Synthesis and investigation of polyaniline, as a conducting polymer, on hollow Cu ferrite nanospheres

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Abstract

Composite of magnetic and conductive Hollow polyaniline/$CuFe_2O_4$ nanosphere with novel core-shell structure were successfully prepared by in-situ polymerization in the presence of ammonium persulfate (APS) as the oxidant and dodecyl benzene sulfonic acid (DBSA) as the surfactant and dopant. The synthesized hollow microsphere composites were characterized by FT-IR and UV/Vis spectrophotometry. X-ray photoelectron spectroscopy was used to determine the degree of coating with a conducting polymer. Its morphology was characterized by scanning electron Microscopy (SEM). The changes of the magnetic properties before and after polyaniline coating were investigated by using vibrating sample magnetometer (VSM).

1. Introduction

polyaniline (PANI) is one of the most important conducting polymers because of its good processibility, environmental stability, and its oxidation- or protonationadjustable electro-optical properties as well as its potential for a variety of applications [1-3].

multifunctionalized PANI nanostructures have been prepared by blending PANI with inorganic electrical, optical, and magnetic nanoparticles to form nanocomposites [4]. Among the inorganic nanoparticles, Ferrite nanoparticles have received great attention because of their interesting magnetic properties as well as extensive potential applications in color imaging, magnetic recording media, soft magnetic materials and ferrofluids [5]. Recently, PANI/ Ferrite nanocomposites have attracted more attention for applications of nanomaterials due to their novel properties. Wan et al. studied a series of PANI composites containing nanomagnets prepared by chemical polymerization [6]. Deng et al. reported the preparation of PANI/ Ferrite nanoparticles with core-shell structure via an in situ polymerization of aniline monomer in an aqueous solution, which contains Ferrite nanoparticles and surfactant DBSA [7].

2. Experimental

2.1. Preparation of hollow Cu-ferrite nanospheres via solvothermal method

Monodisperse Cu ferrite nanocrystals were obtained via a facile solvothermal synthetic route. $FeCl_3 \cdot 6H_2O$ (4 mmol) and $CuCl_2$ (2 mmol) were added into ethylene glycol (70 mL) to form a clear solution. Then a protective agent such as $NH_4 \cdot Ac$ (30 mmol) was added into the solution to form a mixture under vigorous stirring at room temperature. Subsequently, the mixture was put into a Teflon-lined stainless steel autoclave of 100 mL capacity and sealed and maintained at 200 ˚C for 48 h. Finally, the system was allowed to cool to room temperature naturally. The resulting black precipitate was collected by filtration and washed with absolute ethanol and distilled water in sequence for several times. The final products were dried in a vacuum box at 50 ˚C for 4 h.

2.2. Synthesis of PANI/hollow Cn-Fe_2O_4 nanocomposite

4 ml aniline (0.044 mol) and 10 ml distilled water were mixed and agitated for 15 min, in another container 5gr dodecyl benzene sulfonic acid (DBSA) was diluted with 10ml of deionized water to form pulpy mixture, and then solution was poured into prepared solution of aqueous aniline, this emulsion was entirely stirred for 1 hr by magnetic stirrer to form homogenous phase.

In the next step, 5 ml of aqueous solution containing 0.6 g of hollow ferrite spheres was placed in ultrasonic system for 10 minutes and added to above suspension, and mixture was again sonicated for an extra 15 minutes, and then was gently agitated by mechanical stirrer for an additional 15 min, 10 ml of an aqueous solution containing 5 g of APS (0.022 mol) as oxidizing agent was slowly added (during 15 min) while stirring mechanically to begin polymerization reaction. The resulting green precipitate (PANI/ hollow $CuFe_2O_4$ nanocomposite) was filtered, washed with distilled water for two times and then dried overnight in an oven at 60˚C.

3. Results

In the FT-IR spectra of PANI/hollow $CuFe_2O_4$ nanocomposite, the weak peak at ~505 cm^{-1} is attributed to SO_3H group of DBSA surfactant. Absorption band at 598.83 cm^{-1} is corresponding to Fe-O stretching vibration. There are characteristic peaks of PANI-DBSA at 1133.82-1297.40, 1399.52-1625.01, 3420.13 cm^{-1} which are attributed to the C-N stretching vibration band, the C=C stretching vibration in the aromatic ring, the N-H bond vibration respectively, indicating the existence of the main chain structure of the conductive doped PANI in this composite

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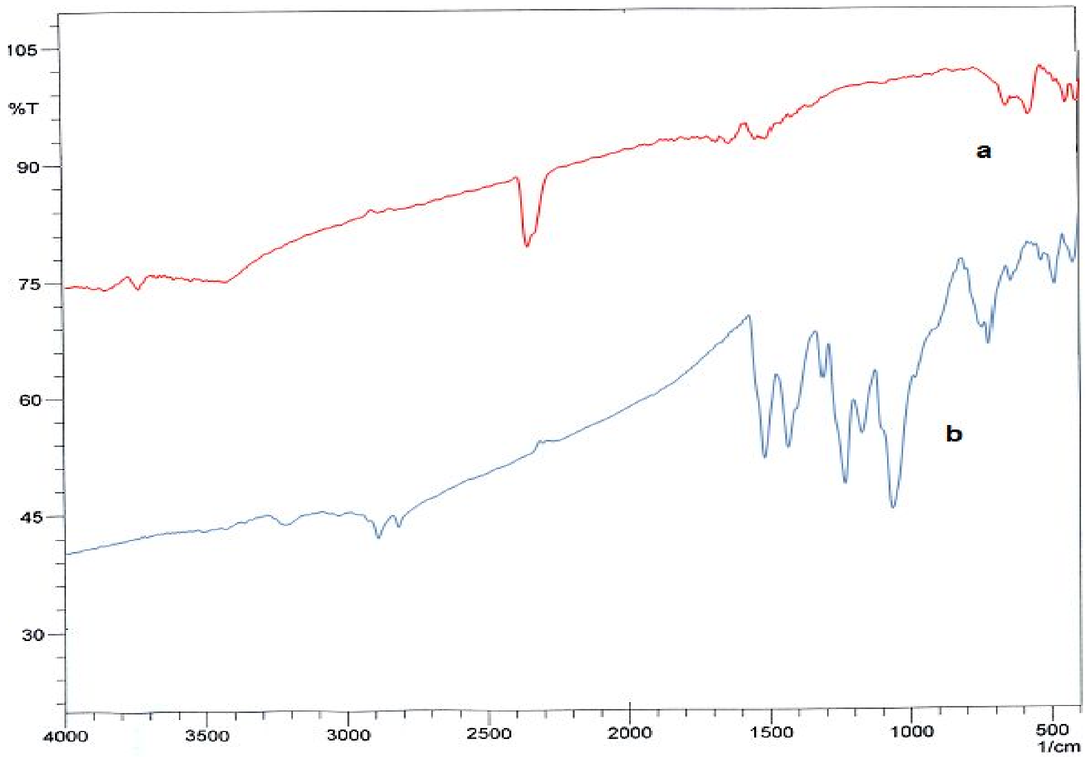


Fig. 1. FT-IR spectra of (a) Hollow $CuFe_2O_4$ (b) PANI/ $CuFe_2O_4$ Nanocomposite

The magnetic properties of the hollow ferrite and composite were analyzed by room temperature VSM with an applied field -8.2≤H≤8.2 kOe field, the value of saturation magnetization (*M*s) is about 66.7 emu/g and 45.7 emu/g for ferrite and composite, respectively. For ferrite, the remnant magnetization (*Mr*) and coercivity field are 17.81 emu/g and 110 Oe respectively. For composite, the remnant magnetization (*Mr*) and coercivity field are 12.3 emu/g and 80 Oe respectively.

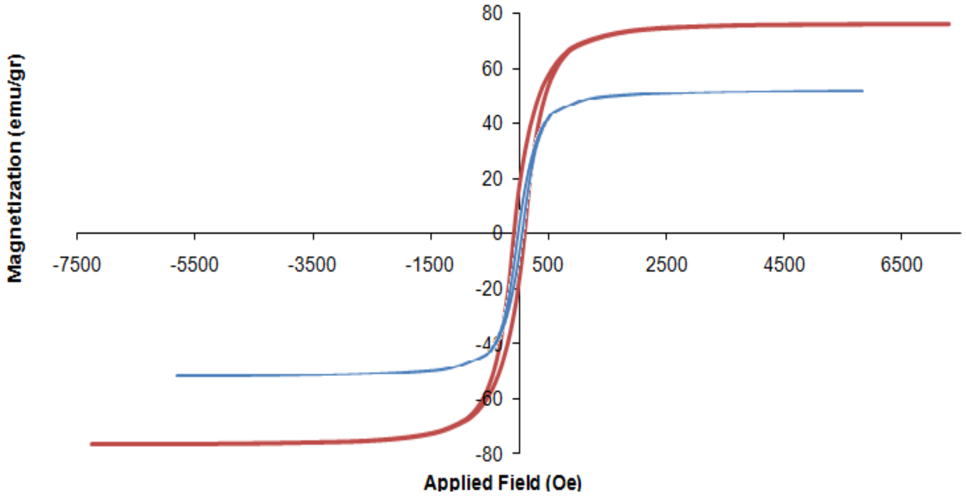
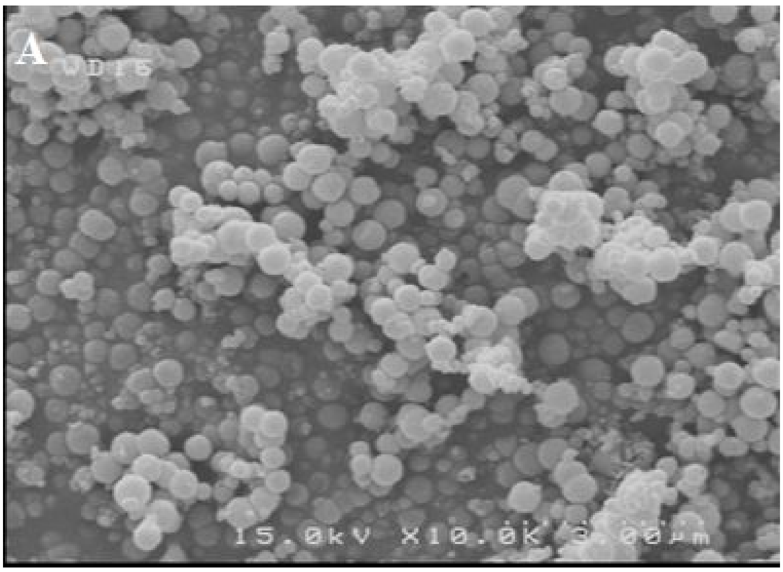


Fig. 2. Magnetization curve of PANI/hollow $CuFe_2O_4$ nanocomposite

The SEM images of hollow $CuFe_2O_4$ nanospheres and PANI/ $CuFe_2O_4$ nanocompositewere shown at Fig. 3 and indicate coating of hollow spheres.



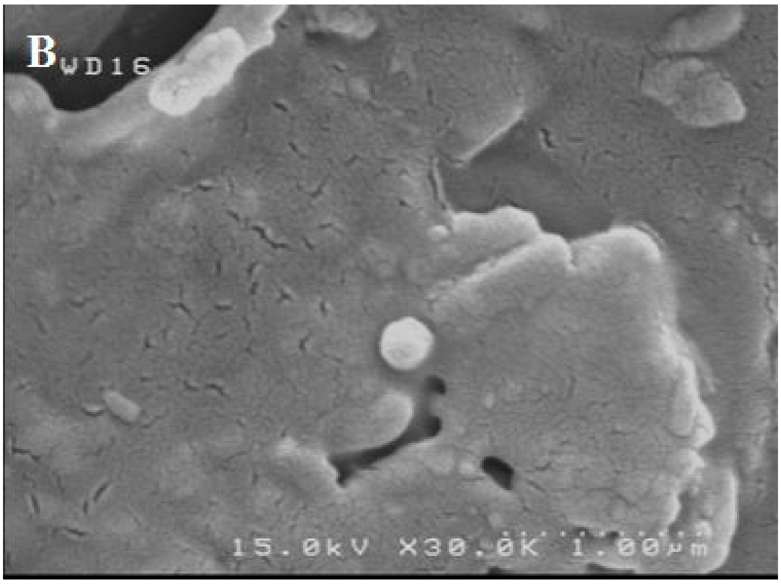


Fig. 3. SEM images of (A) hollow $CuFe_2O_4$ nanospheres (B) PANI/ $CuFe_2O_4$ nanocomposite.

4. Conclusions

In summary, the PANI/ $CuFe_2O_4$ nanocomposite containing hollow ferromagnetic nanoparticles has been synthesized. This report is a helpful method to improve mixability of inorganic particles with an organic phase. The results indicate the even distribution of $CuFe_2O_4$ in the PANI base and this proves the effectiveness of DBSA and ultrasonic devices in mixing two nonhomogenious phases.

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