Exploring Solid-State Electrolyte Separators with Bio-Electrospun Polymer Membranes and Ionic Liquids for Future Eco-Sustainable Solutions

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Introduction

Commercial lithium-ion batteries face safety issues due to hazardous organic electrolytes. Two approaches are being explored to address this: replacing organic solvents with non-volatile, non-flammable ionic liquids, and embedding ionic liquid (IL) electrolytes in polymer matrices to create solid conductive membranes.

Using electrospun membranes as separators, particularly biopolymeric ones, offers advantages in thermal stability, cost, and sustainability. Combining these membranes with ionic liquid electrolytes can result in a safer, more stable, and more efficient battery system.

Experimental Design

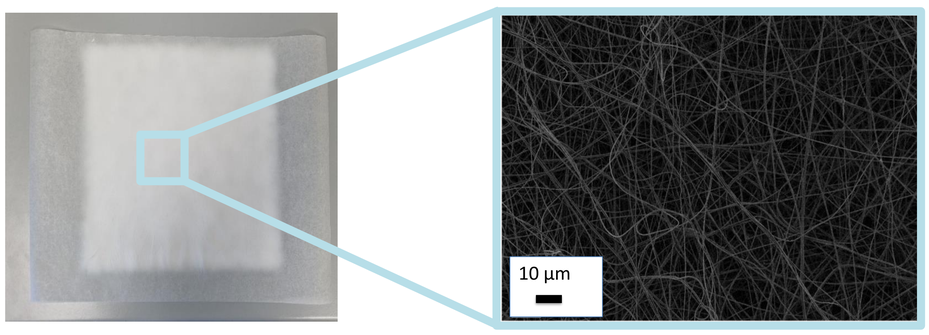
Fabrication of polymeric membranes by electrospinning from polymer solutions such as PCL, PAN/PCL, PSU

Ionic Liquid Synthesis: Water was used as only working solvent for the IL synthesis route

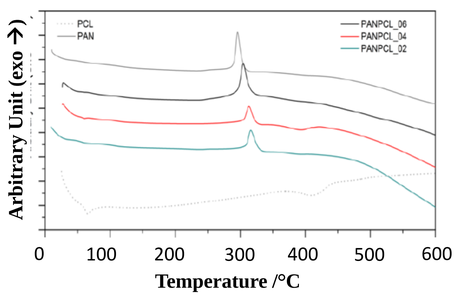
Application in Energy Storage Devices

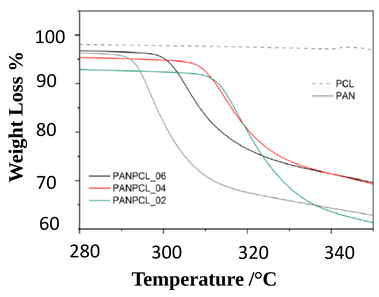
Characterization of Membranes

SEM analysis

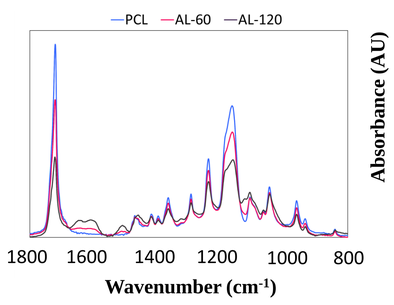


DSC - TGA



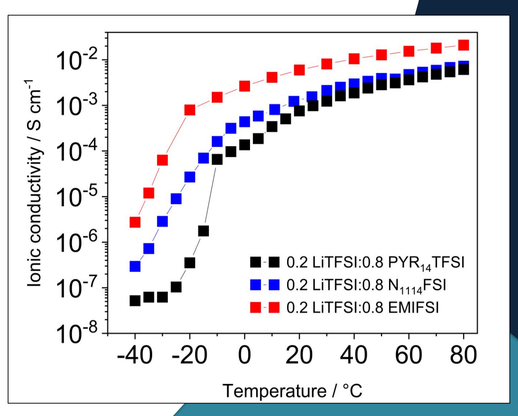


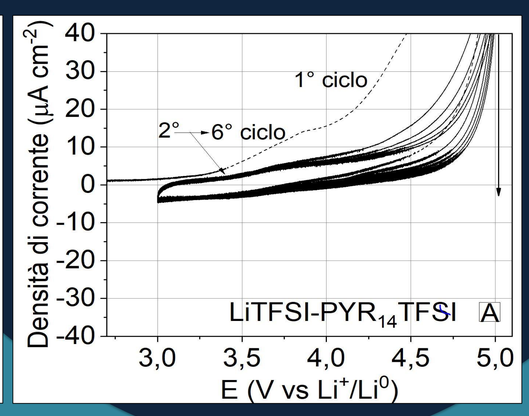
ATR- FTIR

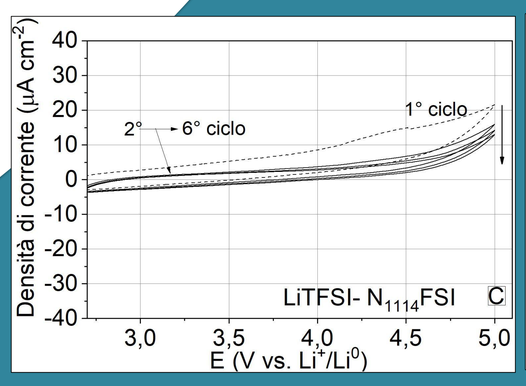


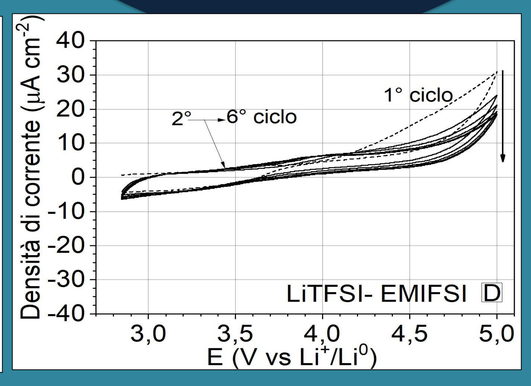
Electrochemical test

Ion transport properties: IL electrolytes shown fast ion transport properties; particularly, that based on EMIFSI exhibits conductivity values approaching 10-3S cm-1 at -20 °C.









Electrochemical stability:
the results show low current flow in the first scan anodic. Less than 20 µA cm^{-2} are recorded above 4.7 V, suggesting negligible electrolyte oxidation up to this cell voltage and indicating wide electrochemical stability of the investigated electrolyte.

Conclusions

The integration of electrospun polymeric membranes as separators with ionic liquid electrolytes represents a significant advancement in battery technology. This synergistic approach enhances safety, stability, and performance by leveraging the separator's protective properties and the electrolyte's conductivity. Consequently, it addresses the evolving demands of modern energy storage systems.

References

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(2) Di Carli, M.; Aurora, A.; Rinaldi, A.; Fiaschini, N.; Prosini, P.P. Preparation of Electrospun Membranes and Their Use as Separators in Lithium Batteries. Batteries 2023, 9, 201.
(3) De Santis, E.; Bergamasco, S.; Rinaldi A.; Araneo R.; Appetecchi G.B.. Explorative approaches for safer, scalable, lithium battery solid electrolyte technologies. 2024, submitted.