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Shear thickening electrolytes for lithium batteries

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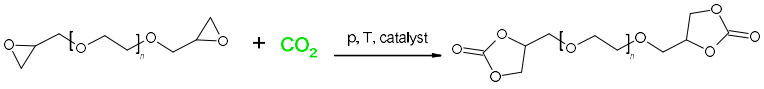
Shear thickening electrolytes (STE) increase their viscosity sharply under shear stress, enhancing lithium battery safety by forming a protective barrier during impacts, such as car crashes. Under normal conditions, they remain liquid, ensuring high ionic conductivity. STEs were developed using silica nanoparticles and lithium salt in a polymer matrix of polyethylene glycol and polypropylene glycol, end-capped with stable five-membered carbonate rings.

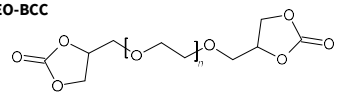
Preparation of electrolytes



Matrix

Lithium salt

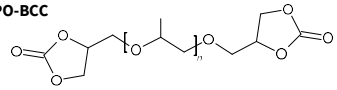
EO-BCC



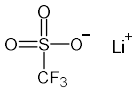
M_n = 970 g mol^{-1}

or

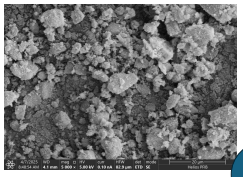
PO-BCC

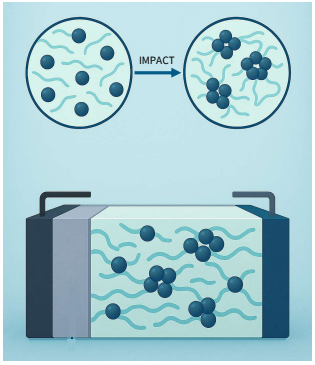


M_n = 690 g mol^{-1}



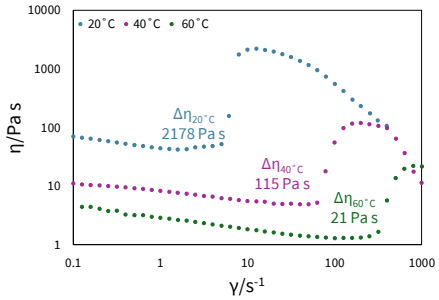
Rheology modifier



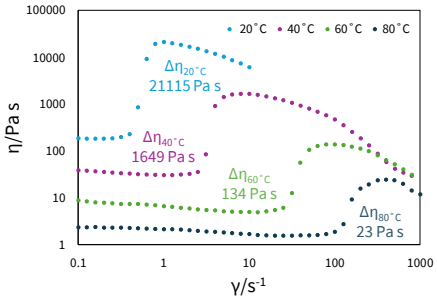


Rheological properties

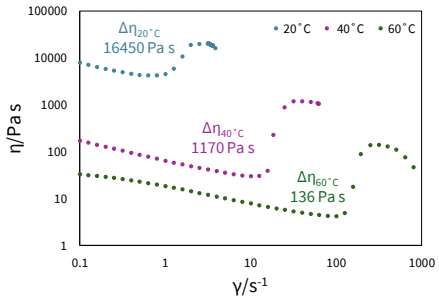
EO-BCC + 20% SiO_2



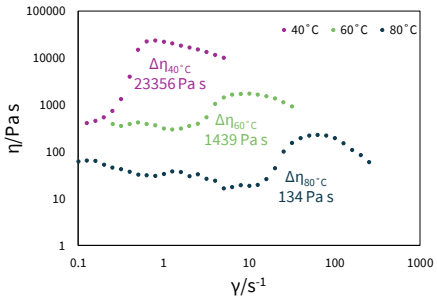
EO-BCC + 20% SiO_2 + LiTf



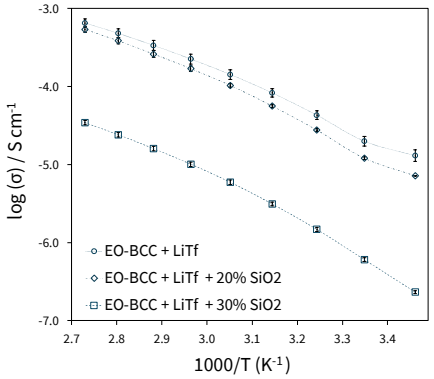
PO-BCC + 20% SiO_2

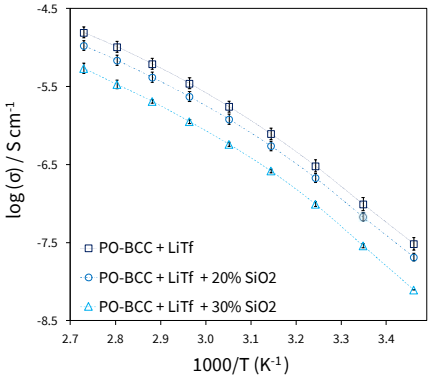


PO-BCC + 20% SiO_2 + LiTf



Electrochemical properties





Summary

- Electrolytes containing EO-BCC and PO-BCC were obtained. Lithium trifluoromethanesulfonate (LiTf) was used as the salt, and fumed nanosilica served as the rheology modifier.
- Both the dispersions containing the bicyclic compounds and the electrolytes derived from them are shear-thickening fluids.
- These materials maintain shear-thickening behavior even at elevated temperatures.
- Dispersions based on EO-BCC exhibit lower viscosity jumps compared to those with PO-BCC. However, the electrolytes obtained from EO-BCC demonstrate conductivity approximately three orders of magnitude higher.
- The highest ionic conductivity observed for shear-thickening electrolytes—approximately 10^{-4} S cm^{-1} at 60 °C—was achieved using EO-BCC with 10 wt% LiTf.
- In the case of EO-BCC, the addition of 20 wt% fumed silica slightly reduces conductivity, but enables the formation of a shear-thickening electrolyte with a viscosity jump exceeding 20,000 Pa s.