High-performance flexible solid-state supercapacitors built from nitrogen-doped hybrid-dimensional nanocarbon materials

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Abstract
The rapid development of portable electronics has increasingly demanded advanced power supply devices with enhanced energy/power efficiency as well as improved portability and durability. Flexible solid-state supercapacitors (FSSSCs) show great potential to fulfill this demand owing to their multiple structural and functional superiorities [1-3]. Herein, we demonstrate a high-performance FSSSC built from nitrogen-doped hybrid-dimensional nanocarbon (N3C) based paper-like electrodes (N3CPs) and a polyvinyl alcohol-potassium hydroxide (PVA-KOH) based gel polymer electrolyte. Three types of representative carbon materials with different dimensions including graphene nanosheets, carbon nanotubes and carbon black nanoparticles are used together as building blocks to construct N3C composites via microwave-assisted solvothermal assembly combined with post-annealing. With melamine serving as both a superior structure-directing agent and a highly effective nitrogen source, an interconnected highly-porous 3D hierarchical structure and a high nitrogen doping level of 10.8 at.% can be achieved. A stepwise negative-pressure filtration process is employed to fabricate the sandwich-structured N3CPs with enhanced flexibility, conductivity and mechanical strength. The as-prepared N3CP possesses a high specific capacitance of 294 $F \cdot g^{-1}$ at 1 $A \cdot g^{-1}$ in a KOH electrolyte, as well as excellent rate capability and cyclic stability, which can be ascribed to its optimized composition and micro-/nanostructure. A further fabricated FSSSC exhibits high areal/volumetric capacitance, remarkable energy/power density and satisfied operational reliability/durability. The results hold promising prospects towards practical applications of N3CP based FSSSCs for powering future portable electronics.

References

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Figures

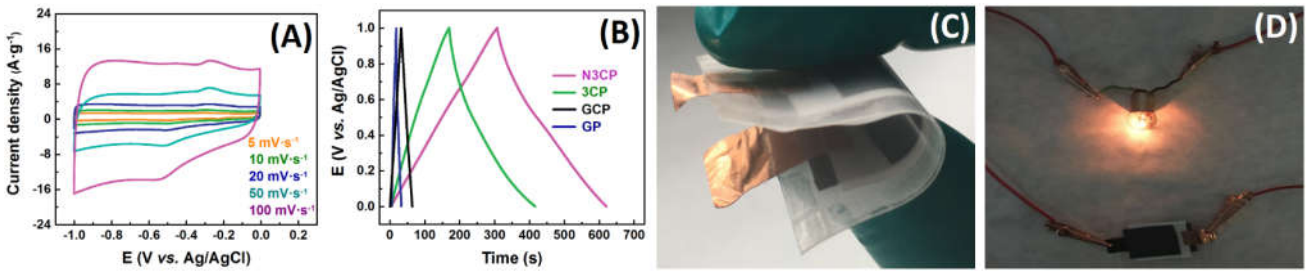

Figure 1: (A) CV curves of the N3CP electrode at different scan rates. (B) Gavalnostatic charge-discharge curves of different paper electrodes at 1 $A \cdot g^{-1}$. (C) A lab-made N3CP based FSSSC. (D) A miniature bulb is lightened up by the FSSSC. Electrolyte: 6 M KOH. Counter electrode: Pt. Reference electrode: Ag/AgCl.