**Roll-to-roll production of alkaline stable anion-exchange membrane for electrochemical energy devices**

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**Abstract**

The intrinsically intermittent nature of renewable energy (e.g., solar and wind) urgently requires the electrochemical energy storage and conversion technology to improve its utilization efficiency1-3. Wherein, aqueous redox flow batteries, water electrolysis, fuel cells as well as ammonia synthesis are typically technologies for realizing electric-chemical energy conversion and storage. Ion conduction polyelectrolyte membranes which are common and core components of these technologies4-6 act as ion transport carriers and electrolyte separators. With increasing reliance on low-cost materials, anion exchange membranes (AEMs) with the advantage of low manufacturing costs and allowing the use of non-precious metal catalysts, are highly competitive with proton exchange membranes (PEMs)7. Therefore, scalable energy-effective AEMs with high ionic conductivity and stability are urgently needed for large-scale grid energy storage and conversion applications.

Herein, we adopt various methods, including Friedel-Crafts alkylation, Suzuki coupling, and the Murray coupling reactions, to synthesize the stable polymer backbones. On this basis, strategies such as morphological engineering and helical conformation regulation derived from polymer topology regulation have been developed to construct ion transport channels. Moreover, the introduction of distorted/rigid monomers in molecular structure design aimed at increasing the free volume to prepare intrinsically ultramicropore AEMs. All these developed strategies significantly enhanced the performance of AEMs. Among them, the AEM synthesized based on Friedel-Crafts alkylation has successfully achieved pilot-scale production. Such AEM has been roll-to-roll manufactured with a width > 1000 mm and a capacity of 20000 m2 y-1. The high anion conductivity and alkaline stability enable the fabricated AEM present fascinating performance and long-term operated stability in a variety of electrochemical devices represented by neutral aqueous organic redox flow battery (energy efficiency of 77 % at 100 mA cm-2, and durability over 1100 h) and water electrolysis (current density of 5.4 A cm-2 at 1.8 V, 90 oC, and durability over 3000 h), etc.

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