Synthesis, characterization and electrochemical study of hydroxy-functionalized graphene/MnO₂ nanocomposite

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Supercapacitors, due to their improved power supply, longevity, and high charge propagation dynamics have appeared as one of the most challenging field to meet the daily rising demands of energy. As far as the electrode materials for “supercaps” are concerned, present research is concentrating on graphene-based composites containing metal oxide nanostructures. Such composite formation would prompt several factors, particularly through exfoliation of multilayer graphene nanosheets, enhancement of the mechanical stability and electrical conductivity of metal oxides anchored onto them, as well as simultaneously improve the charge storing capacities synergistically. Many researchers have explored the influence of different MnO₂ nanostructures namely flower-like, sponges, needle shaped, spherical, rods, wires, plates, nanowalls, honeycomb-like “opened” structure anchored on the graphene layers to achieve superior electrochemical properties. Above explorations suggested that larger surface area, greater loading of pseudocapacitive material (MnO₂) are required to obtain better electrochemical responses. So, researchers contemplated exfoliating graphite to graphene oxide having more oxygen containing functional groups which in one hand would introduce intrinsic pseudocapacitive behavior as well as enforce synergic effect in electrochemical performances in the composite by the ability of holding larger quantity of MnO₂ on the surface of layers due to enhanced functionalization. However, such large exfoliation or functionalization of graphene layers also lead to decrease in electrical conductivity (increase in equivalent series resistance, ESR), thereby reducing the electrochemical efficiency. Hence, there lies the urge for optimizing the oxygen content on graphene sheets so that both the above features can be restored. With this view, we introduce a new facile one-pot synthetic route for hydroxyl-functionalized-graphene/MnO₂ nanocomposite (GM2), where MnO₂ nanosheets are anchored on hydroxyl-functionalized graphene (h-GO) to achieve superior electrochemical properties. FTIR, XRD, TGA and FESEM studies revealed formation of the GM2 composite containing epitaxially grown α - MnO₂ nanosheets anchored on hGO sheets which otherwise is rarely obtained by other reported methods. Cyclic voltammetric studies showed specific capacitance of 376.7 F/g at scan rate 2mV/sec in 1(M) Na₂SO₄ solution. Galvanostatic charging/discharging experiments yielded specific capacitance of 333.3 Fg⁻¹ at current density of 7A/g

supporting the CV results. Moreover the capacitive retention for GM2 sample was about 91% after 1000 cycles, compared to the pristine hydroxy graphene exhibiting only about 60% under similar situation. Hence anchoring MnO₂ nanosheets on the surfaces of hydroxy-graphene resulted in enhanced charge storing capacity of the material by avoiding layer agglomeration, thereby enhancing the recyclability of the system. Thus, a simple, green and wet-chemical method with the aid of ultrasonic energy was adopted to synthesize the GM2 composite which exhibited an appreciable specific capacitance and stable cycling performance for supercapacitor applications. Considering the low cost, abundant resources, simplicity of the preparative method and improved electrochemical properties, we believe that the composite is well suitable to be considered as promising electrode material for energy storage devices.

Figure 1: (A) SEM image of GM2 (B) CV plot of GM2 at different scan rates (inset: CV of hGO at 2mV/s) (C)CD plot of GM2 and hGO at 7A/g current density (D) CD cycles for both the samples

References

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