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Interactions between molten salts and ash components during Zhundong coal gasification in eutectic carbonates

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HIGHLIGHTS

- The distribution patterns of mineral matter in Zhundong coals were characterized.
- The fate of Zhundong coal ashes was studied in the high-temperature molten salts.
- Alkali/alkaline earth metals were predominantly dissolved in the molten salts.
- Si/Al was separated from the molten salts including formed Li/K-aluminosilicates.
- The thermal properties of the molten salts were inevitably affected by coal ashes.

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ABSTRACT

Molten salt gasification provides a promising way for the combined usage of solar energy and coal, during which molten salts act as a heat storage and transfer medium. However, the interactions between coal ash components and molten salts might have undesired effects on the molten salt gasification. The present study investigated the distribution of mineral matters in typical Zhundong coals and the fate of coal ashes in the high-temperature Li_2CO_3-Na_2CO_3-K_2CO_3 eutectic system. The results showed that alkali and alkaline earth metals (AAEMs) were widely distributed in Zhundong coals in the forms of NaCl, $CaCO_3$, $CaSO_4$ and organic matter, which were predominantly dissolved in the molten salts. After the dissolution of these AAEMs, the melting temperature and enthalpy of the molten salts were changed, while the viscosity of the mixtures was hardly affected in melting phase. On the other hand, Si/Al-compounds were also of high content in some Zhundong coals, existing as quartz, kaolin and amorphous species. Some of these compounds tended to react with molten salts, by forming Li-silicate or Li/K-aluminosilicates, which were precipitated out of the system. Meanwhile, the suspension of the unreacted Si/Al-compounds increased the viscosity of molten salts. Additionally, interactions between coal ashes and molten salts brought about the decrease in thermal diffusivity and thermal conductivity of the eutectic system as well as the increase in specific heat capacity.

1. Introduction

In order to meet the large demand of energy and to solve the severe environmental pollution problems, it is encouraged to use renewable energy and to take advantage of traditional energy in a clean way [1,2]. Based on this idea, molten salt gasification offers a promising way for the combined usage of solar energy and solid fuels [3]. In the process, molten salts act as heat storage medium for concentrated solar energy, because of their high thermal stability and high heat capacity [4]. On the other hand, molten salts were used as catalytic medium and heat carrier for the gasification of solid fuels [5,6], meanwhile as in-situ capture agent of polluting gases like HCl and H_2S [7].

Located in northwest China, Xinjiang province is rich in both coal and solar energy resources [8,9]. Solar energy therein is currently not exploited much due to its instability and intermittence [10]. And most of the coal in Xinjiang province (like Zhundong coals) contains a high concentration of alkali and alkaline earth metals (AAEMs), which causes serious fouling and slagging problems in the traditional boiler [11,12]. Molten salt gasification technology, of tremendous benefit to the storage of solar energy in concentrated mode and the conversion of solar energy into chemical energy, could well solve the problems mentioned above [5,13].

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