Contract No:

This document was prepared in conjunction with work accomplished under Contract No. 89303321CEM000080 with the U.S. Department of Energy (DOE) Office of Environmental Management (EM).

Disclaimer:

Title of Project
Study of Ionic Mass Transport in Non-Conventional Electrolytes for Energy Storage and Carbon Capture Applications.

Project Start and End Dates
Project Start Date: April 2021
Project End Date: Ongoing

Project Highlight
The development and study of novel non-conventional electrolyte and eutectics to advance the field of energy storage for applications in vehicle electrification and grid storage.

Project Team
Principal Investigator: Nathaniel Hardin
Other Others, Patrick Ward, Zachary Duca

Abstract
In the field of energy storage, electrolytes are the materials or liquids used to transport ions or redox active chemicals to facilitate an electrochemical process. Conventional electrolytes are the most common form of electrolyte used and consist of salts dissolved in a liquid solvent medium. While conventional electrolytes are generally inexpensive and work well with lithium-ion batteries, they have many shortfalls however, such as corrosion of the cell, flammability, toxicity, price, and incompatibility with other metals. This project investigates the fundamental properties in nonconventional electrolyte systems with an initial focus on eutectics being made. Using electrochemical methods (Cyclic Voltammetry (CV), Impedance, Conductance, etc.), we are studying the study of electrolyte systems containing ions used for thermal, chemical, or electrochemical energy storage such as Li^{+}, Mg^{2+}, Na^{+}, K^{+}, Al^{3+}, CO_3^{2-}, Cl^{-}, and O^{2-}. This research looks at how ion mobility effects the electrochemical characteristics and properties in green energy applications.

Objectives
- Design and build a cell and perform associated experiments
- Develop novel non-conventional electrolytes for analysis
- Initiate electrolyte characterization tests
- Electrochemically test electrolytes in an energy storage system such as batteries.

REVIEWS AND APPROVALS

1. Authors:

__Nathaniel Hardin_____

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Name and Signature Date

2. Technical Review:

Hector Colon-Mercado_____

Name and Signature Date

3. PI's Manager Signature:

_Mark Barnes _____

Name and Signature Date

4. Intellectual Property Review:

This report has been reviewed by SRNL Legal Counsel for intellectual property considerations and is approved to be publicly published in its current form.

SRNL Legal Signature

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Name and Signature

Introduction

In the field of energy storage batteries have risen to the forefront due to multiple advances and applications. The forefront of these is lithium-ion batteries which have allowed for the development of modern electric vehicles and grid storage technologies. Lithium-ion battery research is however dominated by the use of conventional organic solvents which have numerous downsides. Because of the prevalence of conventional electrolytes, the field of non-conventional electrolyte research is behind conventional electrolytes in both number of papers and developed technology.

This project is focusing on the development and study of non-conventional electrolytes to address this shortfall. So far, this work has been able to develop a novel eutectic electrolyte for potential use in lithium-ion batteries. The developed electrolyte has shown satisfactory performance while also allowing for incites on the development of new electrolytes. The knowledge gained from this research can also be applied to non-lithium-based systems such as sodium, potassium, aluminum, magnesium, and calcium.

Approach

The approach used in this project highlights current knowledge in non-conventional eutectic electrolytes. Specifically, it allows for the study of molecular interactions hydrogen bond donors (in this case methyl carbamate) and acceptors with lithium salts and their ability to form a eutectic. The formulated eutectic is then studied using various electrochemical and spectroscopic characterization techniques to identify positives and shortfalls of the system. This approach allows translation of knowledge gained to other non-lithium-based systems and allows SRNL to develop in the field on non-conventional electrolytes. Specifically, electrochemical measurements such as CVs and galvanostatic cycling data provide us a tool to study the properties of the eutectic electrolyte in a battery. Furthermore, Impedance data allows us to directly measure how the change in eutectic conductance changes with regard to cycling and temperature.

Accomplishments

- Formulated a novel lithium eutectic based on TFSI (Bis(trifluoromethane)sulfonimide) and PF_6 (hexafluorophosphate) salts with methyl carbamate in a ratio of 1:5 Li salt: Methyl carbamate wt:wt
- System cycles in full cell containing lithium titanate anode|eutectic electrolyte|lithium iron phosphate cathode.
- Capacity retention at 0.5 C was 98% after 40 cycles and 95% after 50 cycles at room temperature

- Cycling efficiency is over 98%
- Conductance data shows good conductivity at room temperature
- Data and figures have been developed but we are refraining from adding them to this document while developing external publication and IP.

Future Directions

- Final electrolyte characterization
- Manuscript writing
- Translation of current knowledge to the formation of non-lithium based eutectic electrolytes
- Development and study of novel lithium and non-lithium (sodium, potassium, aluminum, magnesium) non-conventional electrolytes for use in electric vehicles and grid storage applications.

FY 2021 Peer-reviewed/Non-peer reviewed Publications

N/A

Intellectual Property

N/A

Total Number of Post-Doctoral Researchers

Nathaniel Hardin (Eisenhower postdoc and also PI)

Total Number of Student Researchers

N/A