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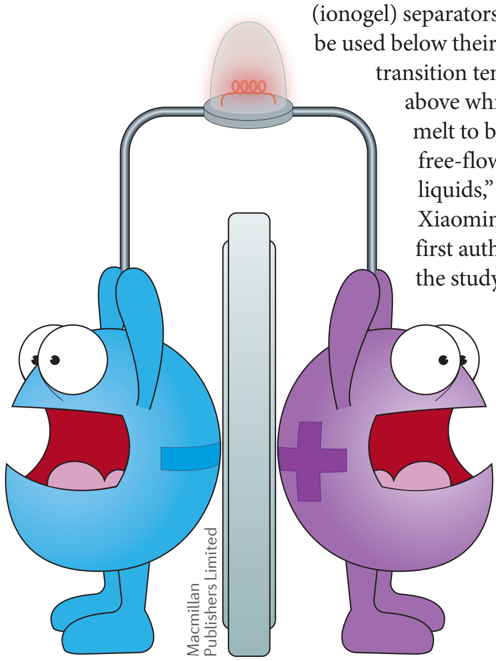
ENERGY-STORAGE DEVICES

All charged up

> “we have developed an easy-to-use methodology to prepare robust SILGMs by incorporating ionogels into commercial porous supports”

Although ionic liquid-based gels are promising materials for use in energy-storage devices — in which they can function as both the solid electrolyte and the separator — their use as separator materials is restricted because their sol–gel transition temperature imposes an upper limit on the operating temperature of devices. Now, writing in *Advanced Energy Materials*, Youting Wu, Douglas MacFarlane and colleagues report a new method for the fabrication of supported ionic liquid gel membranes (SILGMs) that exhibit the high mechanical stability and ionic conductivities required for use in supercapacitors.

“Ionic liquid-based gel (ionogel) separators can only be used below their sol–gel transition temperature, above which they melt to become free-flowing liquids,” explains Xiaomin Zhang, first author of the study.



“To overcome this limitation, we have developed an easy-to-use methodology to prepare robust SILGMs by incorporating ionogels into commercial porous supports to provide the necessary combination of thermal stability and mechanical properties for operation even under extreme conditions, such as high temperatures, puncturing or an external fire.”

Zhang and co-workers first prepare an ionogel by confining an ionic liquid within a polymer matrix. Gelation of 1-ethyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide ($[C_2C_1im][NTf_2]$) and poly(vinylidene fluoride-co-hexafluoropropylene) occurs at polymer concentrations as low as 4 wt%, and the $[C_2C_1im][NTf_2]$-based ionogel is stable over a wide temperature range and has an ionic conductivity of 8.6 mS cm^{-1} at 25 °C. The team prepare the SILGM using a melt-infusion method, whereby the ionogel on a porous support — poly(vinylidene fluoride) — is heated above its sol–gel transition temperature (105 °C); the resulting liquid spontaneously absorbs into the pores of the support and resolidifies on cooling. The SILGM has an ionic conductivity of 0.41 mS cm^{-1} at 25 °C, which, although lower than that of the ionogel alone, is at a level that is suitable for application in energy-storage devices.

The team evaluated the electrochemical performance of a SILGM-based supercapacitor. This device exhibits a high specific capacitance and, particularly important for practical application, excellent cycling stability, with up to 97% of the capacitance being retained over 10,000 charge–discharge cycles at a high rate. Moreover, the SILGM is also suitable for use in flexible devices, with a thin-film, laminated capacitor demonstrating excellent retention of its energy-storage properties during repetitive bending. This encouraging performance could see SILGMs become important components in devices manufactured by high-volume, low-cost, roll-to-roll processing.

One possible drawback of SILGMs is the high cost of the ionic liquid, but MacFarlane suggests that this may not be too problematic because only very thin layers of ionogel are required. Moreover, the development of cheaper ionic liquids for large-scale applications is an active area of research in the field. Far from being discouraged, the team have identified several avenues for further exploration: “We plan to investigate the mechanical properties and the effect on ionic conductivity of the support pore size, and will investigate different ionic liquids in the ionogel, especially those with high conductivities, to achieve better electrochemical performance,” notes MacFarlane.

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ORIGINAL ARTICLE Zhang, X. et al. Supported ionic liquid membrane electrolytes for flexible supercapacitors. *Adv. Energy Mater.* https://doi.org/10.1002/aenm.201702702 (2018)