National Aeronautics and
Space Administration

Advanced Copolymer Gel Electrolyte for Use in Electric and Hybrid Electric Vehicles

Dramatically improves battery safety and increases battery life

TECHNOLOGY OPPORTUNITY

NASA's Glenn Research Center invites companies to license its advanced copolymer gel electrolyte capable of producing batteries with higher energy density than ever before. Because it does not require the addition of volatile or flammable solvents, this new technology offers enhanced safety benefits. Cured at room temperature, the gel can hold over four times its weight in liquid additives, while maintaining good dimensional stability. NASA's gel electrolyte is environmentally friendly, inexpensive, and safe to manufacture, producing batteries with high ionic conductivity, high cycling stability, robust mechanical strength, and increased cycle life.

BENEFITS

- **Improved safety:** Requires no volatile organic compounds, producing a safer and more environmentally friendly battery
- **Improved battery life:** Provides 400 percent liquid saturation (more than four times its weight in liquid additives)
- **Lighter weight:** Uses a thin foil casing, which is 20 percent lighter than the hard shell case needed for lithium-ion batteries
- **Higher specific energy:** Enables a thinner battery
- **Flexible processing:** Accommodates both ionic and organic liquids
- **Simplified fabrication:** Straightforward synthesis method is versatile and can be cured at low temperatures
- **Increased operating temperature range:** Provides high ionic conductivity at ambient and high temperatures; can be used at subambient temperatures by employing solvents
- **Dimensionally stable:** Offers robust mechanical strength due to cross-linked rod-coil structure and aluminum oxide nanoparticles
- **Low interfacial resistance:** Aluminum oxide nanoparticles give an order of magnitude improvement at electrode interfaces

APPLICATIONS

This electrolyte technology would enhance the performance of rechargeable lithium ion polymer gel batteries in the following automotive applications:

- Electric vehicles (EVs)
- Hybrid electric vehicles (HEVs)
- Plug-in hybrid electric vehicles (PHEVs)
- Microhybrid energy storage systems
- Start/stop applications in vehicles

TECHNOLOGY DETAILS

NASA developed the technology to enhance the safety and performance of lithium-based polymer batteries used in aerospace applications, which need to work at temperatures ranging from –70 to +70 °C. NASA scientists created the electrolyte as a polyimide-polyethylene oxide (PEO) rod-coil copolymer gel with a highly cross-linked three-dimensional structure. The resulting nanoscale voids are filled with liquid and, when incorporated with ionic liquids, they can realize an increase in ionic conductivity of two orders of magnitude.

HOW IT WORKS

This technology consists of a composite material with the cross-linked structure of the copolymer, which creates nanoscale voids. The void space is filled with a liquid, and when ionic liquids are incorporated, an increase in ionic conductivity of two orders of magnitude can be achieved. Diamine and dianhydride are reacted and cured in solution to produce an amine end-capped oligomer. The reaction with a trifunctional molecule yields a fully three-dimensional, cross-linked polymer web. The rod-coil copolymer is believed to exhibit a higher liquid uptake than any other material known in a lithium-ion battery.

WHY IT IS BETTER

PEO (and materials based on PEO) is a traditional polymer electrolyte in lithium-ion batteries. However, with conventional PEO, lithium ion conductivity is two orders of magnitude too low for advanced battery designs. Also, PEO melts at temperatures above 80 ºC and does not have good dimensional stability. Other gel electrolytes for lithium batteries are made from polyvinylidene fluoride, which has a less flexible matrix, is less environmentally friendly, and is typically more expensive to manufacture.

An advanced battery made with NASA's gel electrolyte will have enhanced performance and be safer than any existing batteries, because there are no volatile or flammable components. The copolymer has a large capacity, holding more than four times its weight in liquid. Its high ionic conductivity improves lithium ion conductivity over a wide temperature range (particularly at room temperature) and enhances battery usefulness. Its cross-linked rod-coil structure and aluminum oxide nanoparticles provide mechanical strength with low interfacial resistance, enabling an order of magnitude improvement at electrode interfaces.

PATENTS

Glenn has both patents and a patent pending on these technologies (U.S. Patent Nos. 7,704,622, 6,881,820, and 6,855,433).

LICENSING AND PARTNERING OPPORTUNITIES

Glenn's Office of Technology Partnerships and Planning seeks to transfer technology to and from NASA to benefit the space program and U.S. industry. NASA invites companies to consider licensing the Advanced Copolymer Gel Electrolyte suite of technologies (LEW–18205–1, LEW–17592–1, LEW–17299–1, and LEW–17299–2).

FOR MORE INFORMATION

For more information about this and other technology licensing opportunities, please contact

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