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Multicomponent Schiff base/MWCNTs/$FeCl_3$ composite: Facile synthesis and strong absorption properties

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ABSTRACT

Aliphatic Schiff base/MWCNTs/$FeCl_3$ (APSMF) and aromatic Schiff bases/MWCNTs/$FeCl_3$ (AMSMF) hybrids were synthesized by in-situ polymerization with the purpose to fabricate a multicomponent absorbent. which composed of organic-metal ion complexes (OMIC) and carbon material with 3D heterogeneous network. The excellent electromagnetic wave (EMW) absorbing performance derived from the synergy effects generated by triple dielectric relaxation, and well-matched characteristic impedance. Furthermore, the minimum RL value of this absorbent is up to −70.76 dB at 12.34 GHz with the thickness of 2.6 mm. This new multicomponent absorbent composed of OMIC and carbon material may pave the way for OMIC-derived materials as a promising electromagnetic absorbing materials (EAM).

1. Introduction

Electromagnetic wave (EMW) has been widely used in daily life, such as mobile phone, local area network, household appliances, as well as industrial production. However, the thermal effects, non-thermal effects and cumulative effects caused by EWA radiation could cause huge harm to human health. Therefore, the rapid development of electromagnetic absorbing materials (EAM) has received considerable attention due to the potential of wide frequency absorbing bandwidths, powerful absorption, light weight, and thin thickness. These EAM usually include the dielectric loss materials i.e. ZnO, SnO_2, Fe_2O_3, MWCNTs, SiCNW, graphene and the magnetic loss materials i.e. Co [1], $NiFe_2O_4$, Fe_3O_4, $CoFe_2O_4$. By incorporating both kind of materials together, a strong absorption of EMW in a wide frequency range can be achieved. Hence, the multi-element composites are preferred as effective absorption materials.

Schiff bases (SFB) [2] as an important class of ligands play a crucial role in coordination chemistry and have been widely applied in different fields such as asymmetric catalysis, luminescent probes, and biological pharmacy. In addition, transition metal complexes of SFB ligands gradually draw attention as a type of organic EMW absorption agent [3]. A multielement composites absorbent composed of APSMF, AMSMF and MWCNTs were designed to prepare an ideal EAM. The optimum reflection loss (RL) can be achieved by altering the proportion of components. The most attractive advantage of this synthetic strategy is that multicomponent composites induce more dipoles and numerous interfaces, the associated polarization and relaxation facilitate the EMW absorption properties of this new absorbent. This paper is an attempt for organic/polymer-metal ion complexes (OMIC) absorbent instead of traditional ferromagnetic metal particles.

2. Experimental

MWCNTs (outer diameter: 20–30 nm, length: 10–30 μm) was purchased from XFNANO Technology (Nanjing China). The Preparation of aliphatic Schiff base/MWCNTs/$FeCl_3$ (APSMF) hybrids: 0.5 g MWCNTs and 1.08 g *para*-Phenylenediamine were dissolved in 80 mL anhydrous ethanol (AE) and ultrasonic dispersion 30 min. 1.2 g glutaraldehyde was added dropwise into the suspension of MWCNTs, and magnetic stirred 4 h at 80 °C. Then 4.86 g $FeCl_3$ was dissolved in 50 ml AE and added dropwise into the suspension. After magnetic stirring for 4 h at 70 °C, dark brown precipitates were generated, which were filtrated and washed thoroughly and dried for characterization. The synthesis of Schiff bases/MWCNTs/$FeCl_3$ (AMSMF) hybrids was similar to APSMF, only 2.56 g (0.025 mol) benzaldehyde were used instead by glutaraldehyde. The morphology of typical samples was analyzed by field emission scanning electron microscope (FESEM, Quanta 200). The FTIR spectra (500–4000 cm^{-1}) were obtained from Bruker vector-22 by using KBr pellets. The cylindrical sample (with 3.00 mm inner diameter, 7.00 mm outer diameter) was fabricated by mixing uniformly

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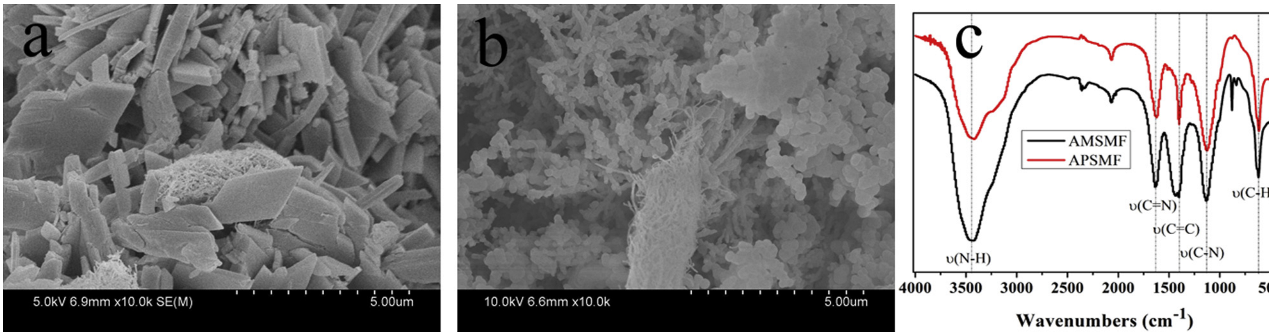

Fig. 1. FESEM photogragh of AMSMF (a) and APSMF (b); FTIR spectra (c) of AMSMF and APSMF.

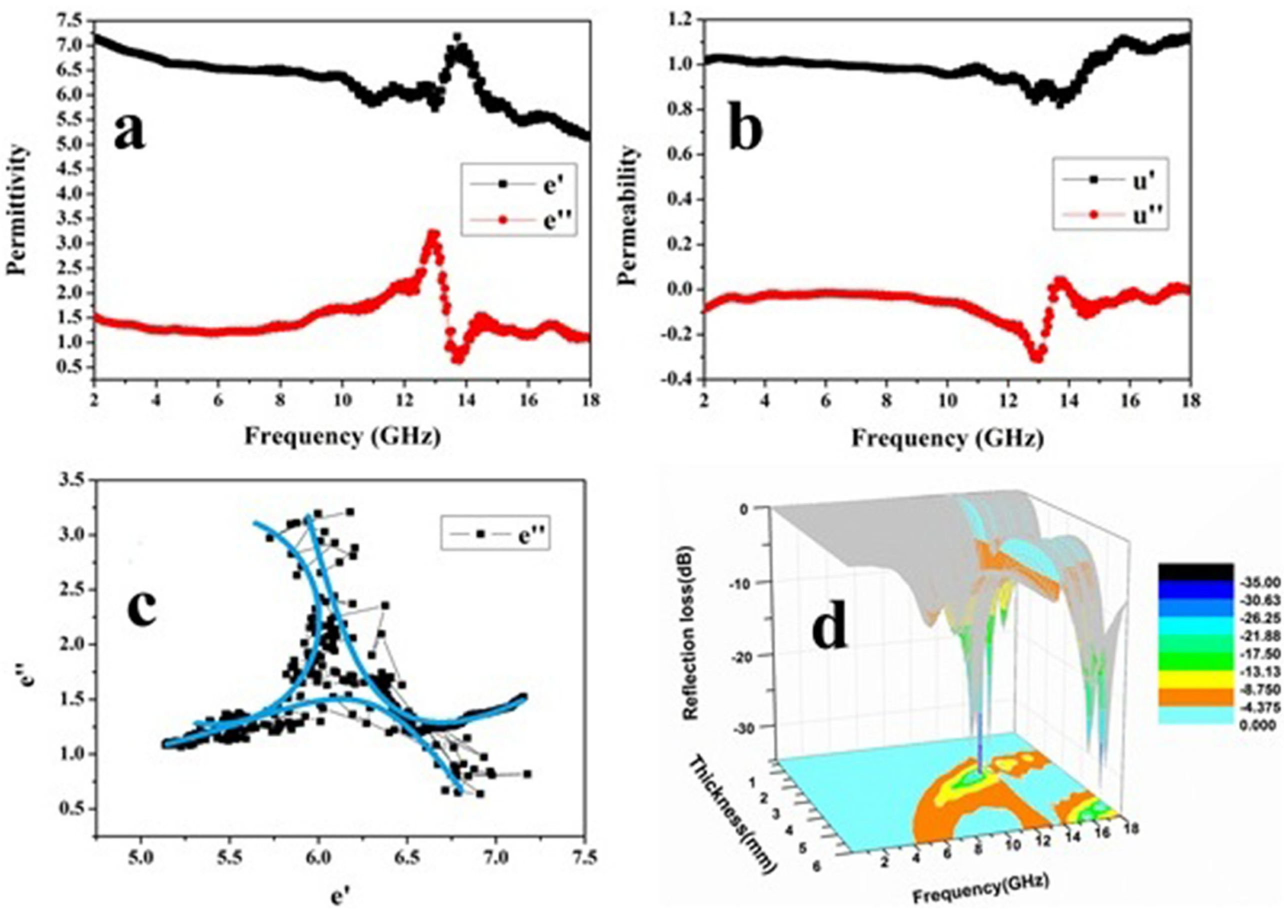

Fig. 2. The complex permittivity (a), complex permeability (b), Cole–Cole semicircle (c), and RL 3D diagram (d) of APSMF/AMSMF/MWCNTs-wax sample.

21.38 wt% of the APSMF/AMSMF/MWCNTs (the mixing radio is 5:5:1) with paraffin matrix. Electromagnetic parameters of the APSMF/AMSMF/MWCNTs-wax samples were recorded at 2–18 GHz by using an Agilent 8722ES network analyzer.

3. Results and discussion

The photographic images of AMSMF and APSMF are shown in the Fig. 1(a) and (b). The AMSMF were presented a 3D heterogeneous microstructure (Fig. 1a), which was stacked and connected by flake-like structure (aromatic Schiff bases iron complexes) with the average size of 0.67 μm in thickness. Most of MWCNTs were embedded into the flake crystal due to the in-situ polymerization, only a part of MWCNTs was exposed. In Fig. 1b, the MWCNTs are grafted by spherical structure (aliphatic Schiff bases iron complexes) with average size of 0.48 μm in diameter. It means the MWCNTs play the role of bridge in the 3D dendrite-like heterogeneous structure and beneficial for the conductivity property of the APSMF. As shown in Fig. 1c, peaks at 1610–1640 cm^{-1} corresponding to υ (C=N) absorption bands, which proves the synthesis about Schiff bases [4].

Fig. 2a and b shows the complex relative permittivity (ε′, ε″), permeability (μ′, μ″), of the prepared sample. The ε′ value shake decreases with increasing frequency from 7.17 to 5.17 in the 2–18 GHz range, and has a peak value 7.17 at 13.76 GHz. Whereas the ε″ is increased from 1.52 at 2 GHz to 3.28 at 12.96 GHz and then declined to 0.60 at 13.66 GHz. The μ′ value exhibits a peak