Fuel 239 (2019) 312–319

Contents lists available at ScienceDirect

Fuel

journal homepage: www.elsevier.com/locate/fuel

Full Length Article

Enhanced sodium adsorption capacity of kaolinite using a combined method of thermal pre-activation and intercalation-exfoliation: Alleviating the problems of slagging and fouling during the combustion of Zhundong coal

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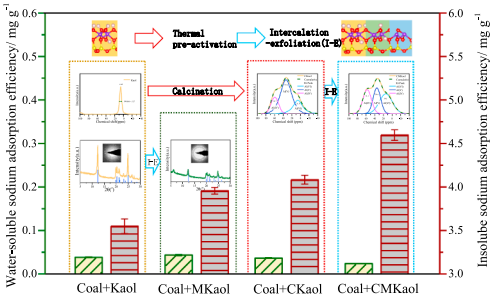
GRAPHICAL ABSTRACT



ARTICLE INFO

Keywords:
Zhundong coal
Kaolinite
Sodium adsorption
Intercalation-exfoliation
Thermal pre-activation

ABSTRACT

The thermal utilization of low-rank coal with high sodium content easily leads to severe fouling and slagging in actual boilers. To alleviate this problem, a combined method of thermal pre-activation and intercalation-exfoliation was developed in order to modify the kaolinite and thus control the release of sodium vapor during the combustion of Zhundong coal. The results show that the sodium capture efficiency of kaolinite increased from 3.59 mg g^{-1} to 4.62 mg g^{-1} when employing the combined modification method. This modified kaolinite can be used more effectively, alleviating fouling and slagging in actual boilers that burn high sodium solid fuels. The experimental data regarding the crystal structure, functional groups, Si/Al-coordination and micromorphology of kaolinite indicate that two modification methods had different effects on the structure of kaolinite, which were closely associated with the sodium adsorption capacity of the modified kaolinite. By thermal pre-activation, metakaolinite formed after dehydroxylation, resulting in the hexa-coordinated Al (VI) being converted to unsaturated Al. During the process of intercalation-exfoliation, the lamellar structure of kaolinite was broken, leading to a decrease in its crystallinity. The combining method contributed to the highest degree of structural disorder and promoted the conversion of Al (V) to Al (IV), thus creating more active sites for sodium fixation. In this case, the chemical sodium adsorption efficiency of kaolinite increased significantly regardless of the purity of raw kaolinite and the temperatures of pre-calcination. Based on a multistage analysis of the modified kaolinite, a relationship between the structure and adsorption capacity was developed, providing a new method of adsorbent modification.

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https://doi.org/10.1016/j.fuel.2018.11.018
Received 13 July 2018; Received in revised form 30 October 2018; Accepted 4 November 2018