Polysulphides confined! New design of the separator for better Li–S cell performance

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The lithium–sulphur (Li–S) battery can provide significantly higher specific energy in comparison to current battery technologies and thus lend itself to future applications in electric vehicles, grid-scale energy storage, and others[1]. This benefit largely comes from sulphur's high theoretical specific charge of 1672 mAh g^{-1} andresulting high theoretical specific energy of ca.2600 Wh kg^{-1}. While sulphur is environmentally friendly and inexpensive, a number of challenges have hampered commercialisation of Li–S electrochemical couple thus far. Most important drawbacks of sulphur are poor conductivity and generationof soluble polysulphide intermediates (Li_2S_n, $4 < n < 8$) upon discharge, which contribute to undesirable cyclic electron transfer reactions, a process known as the polysulphide shuttle[2].

To tacklethe latter challenge, we modified the surface of the polypropylene separator by introducing styrene sulphonate groups (SS) that repel the generated S_n^{2-} species. This new separatorin the form of an asymmetric membrane with cation-exchange SS functional groups (Figure 1) was synthesised by a one-step plasma-induced graft co-polymerisation. Both successful grafting and membrane asymmetry were confirmed by attenuated total reflectance Fourier transform infrared spectroscopy. Morphological changes as a function of the degree of modification were analysed using scanning electron microscopy. Many electrochemical techniques, such as galvanostatic cycling at different C-rates with and without potentiostatic step, and cycling voltammetry, were used to confirmthe benefitsof these materials in the Li–S cell. The reaction mechanism of the Li–S system with modified separatorwas further studied by means ofelectrochemical impedance spectroscopy and operando X-ray diffraction, and compared to the cell with Celgard 2400 reference separator.

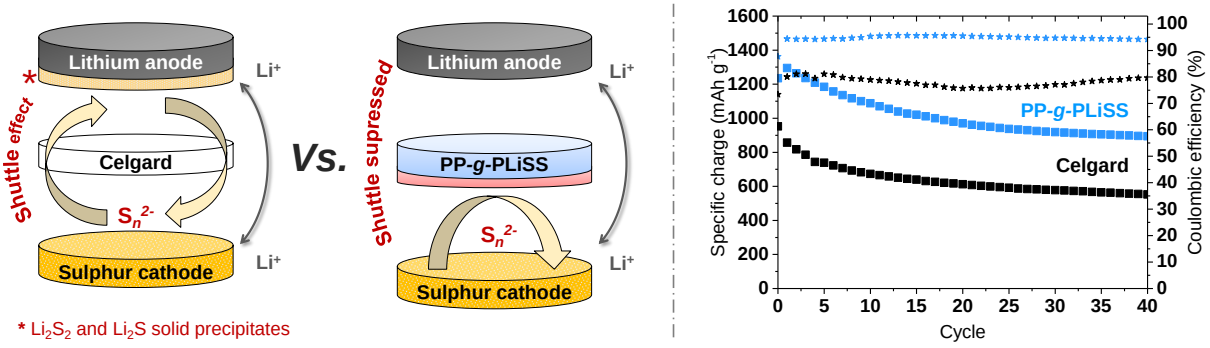

Figure 1 Configuration of Li–S cell assembly showingthe concept of the functionalisedseparator (left)[3]. Cyclingperformance of Li–S cells at C/20 with modified separator,in comparison to Celgard 2400(right).

References:
[1] G. Xu, B. Ding, J. Pan, P. Nie, L. Shenand X. Zhang, J. Mater.Chem. A 2 (2014) 12662–12676.
[2] S. S. Zhang, J. Power Sources 231 (2013) 153–162.
[3] J. Conder, S. Urbonaite, D. Streich, P.Novák, L. Gubler, RSCAdv. 5 (2015) 79654–79660.