ELECTROMAGNETIC FUNCTIONALIZED POLYPYRROLE NANOCOMPOSITES CONTAINING MAGNETIC NANOFILLERS OF HIGH ASPECT RATIOS

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This work reports electromagnetic functionalized PPy nanocomposites containing magnetic nanofillers with high aspect ratios such as α-FeOOH nanorods and γ-Fe_2O_3 nano-needles. The morphologies and structures of the PPy nanocomposites were characterized by transmission electronic microscope (TEM) and X-ray diffraction (XRD). The room-temperature conductivity of the nanocomposites was studied by a four-probe method. And the magnetic properties were investigated at room temperature using a vibrating sample magnetometer with a maximum magnetic field of 10 kOe.

Introduction

Polypyrrole (PPy) nanocomposites have attracted particular attention because of their high conductivity, redox properties, and environment stability.[1,2] Recently, electromagnetic functionalized PPy nanocomposites have attracted great interests owing to their promising applications in gas and humidity sensors,[4,5] electromagnetic interference shielding,[6] electrochemical storage,[7,8] lithium insertion electrode[9] and so on. Therefore, preparation and study of electromagnetic functionalized PPy nanocomposites is of great significance.

In this work, the preparation of electromagnetic functionalized PPy nanocomposites containing magnetic nanofillers with high aspect ratios such as α-FeOOH nanorods, and γ-Fe_2O_3 nano-needles is reported. Then, the morphologies, structures, electrical conductivity and magnetic properties are studied for the PPy nanocomposites.

Experimental

Pyrrole (Py) was distilled and stored under N_2 gas. Other reagents including NaOH, $FeCl_3 \cdot 6H_2O$, $FeSO_4 \cdot 7H_2O$, p-TSA dopant and γ-Fe_2O_3 nano-needles were used without further purification. The γ-Fe_2O_3/PPy nanocomposites were synthesized by a template-free method associated with ferromagnetic γ-Fe_2O_3 needles as the hard-template.[10] Typical synthesis process of α-FeOOH/ PPy nanocomposites is as follows:[11] 1 ml of pyrrole monomer and a given amount of $FeSO_4 \cdot 7H_2O$ were mixed with the given amount of NaOH dissolved in 40 mL of de-ionized water under mechanical stirring at room temperature. The mixture was then cooled down to 0~5°C in an ice bath. After 20 minutes, 30 mL of $FeCl_3 \cdot 6H_2O$ solution (1 mol/L) was added drop by drop to the above mixture and the polymerization took place under stirring for 4 hours. The final product was washed respectively with de-ionized water and ethanol for several times. Finally, the product was dried at 50°C under vacuum for 24 h.

X-ray diffraction was carried out on a RINT 2000 Wilder-angle goniometer. The morphology was characterized by a transmission electron microscope (TEM, Hitachi-9000). The room-temperature conductivity for pressed products was measured by a standard four-probe method with a Keithley 196 SYSTEM DM digital multi-meter and

ADVANTEST R6142 programmable dc voltage/current source. A vibrating sample magnetometer (VSM, Lakeshore 7307, USA) was employed to measure the magnetic properties of the products.

Results and discussion

TEM images as shown in Fig. 1a display that the PPy is coated on the γ-Fe_2O_3 nano-needles (a diameter of about 30 nm). The γ-Fe_2O_3/PPy is a kind of core-shell nanocomposites. TEM images as shown in Fig. 1b display that the α-FeOOH/ PPy nanocomposites contain α-FeOOH nanorods (a diameter of about 3-5 nm and a length of about 20-40 nm) and PPy nanospeheres (a diameter of about 140 nm).

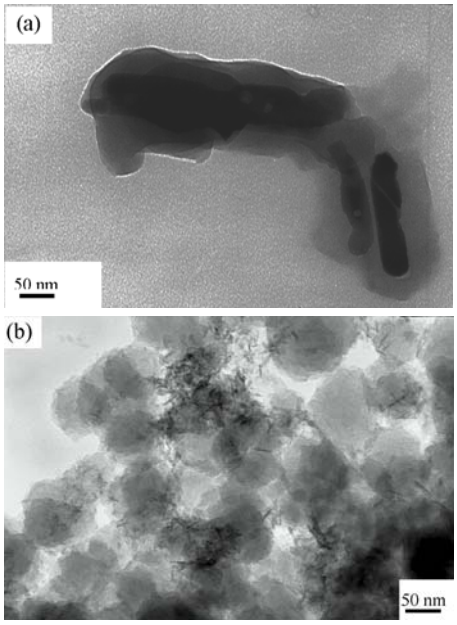

Fig. 1 TEM images of (a) γ-Fe_2O_3/PPy and (b) α-FeOOH/ PPy nanocomposites.

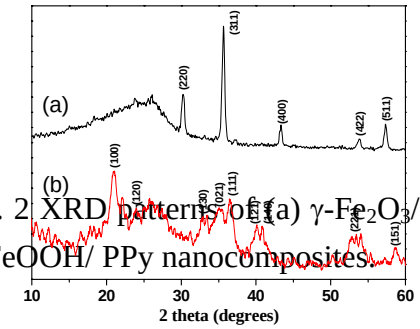

Fig. 2 XRD patterns of (a) γ-Fe_2O_3/PPy and (b) α-FeOOH/ PPy nanocomposites.

Except a broad peak centered at 2θ =25.26 which is the characteristic peak of PPy as shown in Fig. 2a,b, the sharp peaks for Fig. 2a and Fig. 2b can be well indexed to the γ-Fe_2O_3 (JCPDS 39-1346) and α-FeOOH (JCPDS 29-713), respectively.

The conductivity of the γ-Fe_2O_3/PPy and α-FeOOH/ PPy is 50 and 2.85 S/cm, respectively.

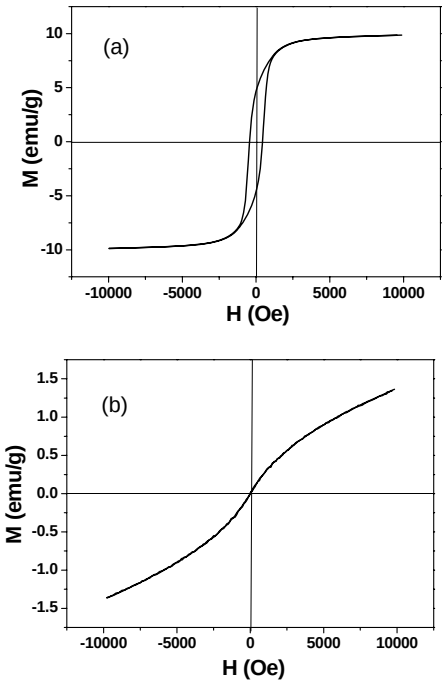

Fig. 3 Hysteresis loops of (a) γ-Fe_2O_3/PPy and (b) α-FeOOH/PPy nanocomposites.

Fig. 3 shows the dependence of the magnetism (M) on the applied magnetic field (H) for (a) γ-Fe_2O_3/PPy and (b) α-FeOOH/PPy nanocomposites. The γ-Fe_2O_3/PPy nanocomposite exhibits excellent ferromagnetic behaviors, in which the saturated magnetization (M_s) and coercive force (H_c) are calculated to be 9.86 emu/g and 440.11 Oe, respectively (Fig. 3a). The α-FeOOH/PPy nanocomposite displays antiferromagnetic behaviors. The magnetization at 10 KOe is 1.36 emu/g (Fig. 3b).

Conclusions

The γ-Fe_2O_3/PPy and α-FeOOH/ PPy nanocomposites have been successfully synthesized by a chemical method. The TEM images show that the γ-Fe_2O_3/PPy nanocomposite has a core-shell structure and the α-FeOOH/ PPy nanocomposite is consisted of γ-Fe_2O_3 nanorods and PPy nanospoeheres. The two kinds of PPy nanocomposites have good electrical and magnetic properties.

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