Chemical Engineering Thesis Defense

Zeolite Synthesis and Its Application as a Separator For Safe Li-ion and Li-metal Batteries

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Abstract

Lithium-ion and lithium-metal batteries represent a predominant energy storage solution with the potential to address the impending global energy crisis arising from limited non-renewable resources. However, these batteries face significant safety challenges that hinder their commercialization. The conventional polymeric separators and electrolytes have poor thermal stability and fireproof properties making them prone to thermal runaway that causes fire hazards and explosions when the battery is subjected to extreme operating conditions. To address this issue, various materials have been investigated for their use as separators. However, polymeric, ceramic, and pure inorganic material based separators have a trade-off between the safety and electrochemical performance. This is where zeolites emerge as a promising solution, offering favorable thermal and electrochemical characteristics.

The zeolites are coated onto the cathode as a separator using scalable blade coating method. These separators are non-flammable with high thermal stability and electrolyte wettability. Furthermore, high intercrystalline porosity of the zeolites enhance electrolyte uptake and the presence of intracrystalline pores helps in homogenizing the Li-ion flux at anode resulting in the improved electrochemical performance. This research delves into the preparation of zeolite separators using a commercial zeolite and spherical silicalite to study their safety and electrochemical performance in lithium-ion batteries. At low C-rates, both zeolites exhibited excellent capacity retention and capacity density displaying their potential in advancing high-performance safe lithium-ion batteries.

Furthermore, based on the previous study made by our research group on the impact of zeolite morphology on electrochemical performance, plate silicalite demonstrated superior electrochemical performance with both lithium-ion and lithium metal batteries. However, achieving precise control over plate silicalite particle size and morphology using the existing synthesis procedure has proven challenging. Thus, the modification of process conditions is studied to enhance control over particle size, aspect ratio, yield, and facilitate a more efficient scaling-up process.

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