Chemical Engineering Journal 220 (2013) 107–116

Contents lists available at SciVerse ScienceDirect

Chemical Engineering Journal

journal homepage: www.elsevier.com/locate/cej

Thermally stable polypyrrole–Mn doped Fe(III) oxide nanocomposite sandwiched in graphene layer: Synthesis, characterization with tunable electrical conductivity

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HIGHLIGHTS

- Novel synthesis and characterization of PPy-metal oxide NCs sandwiched by graphene.
- These hybrid materials behaved as a semiconductor (50–300 K).
- They exhibited significantly high tunable electrical conductivity.
- This material exhibited remarkable enhancement in thermal stability of PPy chain.
- Our method opens a new avenue to develop sandwiched architecture by graphene layer.

ARTICLE INFO

Article history:
Received 12 June 2012
Received in revised form 9 November 2012
Accepted 19 November 2012
Available online 26 January 2013

Keywords:
Conductivity
Graphene
Manganese doped iron(III)oxide
Nanocomposite
Polypyrrole

ABSTRACT

We have manifested a novel approach to fabricate metal oxide supported conducting polypyrrole (PPy) nanocomposites which are sandwiched by graphene layers with regular surface morphology. This method is based on the electrostatic interactions of positively charged surfactant micelles and negatively charged graphene oxide sheets followed by reduction. The prepared composites including pure materials are characterized by X-ray diffraction, Raman spectroscopy, Föurier transform infrared spectroscopy, scanning electron microscopy, transmission electron microscopy, atomic force microscopy etc. Enhanced thermal stability of this hybrid composite is ascribed to the more compact structure of PPy reinforced by metal oxide nanoparticles inserted between thermally stable graphene layers. These hybrid composites exhibit significant increase in electrical conductivity from 7.93×10^{-3} S/cm to 2.9 S/cm with respect to pure PPy, and that can be tuned to 50.9 S/cm with variation of Mn doped Fe(III) oxide nanoparticles loading. The hybrid composites behave like semiconductor and follow 3D variable range hopping model through the whole range of experimental temperature (50–300 K).

1. Introduction

Recent research trend in the field of polymer nanocomposite (PNCs) for suitable modification of existing polymer by incorporating nanostructured materials is explored to enhance their applicability by improving inherent properties such as electrical, electrochemical, thermal, and mechanical. [1–3]. Thus, rapid degradation of polymer has been checked to some extent with such above modification. Various carbonaceous materials like carbon nanotube (CNT), activated carbon, porous carbon, etc. [4,5] have also been widely used as supportive material to overcome their drawbacks because of its excellent mechanical and chemical stability. The discovery of graphene, with its easy isolation, by the exfoliation of graphite has drawn our enormous attention due to its unique superlative properties, such as chemical stability, substantial mechanical strength, and ability to disperse in various polymer matrixes [6–8]. Apart from that its extended double bond conjugation, thermal conductivity, high stretchability and flexibility [9–12] propel us to apply it in conducting PNCs fabrication to enhance electrical conductivity with an advantage of tuning.

However, various PNCs based on conducting polymer, such as polypyrrole (PPy), polyaniline (PANI), and Poly(3,4-ethylenedioxythiophene) (PEDOT) had been reinforced by metal oxides [13–16],

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http://dx.doi.org/10.1016/j.cej.2012.11.139