Thin Film to Improve Lithium Batteries

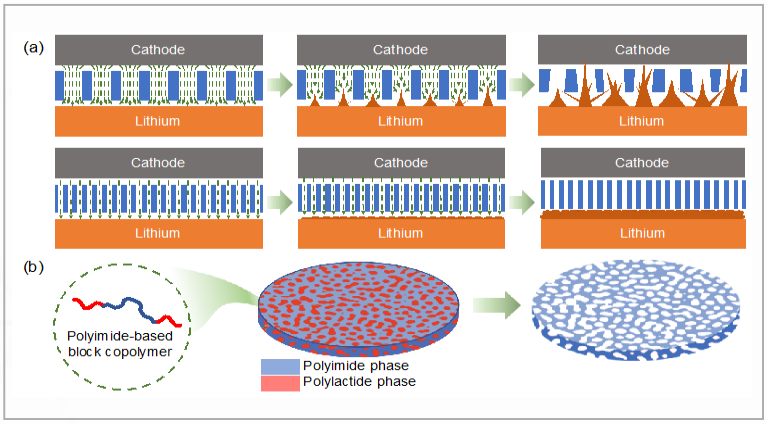
VTIP 22-137: "Mesoporous Polyimide Thin Films as Dendrite-Suppressing Separators for Batteries"

THE CHALLENGE

Lithium ion batteries are extremely popular in modern electronics due to their high energy and power density as well as a lack of memory effect. Unfortunately, Li ion batteries are hampered with problems involving internal short circuits due to lithium dendrite growth. Current coating technologies used to impede dendrite formation have macropores which still enable partial dendrite formation.

OUR SOLUTION

The Liu lab at Virginia Tech has developed a mesoporous polyimide separator for dendrite suppression produced via slow thermolysis of a polylactide-b-polyimide-b-polylactide triblock copolymers. The thermolysis in a temperature range of 250-400 °C gradually removed polylactide to create mesopores with controlled diameters in the range of 10-50 nm, without perturbing the polyimide matrix. The resulting mesoporous polyimide thin films exhibited a storage modulus of 1.80 GPa at room temperature and produced excellent dendrite-suppressing capability. The membrane is flame retardant and survives high temperatures up to 500°C.



Effects of pore size and modulus of separators on dendrite suppression. (a) Upper: conventional macroporous PP/PE/PP separator induces non-uniform Li+ flux and promotes uneven lithium deposition and dendritic growth. The macropores (40 - 400 nm wide) and low modulus of PP/PE/PP separators (~0.5 GPa in the transverse direction) cannot suppress lithium dendrites, resulting in short circuits. Lower: the mesoporous polyimide separator provides uniform Li+ flux and ensures more even lithium deposition. The mesopores and high modulus (1.80 GPa) suppress the invasion of dendrites for safe cycling. The tortuous macro/mesopores are simplified as straight pores, in which the green dashed lines represent the Li+ flux. (b) Our strategy to prepare mesoporous, high-modulus polyimide separators from a polyimide-based block copolymer. The solution casting and chemical imidization of PLA-b-PAA-b-PLA forms a polyimide-based thin film. The subsequent thermolysis produces a mesoporous polyimide separator for the lithium-metal battery.

CONTACT:

David Irvin
davidi86@vt.edu
540-231-7376