

Influence of impurity SO_4^{2-} in the thermo-physical properties of nitrate molten salts

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Highlights

- Typical impurity SO_4^{2-} presented in molten nitrates had an effect on their thermos-physical properties.
- SO_4^{2-} makes no negative influence on melting point, liquidus temperature and density. But keeping its level less than 0.1 wt.% is necessary due to it increases viscosity.
- At high temperature, SO_4^{2-} can increase mass loss of nitrates a little bit, and easily form solids with cations, especially Na^+ . Controlling its below 0.01 wt.% is critical to addressing flow problems.

1. Introduction

The most optimized commercial grade molten salt, widely applied as heat transfer media in Concentrating Solar Power (CSP) plants, is called solar salt, composed by $\text{NaNO}_3\cdot\text{KNO}_3=6:4(\text{wt.}\%)^{[1]}$. This paper is aim to study the influence of SO_4^{2-} on thermal properties of solar salt, including liquid temperature, thermal decomposition temperature, density, viscosity, and constant thermal stability.

2. Methods

Decomposition temperature was determined by SDT Q600, while liquid temperature and density were measured by apparatus built by ourselves. Viscosity were measured by Dynamic Mechanical Analyzer.

3. Results and discussion

The melting points and decomposition temperatures are showed on Figure 1, and both of them decreased with the increasing contents of SO_4^{2-} .

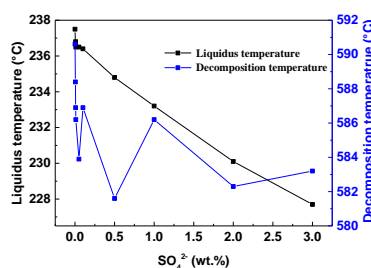


Figure 1. The results of melting point and decomposition temperature

As shown in Figure 2 and Figure 3, density and viscosity increased when more SO_4^{2-} existed. Thus, to keep the viscosities relatively static values less than 1% error, SO_4^{2-} should be lower than 0.1 %.

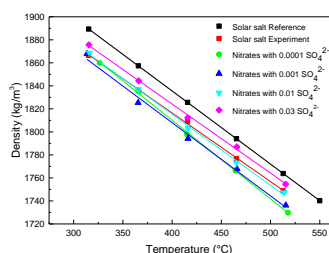


Figure 2. The density of nitrate molten salts

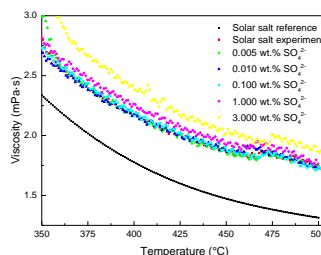


Figure 3. The viscosity of nitrates molten salts

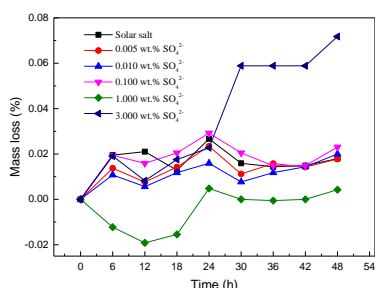


Figure 4. Mass changes of nitrates at 390 °C for 48h

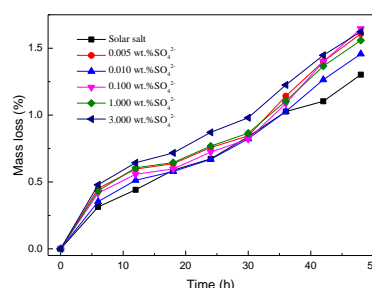


Figure 5. Mass changes of nitrates at 565 °C for 48h

The figure above showed the mixtures quality maintaining basic stability with time at 390 °C. However, an increase of mass loss was observed at 565 °C test, and SO_4^{2-} reduces the thermal stability of nitrates to a certain extent. Besides, solid materials was observed during the experiment.

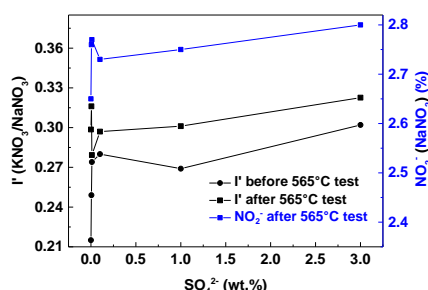


Figure 6. Changes of I' ($\text{KNO}_3/\text{NaNO}_3$) and NO_2^- after 565 °C test

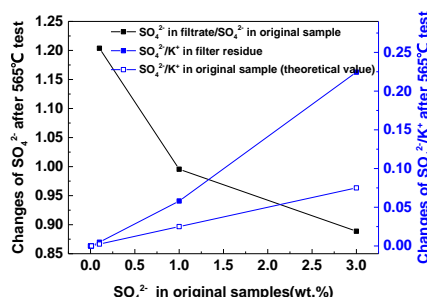


Figure 7. Changes of SO_4^{2-} after 565 °C test for 48h

The results of I' ($\text{KNO}_3/\text{NaNO}_3$) found the SO_4^{2-} incorporated firstly with Na^+ in the crystallizing process. While I' increased after 565 °C test, this could be due to the combination of Na^+ ion with some anions, which ultimately precipitate out from the melt. Only a little different of NO_2^- was found for each mixtures. Thus limit temperature of solar salt should be lower compared to the previously reported value of 565 °C. Figure 7 indicate SO_4^{2-} in the melt easily bind cations to form solids and then separated from the melt. Therefore, controlling the SO_4^{2-} level less than 0.01 wt.% in nitrates is critical for their flow problems in high temperature.

4. Conclusions

Studies the influence of a typical impurity SO_4^{2-} in the nitrates on properties. It can be concluded that:

1. The impurity SO_4^{2-} has no negative influence on melting point, liquidus temperature and density of nitrates.
2. It has negligible impact on viscosity, a small variations less than 0.02 mP·s, when SO_4^{2-} is less than 0.1%.
3. The limit temperature of solar salt should be lower compared to the previously reported value of 565 °C, due to NO_2^- as well as trace oxides was found in the salt after 565 °C test. SO_4^{2-} easily forms insoluble solids with cations, which is the most harmful influences to its using. It agrees with Fernández et al^[2,3]. Thus, controlling $\text{SO}_4^{2-} \leq 0.01\%$ is critical for addressing flow problems.

In conclusion, for better application, the nitrate system studied in this paper is suggested to purify impurity SO_4^{2-} under 0.01 wt.%.

References

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Keywords

Nitrate salts; impurity; thermal properties; thermal stability