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Materials & Methods for High Ionic Conductivity in High-Temperature Amorphous Polymers for Energy Storage

A PEO-ENR blend with high-entropy oxide nanoparticles that enables safe, high-temperature solid-state batteries for EVs, aerospace, and energy.

Researchers from Purdue University have developed a new composite polymer blend electrolyte designed for high-temperature energy storage applications. This overcomes the limitations of current lithium-ion batteries, such as flammability, performance degradation, and failure to operate safely at high temperatures. The composite polymer combines polyethylene oxide (PEO) and epoxidized natural rubber (ENR), with added high-entropy oxide (HEO) nanoparticles to enhance ionic conductivity.

The blend utilizes the high polarity and salt-dissolving capabilities of PEOs, while ENR reduces the crystallinity of PEO and increases the melting point of the blend. HEO nanoparticles with ultrahigh dielectric constants are employed for anion salt dissociation in the blend and reduce ion pairing and aggregation, resulting in higher concentrations of free ions for effective conductivity. Thus, this blend possesses superior thermal stability and ionic conductivity at temperatures well beyond the stability of current liquid electrolytes.

Technology Validation:

The technology was validated through advanced synthesis of HEO nanoparticles, confirmed via XRD, and the fabrication of composite polymer electrolytes using PEO and ENR. Ionic conductivity was measured using EIS, showing significant improvements with added HEO nanoparticles, while FTIR demonstrated enhanced free ion availability. Thermal stability and reduced activation energy for ion transport were confirmed through DSC and the VTF model, proving the material's efficacy for high-temperature energy storage applications.

Advantages:

Technology ID
2025-MARI-70966

Category
Chemicals & Advanced Materials/Polymer Science & Smart Materials
Aerospace & Defense/Defense Electronics & Surveillance Technologies
Aerospace & Defense/Autonomous Systems (UAVs & AVs)

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-Safe operation at high temperatures

-Improved battery performance

-Better electrode contact, potentially unlocking additional anode chemistries with solid-state electrolytes

-Versatile across industries

Applications:

-Electric vehicles (>100C operation)

-Aerospace (satellites, spacecrafts, rovers and landers)

-Military equipment (missiles and drones)

-Renewable energy (concentrated solar power, geothermal)

-Oil and gas (downhole tools, monitoring equipment)

-Industrial (metal smelting, chemical manufacturing, high power machinery)

TRL: 3

Intellectual Property:

Provisional-Patent, 2024-12-03, United States

Keywords: Materials and Manufacturing , Green Technology , renewable energy storage, Batteries, solid state