Super-capacitive electro-chemical performance of polymer blend gel polymer electrolyte (GPE) in carbon-based electrical double-layer capacitors

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ABSTRACT

This study reports on the fabrication and comparative performance characteristics of a symmetrical electrical double-layer capacitor (EDLC) employing gel polymer electrolyte (GPE) assembled between carbon-based electrodes. Three cells, A, B and C were fabricated using different composition of active materials (activated or porous carbon), binder (Pvdc-HF) and conductivity enhancer (super C6). The configuration densities extracted from Fig. 5(a), indicates that the cell operating voltage of 1.6 V has good cyclic durability with 98% capacitance retention after 500 cycles, while the cyclic durability of the cell with 2.4 V is relatively not stable. Extending the cell voltage to 2.4 V largely drops C5 of the cell at the end of the cycles is observed. This observation is verified in the potential window stability study of the GPE, Figs. 2 and the CV, Fig. 5(c).

In the CV response of cell A, an oxidation peak was observed at onset voltage ~2.0 V suggesting that GPE decomposition occurred below the determined potential window stability. Consequently, a higher percentage of the surface area of the electrode can be accessed and utilized by the GPE for double-layer formation and may cause charging at a non-uniform rate [44–46]. This condition will lead to higher capacitance value but will sacrifice the cyclic durability of the tested cell.

The Nyquist complex plane plots for cell A, measured at different cell voltages, are shown in Fig. 6. The complex plane plot consists of a small semi-circle at high frequencies followed by a vertical spike at low frequencies, indicating pure double-layer behaviour [47]. From the figure, $R_s$ and $R_D$ can be obtained. Generally, a semi-circle at high frequencies is considered to be the charge transfer resistance $R_D$ at the electrode/electrolyte interface [48], which can be divided into two parts, ionic and electronic resistances. The ionic resistance is the electrolyte ionic resistance inside the pores of the electrode and can be influenced by the electrolyte conductivity, the porous texture of the electrode and the thickness of the active layer. The electronic resistance includes the intrinsic electronic conductivity of the carbon particles, the electronic contact

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