Electrical Conductivities of UCl_3-LiCl-KCl Molten Salts Measured by Using a Short Time Interval and Multiple-Potential Step Technique

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1. INTRODUCTION

Many physical properties of high-temperature molten salt such as electrical conductivity, viscosity, phase transition and temperature are very critical in designing and operating pyroprocess. Such properties also provide important information with regard to the process operation and nuclear material accountancy. Among the many valuable physical properties, the electrical conductivity is an essential physical property providing information on monovalent and trivalent ions in molten salts. However, almost of the commercially available measurement systems are not adequate for measuring the electrical conductivity of high-temperature corrosive molten salts [1]. Recently, we have developed a new electrical conductivity measurement system installed inside a glove box, which is controlled by a custom-made software based on the LabView program [2].

Uranium trichloride (UCl_3) is one of the most important components in the pyrochemical process because the nuclear spent fuel comprises mainly uranium. The molten salt in the process usually contains up to ~9wt% of UCl_3 so that the physical properties of the molten salt containing a large quantities of UCl_3 are very important in the process. In this work, we have measured and reported the electrical conductivities of the high temperature molten salts containing UCl_3 and lanthanide trichlorides.

2. METHOD

The electrical conductivity measurements of LiCl-KCl molten salts with various compositions of UCl_3, $LaCl_3$, $CeCl_3$, and $NdCl_3$ were performed in a glove box equipped with a high-temperature furnace under an argon atmosphere. In-house designed capillary cell and measurement system were used for the determination of the electrical conductivities of molten salts. In our present study, a chronoamperometry technique featured with short time interval and multiple-potential step was used to minimize measurement errors resulted from polarization. In this technique, the potential is applied for a very short period of time (a few microseconds) to minimize the influence of the polarization of the electrode. With a series of standard solutions with known conductivities, the cell constant was determined from the slope of the peak current at each time interval versus the potential. Subsequently, the same procedure and the same capillary cell were used for the determination of the electrical conductivities with a test sample solution containing 0 to 9 mol% UCl_3 at various temperatures (300 to 630 °C).

3. RESULTS

The measurements of the electrical conductivity revealed one or two phase transition temperatures for the multi-component LiCl-KCl molten salt systems comprising uranium and lanthanides when the temperature was ramping down from 630 to 300 °C.

4. CONCLUSIONS

In the present work, the electrical conductivity measurement technique not only determine the electrical conductivities of LiCl-KCl molten salts containing uranium and lanthanide elements but also show a potential to measure phase transition temperatures of the multi-component molten salts.

Physical property measurement techniques for electrical conductivity and viscosity are under development and will be very useful for safe and efficient process operation. In addition, such fundamental physical properties provide the basis for understanding and predicting the macroscopic behavior of the actinides and lanthanides in the molten salt of the pyroprocess.

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