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Full Length Article

Waxberry-like carbon@polyaniline microspheres with high-performance microwave absorption

Lujun Yu, Yaofeng Zhu*, Yaqin Fu

Key Laboratory of Advanced Textile Materials and Manufacturing Technology Ministry of Education, Zhejiang Sci-Tech University, No. 928 Second Avenue XiaSha Higher Education Zone, Hangzhou 310018, PR China

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ABSTRACT

Polyaniline (PANI) nanorod arrays were facilely grown on the surface of carbon microspheres via a simple dilute polymerization. The as-synthesized carbon@polyaniline nanorod arrays microspheres (C@PANI) show specific waxberry-like shape, and exhibit superior microwave absorption capacities compared with pure PANI and carbon microsphere. The minimum reflection loss (*RL*) value of C@PANI microspheres reaches −59.6 dB at 15.5 GHz with a thin thickness of 2.2 mm and the effective bandwidth (reflection loss values of less than −10 dB) is as wide as 5.4 GHz (from 12.6 to 18 GHz). The in-depth analyses of the geometrical shape and composition relationship demonstrate that the enhanced microwave absorption properties of C@PANI microspheres was mainly correlate with the unique PANI nanorod arrays and synergistic effect.

1. Introduction

High-performance absorbers (low density, tiny thickness, strong wave absorption and broad bandwidth) have been in urgent demand owing to increasing electromagnetic wave (EW) pollution caused by the rapid development of information technology [1,2]. To achieve aforementioned performance of absorbers, rational design of composition, morphology and structure is considered as a vital principle. In light of this, well-balanced combination of dielectric, magnetic and resistance materials is extensively used to fabricate strong wave absorption absorbers [3–5]. However, absorbers just with different combination of composition are still difficult to satisfy the practical requirement due to the restriction of narrower effective absorption bandwidth.

More recently, reasonable morphology and structure which could tremendously improve the microwave absorption properties of absorbers have attracted increasing attention, such as porous flower-like NiO@graphene [6], helical polypyrrole [7], hollow carbon nanospheres [8], etc. In particular, considerable efforts have been devoted to fabrication of high-performance microwave absorber microspheres. For example, Zhou et al. [9] fabricated three types of hollow urchinlike α-MnO_2 nanostructures by a simple hydrothermal method, of which tetragonal nanorod clusters exhibited minimum reflection loss (*RL*) of −41 dB at 8.7 GHz. Liu et al. [10] reported that CoNi@SiO_2@TiO_2 and CoNi@Air@TiO_2 microspheres had excellent microwave absorption properties, which a minimum *RL* reached −58.2 dB at 10.4 GHz and the absorption bandwidth of $RL < -10$ dB was up to 8.1 GHz. Liu et al. [11] prepared Fe_3O_4@BS@BTO yolk-shell microspheres with double-component shells and the absorption bandwidth of $RL < -20$ dB was up to 7.5 GHz. The loss mechanisms of the aforementioned absorber microspheres are consist of dielectric and magnetic losses, yet non-magnetic loss microspheres with light weight and high-performance microwave absorption properties have not been extensively studied. On the other hand, typical geometric transition shape including pyramid, wedge and conelike which used for absorbers in anechoic chamber were neglected in the design of micro level absorbers. The typical geometric transition shape not only provide a smooth transition of impedance to reducing the impedance mismatch at the air-absorber interface, but also create multiple reflection and scattering of incident EW, so the efficiency of absorption can be significantly improved [12]. Therefore, it remains an interesting challenge to construct typical geometric transition shape of absorber microspheres only using dielectric materials.

Polyaniline (PANI) has been expected to be the most promising candidate due to its excellent properties, including lightweight, corrosion resistance, facile synthesis and dielectric loss ability [13]. And many PANI-based composites

* Corresponding author.
E-mail addresses: 201610301016@mails.zstu.edu.cn (L. Yu), yfzhu@zstu.edu.cn (Y. Zhu), fyq01@zstu.edu.cn (Y. Fu).

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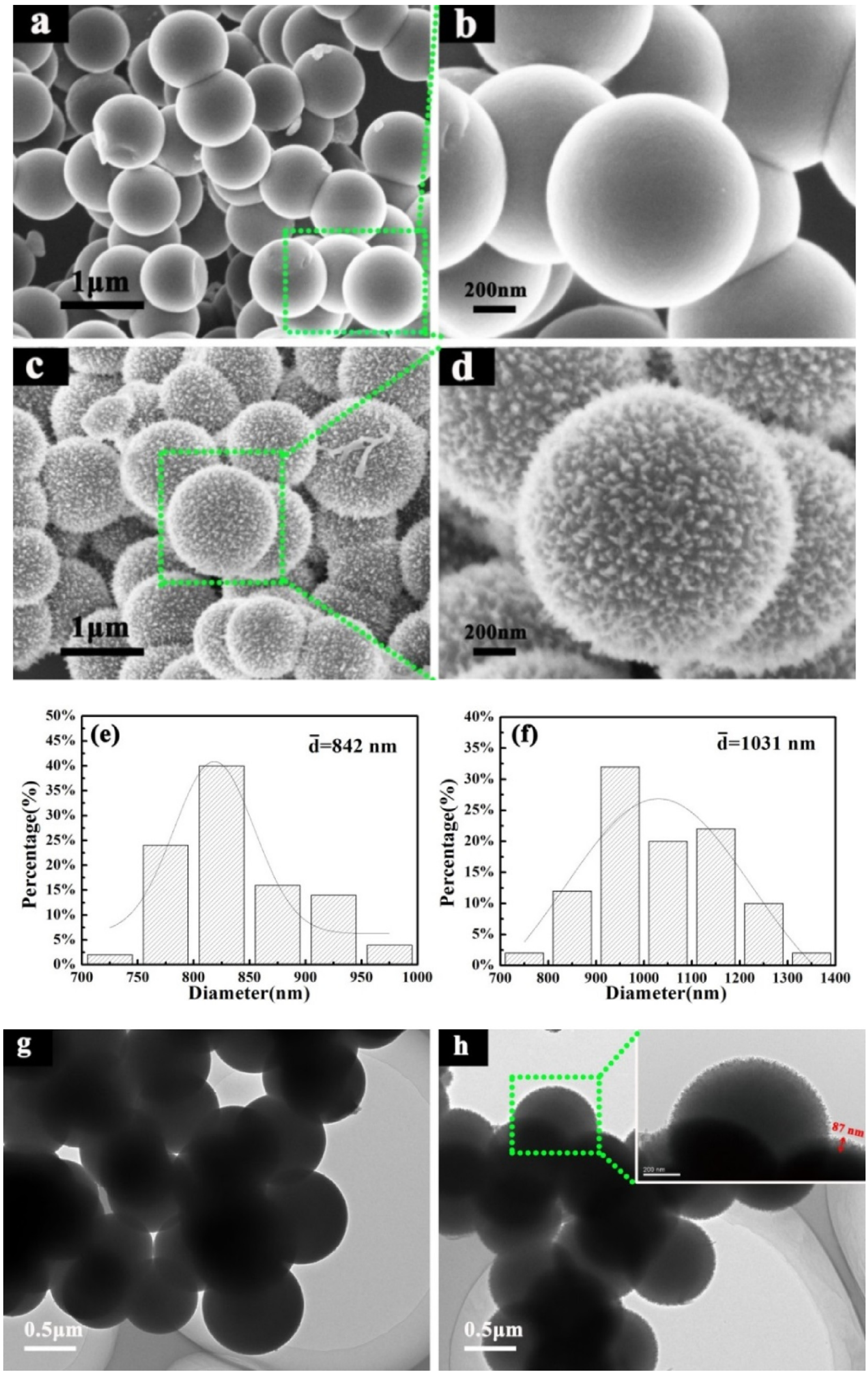

Fig 1. FE-SEM images of C (a, b) and C@PANI microspheres (c, d) under different magnifications. (e) diameter size distributions of C microspheres in a and (f) diameter size distributions of C@PANI microspheres in c. TEM images of C (g) and C@PANI microspheres (h). Inset: magnified image of C@PANI microspheres.