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Asymmetric Ether Solvents for High-Performance Lithium-Metal Batteries

Stanford researchers have developed a new class of asymmetric ether solvents — both non-fluorinated and fluorinated — for next-generation lithium-metal batteries. These innovative solvents, which include 1,2-methoxy ethoxy ethane (MEE) and its fluorinated derivatives (F1MEE, F2MEE, F3MEE), are synthesized *via* scalable methods from widely available chemical feedstocks and can serve as core components in advanced battery electrolytes.

Lithium-metal batteries promise much higher energy density than conventional lithium-ion batteries, but their commercial adoption has been hindered by poor cycling stability, low coulombic efficiency, and safety concerns stemming from unstable solid-electrolyte interphases (SEI) and dendrite formation. The inventors' new asymmetric ether solvents address these challenges by optimizing lithium-ion solvation and promoting the formation of stable, robust SEI layers. This results in electrolytes that deliver high coulombic efficiency (up to 99.5%), low overpotential, and exceptional cycling stability across a range of high-voltage and high-rate battery electrode chemistries — including $LiFePO_4$ (LFP), $LiNi_{0.8}Mn_{0.1}Co_{0.1}O_2$ (NMC811), sulfurized polyacrylonitrile (SPAN), and silicon electrodes.

Notably, F3MEE-based electrolytes combine exceptional ionic conductivity with enhanced oxidative stability and enable robust operation in demanding applications such as electric vehicles, electric vertical take-off and landing (eVTOL) aircraft, and grid storage. This technology offers a practical, scalable pathway to safer, longer-lasting, and higher-performing lithium-metal batteries, unlocking new possibilities for energy storage and electrified transportation.

Stage of Development

Proof of concept — validated in laboratory-scale lithium-metal batteries.

Applications

- Lithium-based batteries for electric vehicles (EVs) and eVTOL aircraft
- Grid-scale lithium-metal energy storage systems
- High-performance power sources for advanced consumer electronics

Advantages

- Supports high coulombic efficiency and cycling stability with low overpotential
- Offers enhanced oxidative stability and rate performance for high-voltage operation
- Facile and scalable synthesis from common feedstocks
- Broad compatibility with diverse battery electrodes

Publications

- Choi, I.R., Chen, Y., Shah, A., *et al.* (2025). Asymmetric ether solvents for high-rate lithium metal batteries. *Nature Energy*, **10**, 365–379.

Innovators

- Il Rok Choi
- Yangju Lin
- Zhenan Bao
- Yi Cui

Licensing Contact

Evan Elder

Associate Director, Licensing and Strategic Alliances, Physica

Email