

A trilayer poly(vinylidene fluoride)/polyborate/poly(vinylidene fluoride) gel polymer electrolyte with good performance for lithium ion batteries

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Electronic supplement information (ESI):

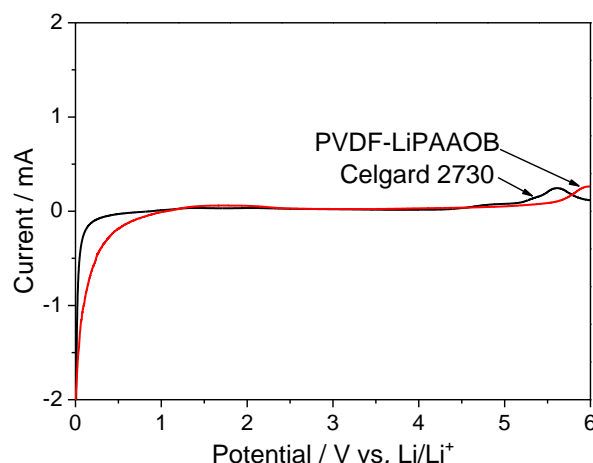


Fig. S1 The linear sweep voltammograms of Celgard 2730 and PVDF-LiPAAOB after saturated with 1 M LiPF₆ electrolytes.

As can be seen from Fig. S1, no current peak is found through the working electrode from open circuit potential to 4.8 V (vs. Li/Li⁺) for the commercial separator Celgard 2730 saturated with the organic electrolytes. When the open circuit potential is more than 4.8 V, the LiPF₆ electrolytes begin to decompose and there is a current peak. The result is consistent with commercial lithium batteries. In the case of the electrochemical stability of the gel PVDF-LiPAAOB composite membrane, it is similar to that of Celgard 2730 since the amount of the organic electrolyte is almost the same and contacts directly with the electrodes. That is, the electrochemical window of gel PVDF-LiPAAOB membrane is about 4.8 V, which is enough for lithium ion batteries.

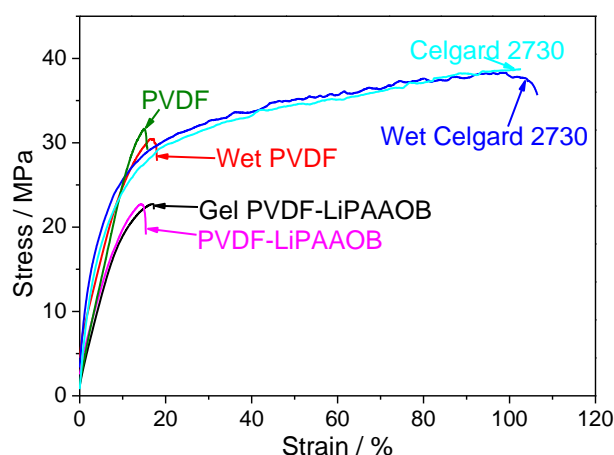


Fig. S2 Stress-strain curves of the Celgard 2730, the Celgard 2730 soaked LiPF₆ electrolyte (wet Celgard 2730), the electrospun PVDF, the electrospun PVDF soaked LiPF₆ electrolyte (wet PVDF), the PVDF-LiPAAOB composite membrane and gel PVDF-LiPAAOB.

As can be seen from Fig. S2, the membranes/separator show the same stress-strain level no matter what state they are, dry state or wet state. The maximums of the stress and the strain of the gel PVDF-LiPAAOB composite membrane are 22.7 MPa and 17.2 %, respectively, which is acceptable for lithium ion batteries. This means that the existence of the organic electrolyte in the PVDF-based electrolyte does not impair the mechanical strength of the polymer matrix.

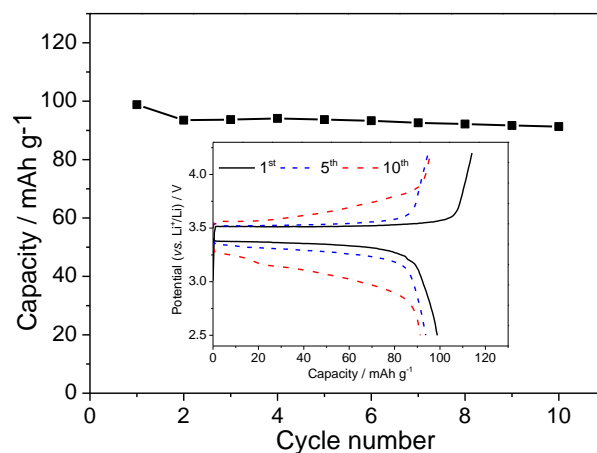


Fig. S3 Electrochemical performance of the LiFePO₄ cathode tested by using electrospun PVDF as the separator saturated with 1 mol L⁻¹ LiPF₆ electrolyte and Li metal as the counter and reference electrode.

Fig. S3 shows the the cycling behavior of LiFePO₄ for the electrospun PVDF-LiPAAOB saturated with the organic electrolyte. To make the thickness of the electrospun PVDF and the gel PVDF-LiPAAOB equal, we used three layers PVDF membrane as the separator. The charge-discharge curves for selected cycles are placed as insets in the figure. The reversible capacity of LiFePO₄ is about 95 mAh g⁻¹ at 0.2 C for the PVDF, which is lower than that for the PVDF-LiPAAOB gel electrolyte (118 mAh g⁻¹, Fig. 6a) and the commercial separator (100 mAh g⁻¹, Fig. 6b). The cycling performance of the PVDF is also good and there is still no evident capacity fading after 10 cycles. From the corresponding charge-discharge curves, typical flat-shaped voltage profiles are observed. But the difference between the charge and discharge voltages becomes larger and larger during cycling, from 0.2 to 0.5V. Evidently, this higher voltage difference is due to the polarization caused by the lower transference number of Li⁺ ions.