter were expanded through modification, which is beneficial to adsorption in physical aspect. On the other hand, the reduction of mass loss rate (from 10.6% to 6.8%), i.e. the loss of hydroxyl groups during modification process was verified, which contributed to sodium-capturing through providing more available adsorption sites. There was little difference between raw kaolin and modified kaolin with regard to XRD patterns, suggesting that the main crystal structure of kaolin remained after modification. Sodium reacted with modified kaolinite to form nepheline during adsorption process, realizing its chemical fixation. It is concluded that intercalation-exfoliation method is capable of improving the sodium-capturing capacity of kaolin at high temperature. Kaolin intercalated with potassium acetate has the most significant sodium-capturing capacity, which increased from 77 mg/g to 100 mg/g, with the adsorption efficiency reaching 100%.

1. Introduction

Zhundong coalfield, located in the east of Junggar Basin, is a promising fuel resource in China for its large reserves up to 164 Gt [1]. However, the severe fouling and slagging often occurred on the boilers burning Zhundong coal, which hindered its widespread application. [2,3]. According to the literature [4], the content of sodium in Zhundong coal ash generally exceeds 5%, far more than the recommended limit of 1% for power coals. The released sodium vapor has been proven to be a precursor of condensates such as sodium sulfate, which adhered to the heating surfaces resulting in fouling, slagging or corrosion [5–7]. It is regarded that the sodium release is one of main causes of poor boiler efficiency, hence the capture of sodium attracted the concern of many researchers.

Kaolin is often the top choice among additives to capture alkali metals at high temperature [8]. Linjewile et al. [9] investigated that clay additive rich in kaolinite was effective to control agglomeration and defluidisation during combustion of two coals from South

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