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

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Sequential and Convergent Synthesis of Ordered Block Copolymers (BCPs) for Advanced Battery Applications

Technology Description

Our new technology involves a method for the sequential and convergent production of ordered block copolymers (BCPs), consisting of at least one nonpolar and one polar polymer block. It also comprises specific block copolymers with short polar chains of very uniform chain length and their use as polymer electrolytes in advanced secondary alkali batteries. We thus overcome known disadvantages of the prior art and propose a highly scalable synthesis route that is simple, cost-effective, and delivers high yields, resulting in ordered block copolymers with adjustable and defined structure and molecular weight of each block.

Problem

Conventional synthesis routes of ordered block copolymers for use as polymer electrolytes in energy storage devices restrict the practical application in demanding and energy-intensive fields of application such as electromobility. Existing polymer electrolytes lack the ability to independently control mechanical stability and lithium-ion conductivity, which is crucial for suppressing lithium dendrite growth. Previous approaches also included limitations such as the need for a complex and expensive multi-step synthesis processes, involving the use of toxic and highly explosive ethylene oxide gas, and the lack of synthesis reproducibility and possibility, especially for very short polar poly(ethylene oxide) (PEO) chains. So, there is a need for improved synthesis approaches which address these limitations, offering simplicity, safety, scalability, and efficiency while ensuring the reproducibility of the resulting block copolymers.

Solution

Our approach provides a highly reproducible and uniform distribution of chain lengths for block copolymers (BCPs), making them suitable for the construction of advanced polymer electrolytes. Also, highly asymmetric BCPs can be created, which are characterised by strongly differing block lengths and/or by strongly differing polarities, maintaining a high overall ionic conductivity (see graph). Additionally, our method offers a low

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Keywords: Block copolymers, BCP, polymer blocks, polymer electrolytes, polydispersity index, PDI

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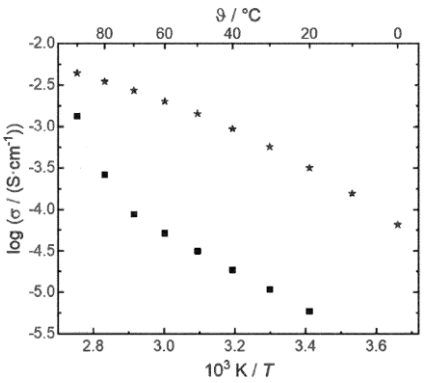
synthesis effort and enables the attachment of very short polar blocks in a reproducible manner. The resulting block copolymers have a very narrow molecular weight distribution with a polydispersity index (PDI) lower than 1.02. Moreover, the technology allows for the incorporation of specific ion-conducting segments, such as polymer segments that facilitate fast lithium-ion transport. Overall, we provide easier access to self-organized and highly structured block copolymers with desirable mechanical and ion-conducting properties.



Potential Use

Our invention finds relevance in the development of advanced secondary battery technology and thus offer attractive opportunities for potential licensees. The highly reproducible and ordered structure of the described block copolymers with short polar chains of very uniform chain length makes them ideal for use as polymer electrolytes in secondary alkaline batteries. The unique advantages of these block copolymers, such as their uniform structure and low PDI contribute to the provision of high ion conductivity over a wide temperature range, comparable to liquid electrolytes.

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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