Enhanced Electrical Conductivity by Modifying LiCl-KCl Mole Fraction at High Temperature

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Abstract*— Thermal batteries use molten salt mixture as electrolyte. The molten salt system lithium chloride-potassium chloride (LiCl-KCl) was chosen for initial investigation. They are preferred because of their compatibility with the electrode and their high conductivity. The electrical conductivity is a key factor for achieving high performance in thermal batteries. A main requirement for molten salt electrolyte, besides high conductivity, is operating temperature. One of the primary factors behind thermal battery active life is molten salt and binder composition properties that are determined simultaneously. Consequently, three factors were investigated to find high electrical conductivity of electrolytes; molten salt composition, temperature range, and binder composition by using equations and data from reliable literature. In this paper, a new composition of LiCl-KCl electrolyte and its optimum temperature were proposed to achieve higher electrical conductivity for LiCl-KCl composition design at high temperature. The electrical conductivity of the new LiCl composition was 44.37 % higher than the electrical conductivity of general LiCl compositions.

***Index Terms*— Composition, Electrical Conductivity, Electrolyte, Mole fraction, LiCl·KCl molten salt.**

I. INTRODUCTION

The military identified the need for a high power density battery with a very long shelf life (up to 25 years) for use in equipment such as guided missiles. Thermal batteries are specially designed according to the requirements for such guidance applications. Thermal batteries contain a molten salt electrolyte that is non-conducting when solid at ambient temperatures, but which becomes an excellent ionic conductor when molten. The principle of operation is producing chemical reactions at the electrodes and molten salt electrolyte of materials to generate electricity energy. It depends on electrical conductivity that is a key factor for achieving high performance of molten salts electrolytes, which plays a key role in thermal batteries.

A. Electrolyte

The electrolyte of thermal battery is a salt mixture which is solid at room temperature and melts once the battery is thermally activated by pyrotechnics. The salt mixture produces an electrically conducting molten salt when it is melted. The electrolyte is a part of the thermal battery as shown in fig.1. The electrolyte separates into cations and anions, which disperse uniformly through molten salt.

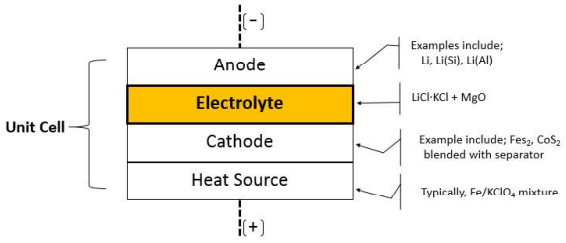

Fig.1. Schematic Representation of a Typical Thermal Battery

An electrolyte consists of a molten salt and binder as follows;

1. Molten Salt

The advantages of molten salts as battery electrolytes have high conductivity so high currents. This work chose lithium chloride-potassium chloride (LiCl-KCl) molten eutectic mixture as the electrolyte for investigation. The factor which determines strength of these salt crystal is called lattice energy or heat energy for ionization. The pure salt of LiCl-KCl mixture salt radius of ions influenced energy for ionization. A LiCl-KCl molten salt is composed of two charged ions: cations (Li^+, K^+) and anions (Cl^-). The Li^+ ions, which are smaller than K^+ ions that may be considered a better glue for holding together the Cl^- anions. The effect of those factors is: as the size of the ions decreases, the lattice energy increases. However, lattice energy of LiCl and KCl which are quite different due to its constituent element. The lattice energy of two LiCl and KCl pure salt is compared in Fig.2.

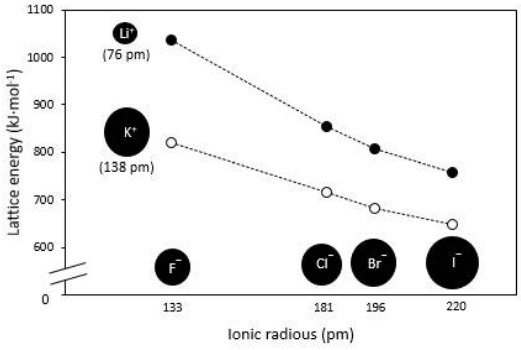

Fig.2. the Influence of LiCl and KCl Pure Salt Ions Radius on the Lattice Energy