Ternary nickel ferrite/graphene/polyaniline hierarchical nanocomposites for high-performance supercapacitors

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As typical active electrode materials for pseudocapacitor, transition metal oxides, hydroxides, and conductive polymers possess multiple oxidation states/structures that enable rich redox reactions for pseudocapacitance generation [1,2].

Spinel ferrite oxides (MFe$_2$O$_4$, M=Fe, Co, Ni, Cu, Mn) has been conceived as a promising cost-effective and scalable alternative for supercapacitor. It is expected that ferrite oxides (MFe$_2$O$_4$) may offer richer redox reactions, including contributions from both M and Fe ions, than those of the monometallic oxide [3-8]. However, it is noted that the pure ferrite oxides cannot be conductive to satisfactory performance. A promising approach to enhance the performance is designing novel ferrite-based hybrids.

Conducting polymer, such as polyaniline (PANI) is usually used to hybrid with metal oxides to enhance the electronic conductivity and achieve higher capacitance, owing to its low cost, environmental compatibility, excellent electrical conductivity, large pseudo-capacitance, and fast doping/dedoping rate. However, the poor cycling stability is a noticeable shortcoming [9-11]. Graphene is a rising star in supercapacitor owning to its extremely high specific surface area, superior mechanical properties, good electrochemical stability and high intrinsic electrical conductivity [12,13]. Recently, a hierarchically ternary composites composed of carbon nanomaterials, conducting polymers and transition metal oxides have been explored. This novel ternary hybrids provide a new direction for the fabrication of the next generation high-performance electrochemical electrodes [14,15]. Based on the above, it is of great interest to fabricate the ternary ferrite-based composites as a capacitor material. To the best of our knowledge, very few studies on the synthesis of ferrite-based hybrids have been reported so far, especially this intriguing ternary nanostructure.

Herein, we first reported ternary nickel ferrite/graphene/PANI hybrid by a facile two-step method. The NiFe$_2$O$_4$ nanoparticles are deposited on the surface of graphene, then the conducting PANI layer are coated onto this binary hybrids (Figure 1). This ternary nanomaterials show enhanced electrochemical capacitance and improved cycling stability (Figure 2).

References:

Figure 1: The TEM images of binary NiFe$_2$O$_4$/GO (a, b) and ternary NiFe$_2$O$_4$/GO/PANI (c, d).

Figure 2: The CV curves of NiFe$_2$O$_4$ (a), binary NiFe$_2$O$_4$/GO (b) and ternary NiFe$_2$O$_4$/GO/PANI (c). The charge-discharge curves of NiFe$_2$O$_4$, binary NiFe$_2$O$_4$/GO and ternary NiFe$_2$O$_4$/GO/PANI (d).