High-Voltage Electrical Double-Layer Capacitors

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Here we propose a guideline, "choosing a matching pair of electrode materials and electrolytes", to effectively extend the cell voltage of EDLCs according to three general strategies. Based on the new strategy proposed in this work, materials with an inert surface enable to tolerate a wider potential window in commercially available organic electrolytes in comparison with activated carbons (ACs). The binder-free, vertically grown graphene nanowalls (GNW) and nitrogen-doped GNW (NGNW) electrodes (Figure 1) respectively provide good examples for extending the upper potential limit of a positive electrode of EDLCs from 0.1 to 1.5 V (vs Ag/AgNO3) as well as the lower potential limit of a negative electrode of EDLCs from −2.0 V to ca. −2.5 V in 1 M TEABF4/PC (propylene carbonate) compared to ACs (Figure 2). This newly designed asymmetric EDLC exhibits a cell voltage of 4 V, specific energy of 52 Wh kg−1 (ca. a device energy density of 13 Wh kg−1), and specific power of 8 kW kg−1 and ca. 100% retention after 10,000 cycles charge−discharge, reducing the series number of EDLCs to enlarge the module voltage and opening the possibility for directly combining EDLCs and LIBs in advanced applications.

References

[1] Yu-Wen Chi,Chi-Chang Hu, Hsiao-Hsuan Shen, and Kun-Ping Huang, Nano Lett., 16 (2016) 5719

Figures

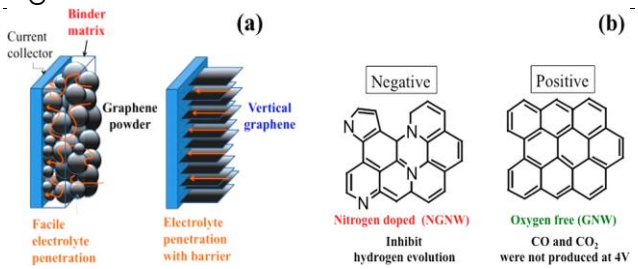

Figure 1: (a) In comparing with AC powder-coated electrodes, GNW/Ti and NGNW/Ti display a binder-free, vertical structure, favoring the penetration of electrolytes and electron transport in the whole graphene matrix. (b, right) The oxygen-free, binder-free GNWs circumvent the issue of oxygen-functional group removal, which are inert to the irreversible oxidation of organic electrolytes, enlarging the upper limit of working potential window. (b, left) The uniform N doping on the binder-free, vertical NGNWs significantly depresses the irreversible reduction of residual water and organic electrolyte at the negative potential end, further enlarging the working potential window.

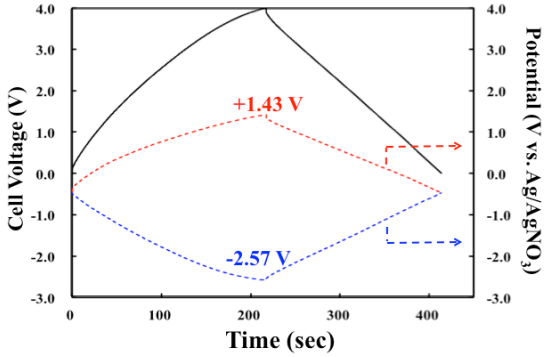

Figure 2: The binder-free, vertically grown graphene nanowalls (GNW) and nitrogen-doped GNW (NGNW) electrodes respectively provide good examples for extending the upper potential limit of a positive electrode of EDLCs from 0.1 to 1.5 V (vs Ag/AgNO3) as well as the lower potential limit of a negative electrode of EDLCs from −2.0 V to ca. −2.5 V in 1 M TEABF4/PC