Solid Electrolytes for Fluoride Ion Batteries

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Lithium-ion batteries (LIB) are widely in use for portable applications. However, their energy density fall short for transportation and stationary power generations. Moreover, less lithium availability, safety issues are concerns for large scale development of lithium based technologies. This necessitates the search for alternative battery technologies. Many alternative technologies are being developed, which includes earth abundant sodium, magnesium, aluminum based batteries and liquid metal batteries. In this line, recently we have demonstrated a rechargeable fluoride ion battery (1). The battery consists of a metal and a metal fluoride separated by a fluoride conducting solid electrolyte. The battery operates at 150 ºC. The performance of the battery was limited by the use of solid electrolyte. In order to further develop these fluoride ion batteries more efficient fluoride ion conductors are necessary. Thus, in the present study we aim to develop efficient fluoride ion conductors.

Among various metal fluorides, two prototype structures show particularly high fluoride ion conductivity. One is based on fluorite (CaF_2) type structure and another based on or tysonite (LaF_3) type structure. Alkaline-earth fluorides (Ca, Sr, Ba) crystallises in fluorite-type structure and some rare-earth fluorides have a tysonite-type structure (La, Ce, Pr, Sm). In the present study we investigated the fluoride ion conductivity in both structures. We synthesized highly fluoride ion conductive $Ba_{1-x}La_xF_{2+x}$ and $La_{1-x}Ba_xF_{3-x}$ system by mechanical milling. The fluoride ion conductivity was measured by electrochemical impedance spectroscopy. These two structures follow different fluoride conducting mechanisms. Additionally the effect of sintering on the fluoride ion conductivity is investigated. Electrochemical cells were built with BiF_3, CuF_2, and FeF_3 based composites as cathode, $La_{1-x}M_xF_{3-x}$ as electrolyte and Ce metal as anode. Electrochemical studies were done at 150 ºC. The structural and electrochemical characterization will be presented and discussed.

Reference

1. M. Anji Reddy and M. Fichtner, J. Mater. Chem., (2011), 21, 17059 -17062.