Study of Stable Cathodes and Electrolytes for High Specific Density Lithium-Air Battery

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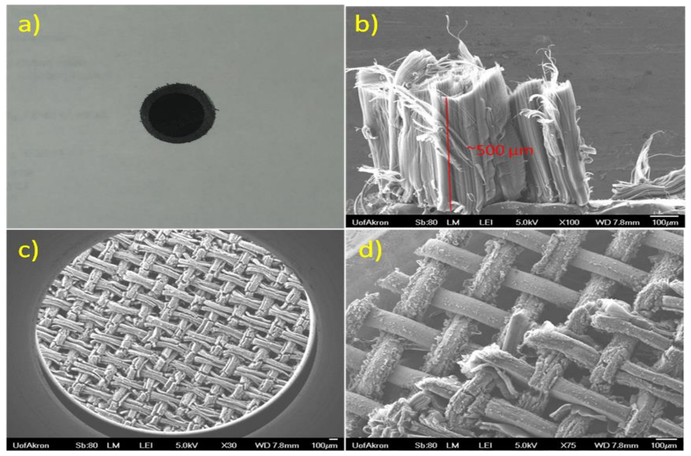
Abstract

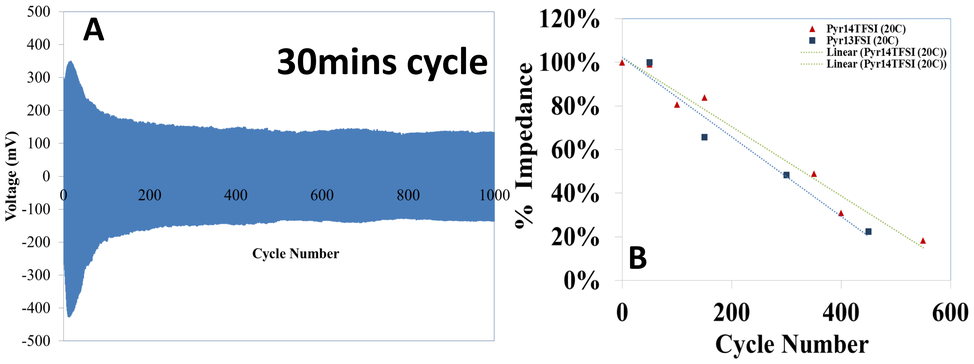
Future NASA missions require high specific energy battery technologies, > 400 Wh/kg. Current NASA missions are using "state-of-the-art" (SOA) Li-ion batteries (LIB), which consist of a metal oxide cathode, a graphite anode and an organic electrolyte. NASA Glenn Research Center is currently studying the physical and electrochemical properties of the anode-electrolyte interface for ionic liquid based Li-air batteries. The voltage-time profiles for Pyr13FSI and Pyr14TFSI ionic liquids electrolytes studies on symmetric cells show low over-potentials and no dendritic lithium morphology. Cyclic voltammetry measurements indicate that these ionic liquids have a wide electrochemical window. As a continuation of this work, sp^2 carbon cathode and these low flammability electrolytes were paired and the physical and electrochemical properties were studied in a Li-air battery system under an oxygen environment.

Vertically Aligned –CNT cathode



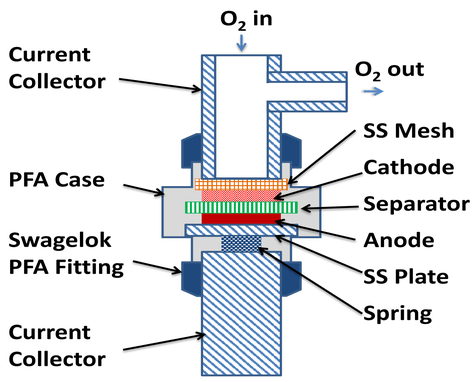
Vertically aligned carbon nanotubes (VACNT) directly grown on stainless steel mesh. The VACNT have a height of 500µm. U. of Akron

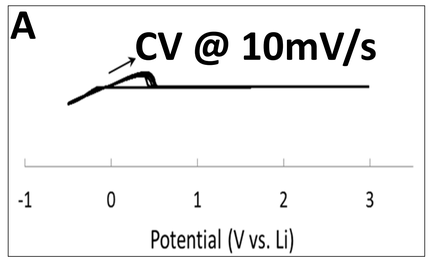
Electrochemical Characterization

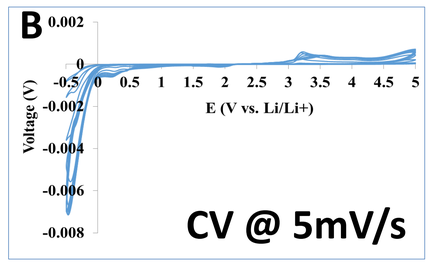


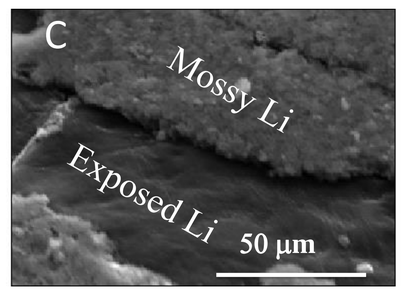
A. Voltage vs. Cycle Number of 0.5m LiTFSI in Pyr14TFSI symmetric cycling at 1mA/cm2, 30 mins cycle. B. % Impedance vs. cycle number for 0.5m LiTFSI in Pyr14TFSI and 0.5m LiFSI in Pyr13FSI

Li-O_2 System







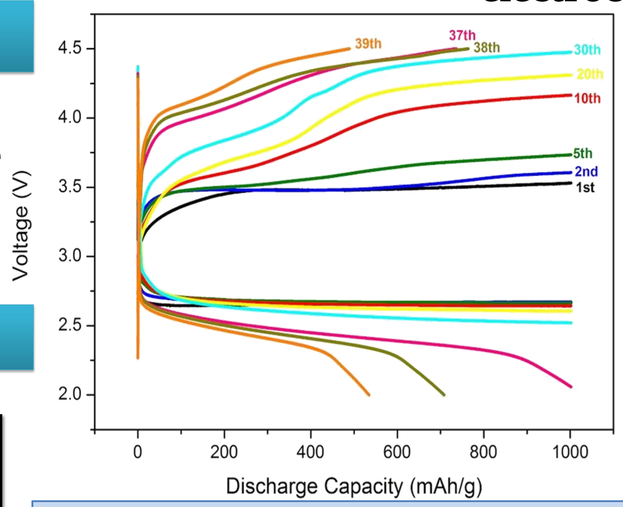


Cyclic voltammetry measurements (vs. Ni) show the ionic liquid has a wide-stable electrochemical window

Applications

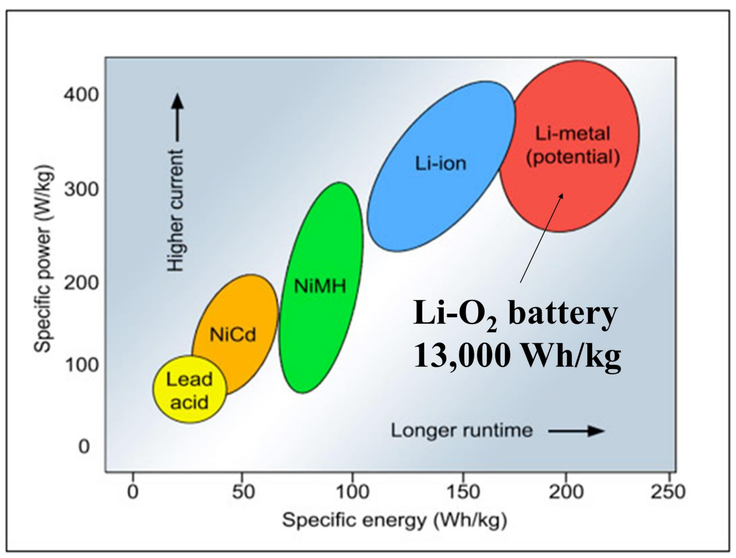
Ionic Liquids Characteristics

- Low flammability
- Thermally and electrochemically stable
- Suppress dendrite formation vs. traditional organic electrolytes



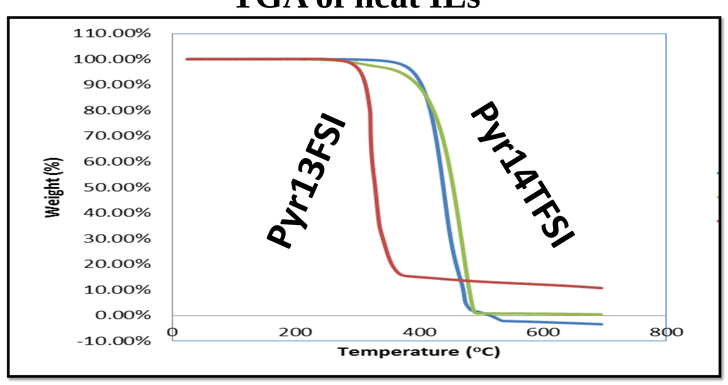
Vertically Aligned-CNT cathode tested in an in-house built Li-O2 system with The (1:1 v/v) NMP LiTFSI/Pyr14TFSI electrolyte U. of Akron

Why Lithium Metal?



Physical Properties of Electrolytes

TGA of neat ILs



ILs show a decomposition temperature >300°C.

Summary

1. The air cathode demonstrated rechargeable cycles for 40 cycles with 1000mAh/g.
2. [Pyr14][TFSI] and [Pyr13][FSI] have decreasing resistance (increasing Li surface area).
3. SEM images at 1000 cycles show no dendrites.
4. Air cathodes with other compositions will be synthetize to enhance the cycle life.