Mesoporous carbon sheets made of edge-free graphene walls for ultra-stable supercapacitors

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Supercapacitors are rechargeable devices with advantages of high power density and long-term stability and a disadvantage of low energy density, compared with secondary batteries. Conventionally, activated carbons (ACs) are used as an electrode material, but their insufficient stability restricts the voltage of a single cell (typically using an organic electrolyte) within 2.8 V. It is therefore necessary to stack a large number of cells to achieve required voltage (ca. 50 to 400 V) for practical applications. Thus, increase of single-cell voltage is crucial to reduce the stacking number, and to make a whole module size more compact. A high-temperature stability is also required for many applications. The stability of supercapacitors highly depends on the structure of electrode material. It is known that single-walled carbon nanotubes are superior to ACs regarding the stability and achieve up to 4.0 V at room temperature. In this work, we report a new electrode material which is a seamless mesoporous carbon sheet consisting of continuous graphene walls with a very small amount of carbon edge sites which are the origin of the corrosion reactions. This new material makes it possible to assemble symmetric supercapacitors with excellent stability under the conditions of 3.5 V @60 °C and 4.4 V @25 °C even with a conventional organic electrolyte. Moreover, the high-voltage operation at 4.4 V makes it possible to achieve 2.7 times higher energy density compared to conventional ACs. Our findings enable the development of highly durable and high-voltage type supercapacitors useful for many applications including automobiles.