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Institute of Energy and Climate Research
Ionics in Energy Storage (IEK-12)

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Novel Non-Aqueous Liquid Electrolytes for High-Performance Lithium Secondary Batteries

Technology Description

Our technology comprises novel non-aqueous liquid electrolytes that can be used in lithium-ion, lithium-metal, and lithium-sulfur secondary batteries. As solvents, the electrolytes include non-linear organic carbonates, such as propylene carbonate, as well as noval sulfur-based additives and co-solvents. The goal is to provide a new liquid electrolyte for future battery applications that is liquid and highly conductive over a wide temperature range. It shows an improved ion transport, good cycling properties, and a long lifespan (>2000 charging cycles), especially when used with carbon-based electrodes. The use of volatile and flammable substances, particularly linear carbonates, was avoided to ensure safety of the invention.

Problem

Conventional non-aqueous, aprotic electrolytes used in most commercial rechargeable lithium-ion batteries contain organic carbonates, along with lithium hexafluorophosphate as a conductive salt. However, some of these electrolytes have a crucial drawback due to their high melting point, resulting in poor battery performance at low temperatures. Linear carbonates are added to facilitate ion transport, but their high volatility and flammability pose safety risks. Therefore, there is a need for alternative solvents with high relative permittivity, capable of forming stable protective layers on both anode and cathode, while remaining liquid over a wide temperature range. Various additives and co-solvents have been explored to address these issues, but finding additives that can simultaneously protect the cathode remains a challenge.

Solution

The invention solves these challenges by using propylene carbonate-based liquid electrolyte in combination with cyclic sulfoxides (e.g., tetrahydrothiophene-1-oxide) as additive or co-solvents with specific characteristics. The electrolyte shows advantages like a high specific discharge capacity and high relative permittivity to enable high solubility

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More Information
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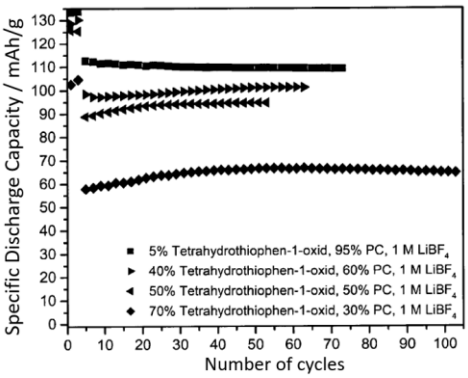

and dissociation of the lithium salt. It is also able to form stable protective layers on the electrodes, particularly an anode protective layer (SEI) and a cathode protective layer (CEI), which are both permeable to lithium ions and insulating to prevent irreversible oxidation and reduction of the solvent. The invention particularly proposes a propylene carbonate-based electrolyte with the features described comprehensively in the invention's main claim.

Potential Use

Our electrolytes are a safe option for use in future lithium secondary batteries. It has similar high flash points and boiling points to other non-linear organic carbonates, making it suitable for applications in stationary energy storage systems, including private households. The electrolyte poses no risks to human health and can be safely handled. It exhibits improved ion transport and reversible capacity, allowing for high-capacity and long-lasting batteries. The electrolyte also performs well at low temperatures, with increased conductivity and reduced crystallization. These properties make it suitable for use in cold regions and space applications. The electrolyte shows good compatibility with carbon-based electrodes and forms effective protective layers on both carbon-based anodes and transition metal cathodes.

Development Status and Next Steps

Forschungszentrum Jülich has extensive expertise in this field and holds several patents. The technology described above has already been initially verified through prototypes and is continuously being developed further. The Institute of Energy and Climate Research (IEK-12) – Ionics in Energy Storage – already cooperates with numerous national and international companies and scientific partners. Forschungszentrum Jülich focuses on energy and cost-efficient devices, suitable for various emerging technologies. We are continuously seeking for cooperation partners and/or licensees in this and adjacent areas of research and applications.

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