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α -Fe₂O₃/graphene nanocomposite as anode material for sodium-ion batteries with enhanced capacity retention

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α -Fe₂O₃/graphene nanocomposite as anode material for sodium-ion batteries with enhanced capacity retention

Abstract

Among the different energy storage systems, rechargeable lithium-ion batteries (LIBs) have been widely applied in various portable electronic devices due to their high energy densities, long cycle life, and lack of significant memory effect [1]. For wide-scale implementation of renewable energy, LIBs, however, face challenges related to their safety, lifetime, and cost. Based on the wide availability and low cost of sodium, sodium-ion batteries (SIBs) have the potential for meeting the demands of large-scale and sustainable applications. Many cathode materials have been proposed, whereas only a few anode materials have been investigated for SIBs [2]. The sodium ion (1.02 Å) has a larger ionic radius than the lithium ion (0.76 Å), so that graphite cannot be used as anode for SIBs [3]. There is less choice of anode materials for SIBs. Transition metal oxides have been investigated as possible negative electrodes, relying on insertion of Na⁺ at low voltages. Valvo et al. reported that the electrochemical sodiation of nanostructured Fe₂O₃ is reversible with the voltage range of 0.05-3.0 V vs. Na⁺/Na, and its specific capacity is 350 mAh g⁻¹ over 30 cycles at 40 mA g⁻¹ [4, 5]. Fe₂O₃ requires further modifications, however, to overcome its limitations for SIBs, such as poor electronic conductivity, volume variations, and related cycling issues. To improve the electronic conductivity and capacity retention, we prepared α -Fe₂O₃/Graphene nanocomposite using the ultrafast and environmentally friendly microwave autoclave method [6].

Keywords

sodium, graphene, nanocomposite, fe₂o₃, anode, material, retention, capacity, enhanced, batteries, ion

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α -Fe₂O₃/Graphene Nanocomposite as Anode Material for Sodium-Ion Batteries with Enhanced Capacity Retention

Tuesday, 10 June 2014

Cernobbio Wing (Villa Erba)

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Among the different energy storage systems, rechargeable lithium-ion batteries (LIBs) have been widely applied in various portable electronic devices due to their high energy densities, long cycle life, and lack of significant memory effect [1]. For wide-scale implementation of renewable energy, LIBs, however, face challenges related to their safety, lifetime, and cost. Based on the wide availability and low cost of sodium, sodium-ion batteries (SIBs) have the potential for meeting the demands of large-scale and sustainable applications. Many cathode materials have been proposed, whereas only a few anode materials have been investigated for SIBs [2]. The sodium ion (1.02 Å) has a larger ionic radius than the lithium ion (0.76 Å), so that graphite cannot be used as anode for SIBs [3]. There is less choice of anode materials for SIBs. Transition metal oxides have been investigated as possible negative electrodes, relying on insertion of Na⁺ at low voltages. Valvo et al. reported that the electrochemical sodiation of nanostructured Fe₂O₃ is reversible with the voltage range of 0.05-3.0 V vs. Na⁺/Na, and its specific capacity is 350 mAh g⁻¹ over 30 cycles at 40 mA g⁻¹ [4, 5]. Fe₂O₃ requires further modifications, however, to overcome its limitations for SIBs, such as poor electronic conductivity, volume variations, and related cycling issues. To improve the electronic conductivity and capacity retention, we prepared α -Fe₂O₃/Graphene nanocomposite using the ultrafast and environmentally friendly microwave autoclave method [6].

The α -Fe₂O₃/Graphene nanocomposite was analysed by field emission scanning electron microscopy (FESEM) and X-ray diffraction (XRD) to determine their morphology and structural properties. Graphene contents in the composites were determined by thermogravimetric analysis (TGA). α -Fe₂O₃ nanoparticles are embedded in conductive and interconnected graphene networks [Fig 1(a)]. This nano-architecture increases the electronic conductivity and buffers volume change in α -Fe₂O₃/Graphene nanocomposite electrode. It can be observed in the XRD pattern in Fig. 1 that the α -Fe₂O₃/Graphene nanocomposite has more broad peaks than the α -Fe₂O₃ [Fig 1(b)]. The electrochemical results show that the composite electrode containing 10 wt.% graphene has higher initial capacity recovery (69 %) than the pure Fe₂O₃ electrode (59 %) [Fig 1(c)] [4]. Moreover, the composite shows better capacity retention than in the reported results in the literature, retaining 401 mAh g⁻¹ at current density of 40 mA g⁻¹ after 30 cycles in the range of 0.05-2.60 V vs. Na⁺/Na [Fig 1 (d)] [3, 4].

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Figure captions

Figure 1. (a) FESEM image and (b) XRD pattern of α -Fe₂O₃/Graphene nanocomposite with 10 wt.% graphene; (c) discharge/charge curves of the selected cycles between 0.05 and 2.60 V vs. Na⁺/Na at a gravimetric current density of 40 mA g⁻¹ for the α -Fe₂O₃/Graphene nanocomposite electrode with

10 wt.% graphene.



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