# Rehydration in the Melting Process of Chloride Salts

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## 1. Introduction

The Molten Salt Reactor (MSR) is a next-generation nuclear reactor that employs molten salts as both fuel and coolant. These salts exhibit high melting points, excellent thermal conductivity, and stability at elevated temperatures. However, they also pose significant corrosion challenges. The presence of impurities, such as oxygen and moisture, enhances their corrosive nature, making the removal of moisture from the salts a critical concern [1].

Traditional salt purification methods involve the use of toxic gases or additives like metallic magnesium [2,3]. However, these approaches present operational difficulties and raise environmental concerns. In our previous study, we demonstrated that moisture in the salt can be effectively removed through a vacuum heat treatment process without additives. This finding provided a foundation for our current research, as it confirmed that moisture removal is feasible without introducing additional chemicals.

However, in MSR, salts are used in their molten state, making it essential to maintain low moisture concentration even after melting. Experimental results showed an increase in moisture concentration during the melting process. Here, we report rehydration phenomenon in various chloride salts and investigated its characteristics.

## 2. Experimental

### *2.1 Materials*

$MgCl_2$(Anhydrous, 99 %) were purchased from Thermo scientific. LiCl-KCl (55.7 mol% LiCl-44.3 mol% KCl; Anhydrous, 99.9 %) and $CaCl_2$(Anhydrous, 96 %) were purchased from Sigma-aldrich. LiCl (99 %) were purchased from Alfa Aesar. KCl (99.999 %) were purchased from Merck. Hygroscopic reagents were stored and prepared in an Ar atmosphere glove box ($[O_2]$, $[H_2O]$ < 5 ppm). Carbon crucibles were used as experimental cells.

### *2.2 Experimental Setup*

The experiment was conducted inside a glove box using an electric furnace. The salt was placed in a carbon crucible and heated up to a temperature above its melting point using the furnace. Before the salt melted, samples were collected from the crucible using a laboratory spoon. After melting, the dip-stick method was employed for sampling using a stainless steel rod. A schematic of experimental procedure is in fig. 1.

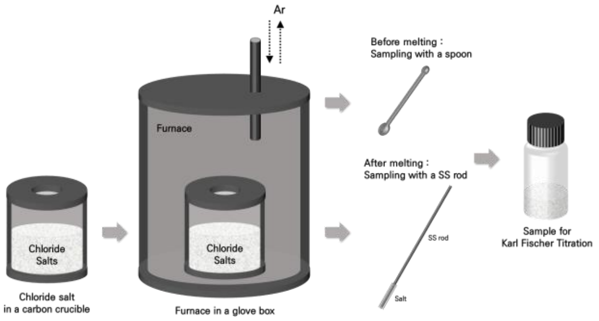


Fig. 1. Schematic of experimental procedure.

The collected samples were finely ground using a mortar and analyzed for moisture concentration using a Karl Fischer titrator (Fig. 2).

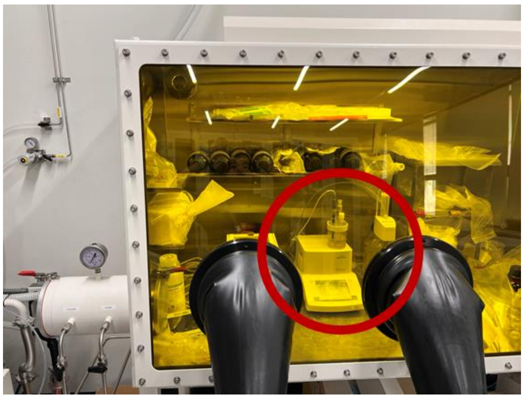

Fig. 2. Karl Fischer Titrator in a glove box.

## 3. Results and Discussion

The experiment was conducted using $MgCl_2$, LiCl, KCl, $CaCl_2$, and LiCl-KCl salts. In Fig. 3(a), the moisture concentration in $MgCl_2$ decreased as the temperature increased from 600°C to 660°C. However, at 725°C, the moisture concentration in the salt began to rise. At 740°C, the salt was observed to be in a molten state during sampling, and the moisture concentration continued to increase, reaching approximately 500 ppm at 750°C. Fig. 3(b) presents the temperature-dependent moisture concentration of LiCl. As the temperature increased from 500°C to 560°C, the moisture concentration decreased, but an increase was observed at 625°C and 630°C. Similarly, in Fig. 3(c), the moisture concentration in KCl decreased as the temperature rose from 650°C to 716°C, followed by an increase at 740°C and 810°C. For $CaCl_2$, as shown in Fig. 3(d), the moisture concentration slightly decreased from 650°C to 710°C, followed by a minor increase at 760°C. A more pronounced increase was observed at 790°C, where a significant standard deviation was also noted. In contrast, Fig. 3(e) demonstrates that the moisture concentration in LiCl-KCl continuously decreased as the temperature increased from 300°C to 500°C.

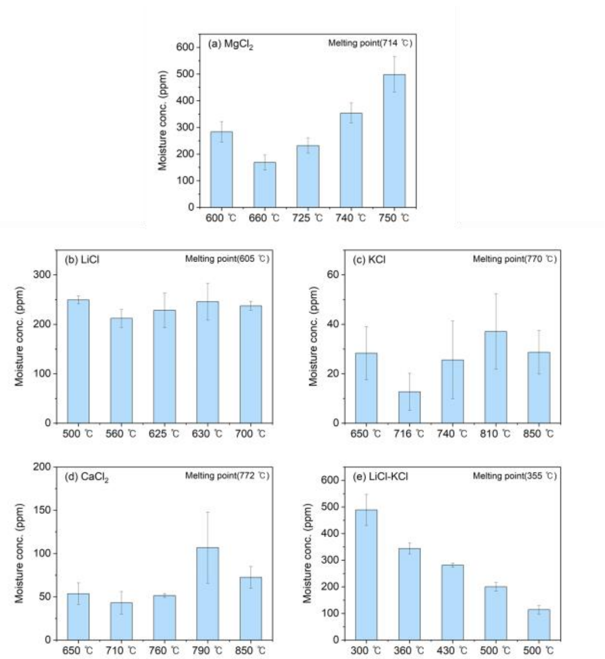


Fig. 3. Moisture concentration at different temperatures before and after the melting point of chloride salts; (a) $MgCl_2$, (b) LiCl, (c) KCl, (d) $CaCl_2$ and (e) LiCl-KCl.

## 4. Conclusions

This study investigated the changes in moisture concentration during the melting process of various chloride salts ($MgCl_2$, LiCl, KCl, $CaCl_2$, and LiCl-KCl). The experimental results showed that $MgCl_2$, LiCl, KCl, and $CaCl_2$ exhibited an increase in moisture concentration upon melting, whereas this phenomenon was not observed in LiCl-KCl. These findings suggest that salts with higher melting points may be more vulnerable to moisture reabsorption during the melting process.

## REFERENCES

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