BIFUNCTIONAL (JANUS) FLEXIBLE AND SCALABLE SEPARATORS FOR SODIUM–SULFUR BATTERIES

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PROJECT PROFILE
Topic: Flow Batteries|Vertical: Materials and Systems Innovation
Strategic Pathway: Grow
Project start and finish: FY26-FY27

PROBLEM

- ❑ Advantages of sodium-sulfur (Na-S) batteries
  - Low-cost battery configuration, based on abundance material, high energy density values,
  - Lowest cost battery operating at room temperature
- ❑ Disadvantages of Na-S batteries
  - Low discharge capacity values
  - Capacity decay
  - Shuttling of polysulfides
- ❑ Needed a separator to:
  - i) Minimize passing of polysulfides
  - ii) Suppress dendrite formation

APPROACH

- ❑ Integration of 2 functional separator layers based on electrospun fibers
- ❑ Fiber functionalization through the abundant C≡N groups on the PAN surface
- ❑ Good electrolyte wetting properties and chemical stability
- ❑ Single ion Na^+ conduction
- ❑ Mechanical strength
- ❑ Polysulfide blocking due to physical and electrostatic repulsion
- ❑ Formation of uniform SEI layer (dendrite free)

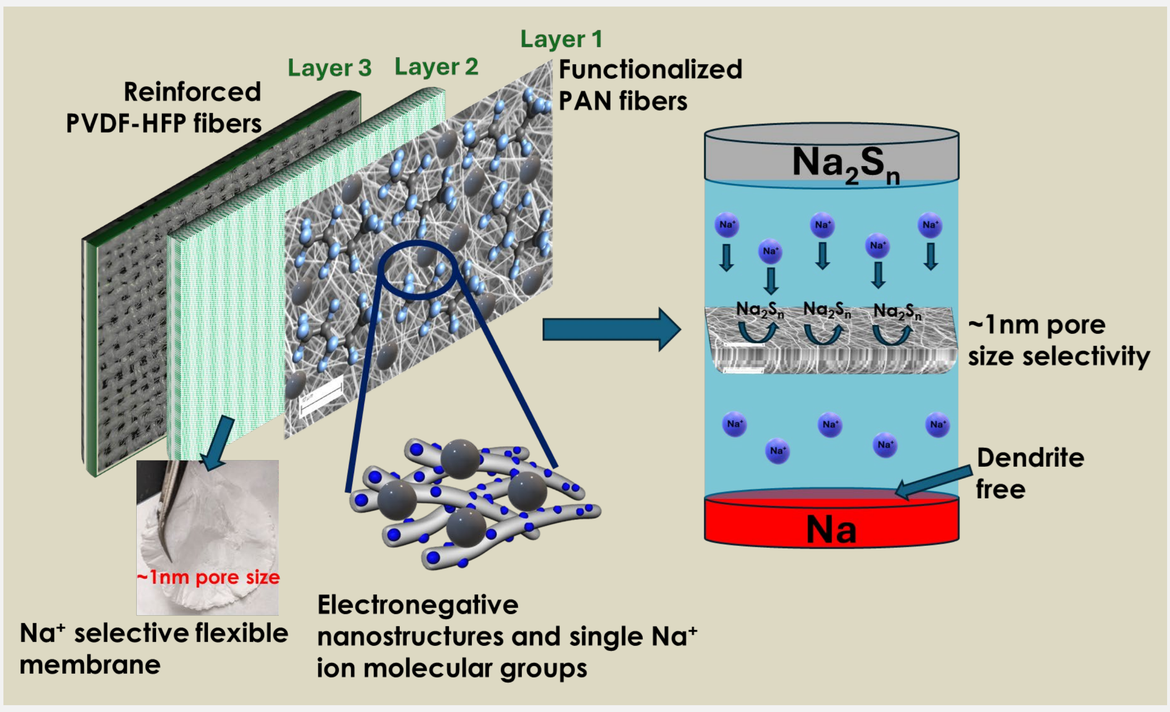

Fig. 1. Schematic illustration of the proposed bifunctional (Janus) separators to allow the Na+ diffusion while blocking the polysulfides. The separators synergistically combine chemical and geometrical selectivity.

RESULTS

- ❑ Stand-alone and flexible dense separator
- ❑ Compressed separator is less than 100 μm thick

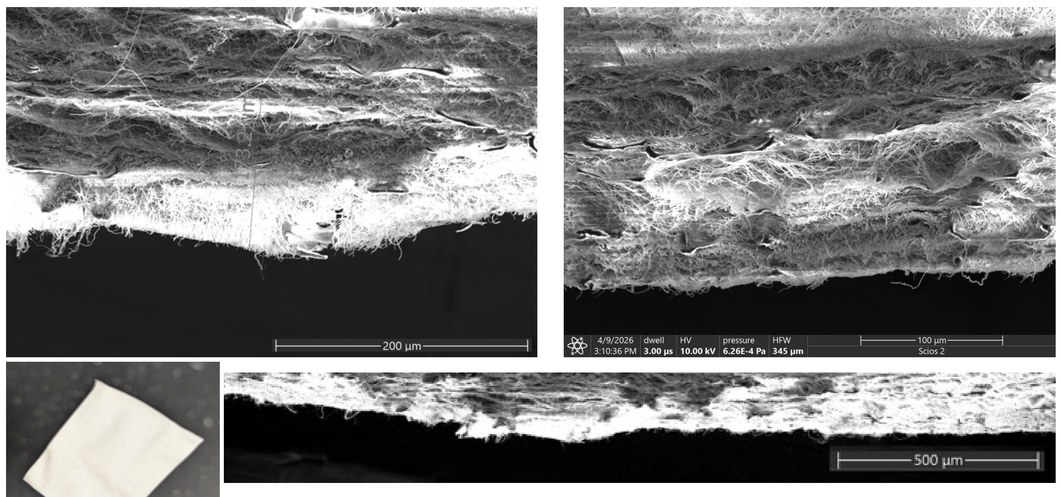

Fig. 2. Optical and SEM cross-sectional images of the membrane separator

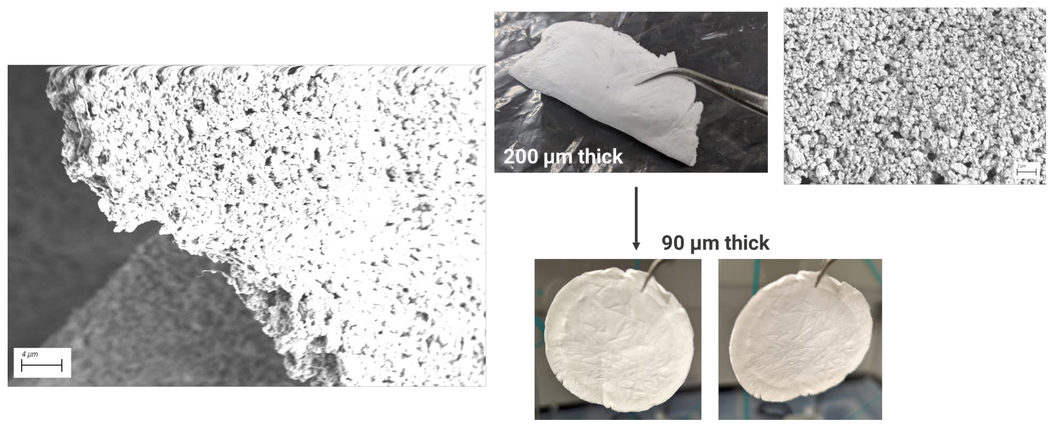

Fig. 3. Hybrid Membranes with Metal Oxides

CONCLUSIONS & IMPACT

- ❑ Flexible, robust separators with controlled porosity
- ❑ Multi-layer configuration
- ❑ Controlled chemical functionality
- ❑ Low impedance values, good wetting properties

The proposed structures will

- ❑ Replace thick and brittle ceramic separators
- ❑ Provide synergistic advances in existing OE-30 projects in the areas of sodium and redox flow batteries

FUTURE DIRECTIONS

- ❑ Investigate and optimize the Na^+ ion transport properties
- ❑ Molecular dynamics and Ab initio simulations
- ❑ Fully developed separators with minimal shuttling of polysulfides
- ❑ Long-term cycling and post-mortem evaluation

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