Materials Processing to Create Fibrous Structures and its Application to Battery Manufacturing

Abstract

We have developed electrospinning-based manufacturing processing applicable for battery systems that involve metallic lithium. With manufacturing feasibility, electrospinning is a widely used to create nano- and micro-porous layers of functional fibers. The electrospinning-produced layers can afford a wide variety of functionalities applicable to biomedical templates, separation membranes, and energy storage by tailoring fiber compositions. However, its manufacturing capability is limited at producing randomly-oriented fibrous structures. Topology and tortuosity of the electrospun fibers are poorly controlled, making it difficult to systematically investigate structure-property relationships for any given applications, especially electrochemical systems.

In this presentation, we will demonstrate how to we have obtained precise geometrical control of fiber construction by advancing the electrospinning method. Unlike conventional electrospinning, our approach employs a mobile stage that allows alignment of fibers. Produced fibrous structures will be used to construct the anode current collectors of an anode-free battery, one of the most promising energy-dense batteries beyond the Li-ion. While incorporating Li metal has proven difficult due to uncontrolled dendrite growth upon repetitive Li plating and stripping, we found that the anode current collector reinforced by the three-dimensional fibrous structure enhances Li storage efficiency over the extended number of cycles, compared to the planar current collector. We will discuss the effect of fiber compositions and controlled geometrical configurations on stabilizing Li plating and stripping morphologies to suppress Li dendrite growth. We will also provide a cell design principle to fundamentally extend the cycle life of anode-free batteries. Significantly, we consider that battery manufacturing advanced by this work will offer a systematic strategy to develop next-generation energy storage systems for a sustainable energy future.