Materials Letters 123 (2014) 107–111

Contents lists available at ScienceDirect

Materials Letters

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

Dual functional carbon dots derived from cornflour via a simple one-pot hydrothermal route

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ARTICLE INFO

Article history:
Received 28 October 2013
Accepted 26 February 2014
Available online 6 March 2014

Keywords:
Carbon materials
Nanoparticles
Luminescence
Biomaterials

ABSTRACT

Highly Photoluminescent (PL) carbon dots (CDs) with a PL quantum yield (PLQY) of 7.7% have been prepared from cornflour by a simple hydrothermal method. The as-prepared carbon dots have good water solubility, well distributed particle size, amorphous structure and acceptable fluorescence lifetime. Besides, due to the fairly good biocompatibility and outstanding fluorescent properties, the CDs were successfully applied to cell imaging and Cu^{2+} detecting.

1. Introduction

Photoluminescent CDs have attracted growing interest in recent years due to their great potentials in biological labeling, bioimaging, drug delivery and optoelectronic device applications [1–3], and CDs are emerging as viable alternatives to semiconductor quantum dots (QDs) owing to their important photoluminescent properties and lack of any known cytotoxicity [4]. These advantages have led to increased interests in developing methods for their syntheses, involving both top-down and bottom-up approaches [5]. Several top-down approaches such as laser ablation have been proposed to produce fluorescent CDs [6]. On the other hand, bottom-up approaches like carbonization of glucose, sucrose, glycol, citric acids, *etc.* have achieved significant attention for the production of fluorescent CDs [7]. However, these approaches commonly suffer from the involvement of complex or post-treatment processes, severe synthetic conditions, and the use of large amounts of strong acid or expensive starting materials, which severely limit the practical applications of CDs. In this paper, we report that the water-soluble fluorescent CDs can be readily prepared by a simple, one-step, green hydrothermal method using low-cost, natural corn as carbon source. The fairly good biocompatibility and unique luminescence properties can enable the as-prepared CDs to be applied to cell imaging and Cu^{2+} detecting.

2. Experimental section

Cornflour was purchased from the local flourmill and was used without further purification. The CDs were synthesized by the hydrothermal treatment of cornflour in deionized (DI) water. Briefly, 0.5 g of cornflour was dispersed into 30 mL DI water under magnetic stirring and sonicated for 30 min. Then the mixture was transferred into a 40 mL Teflon-lined stainless steel autoclave and heated at 180 °C for 5 h. After the completion of the reaction, the autoclave was cooled to room temperature naturally. A dark brown solution was obtained; the solution was filtrated to separate the deposit, and the brown filtrate was then centrifuged at high speed to obtain highly fluorescent CDs.

3. Results and discussion

The obtained CDs exhibit fairly good monodispersity, a uniform spherical morphology (Fig. 1(a)), and the diameters of CDs are in the range of 2–6 nm, with an average value of 3.5 nm (inset of Fig. 1(a)). Fig. 1(b) shows the amorphous structure of the CDs, which also can be confirmed by selected area electron diffraction (SAED) pattern. As shown in Fig. 1(c), these characteristic absorption bands of Fourier transform infrared spectroscopy (FTIR) spectrum indicate the existence of the functional groups including carbonyl, carboxyl, hydroxyl, epoxy groups and amino group [8,9]. The presence of these functional groups imparts excellent solubility of CDs in water without further chemical modification. X-ray

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http://dx.doi.org/10.1016/j.matlet.2014.02.090
0167-577X/

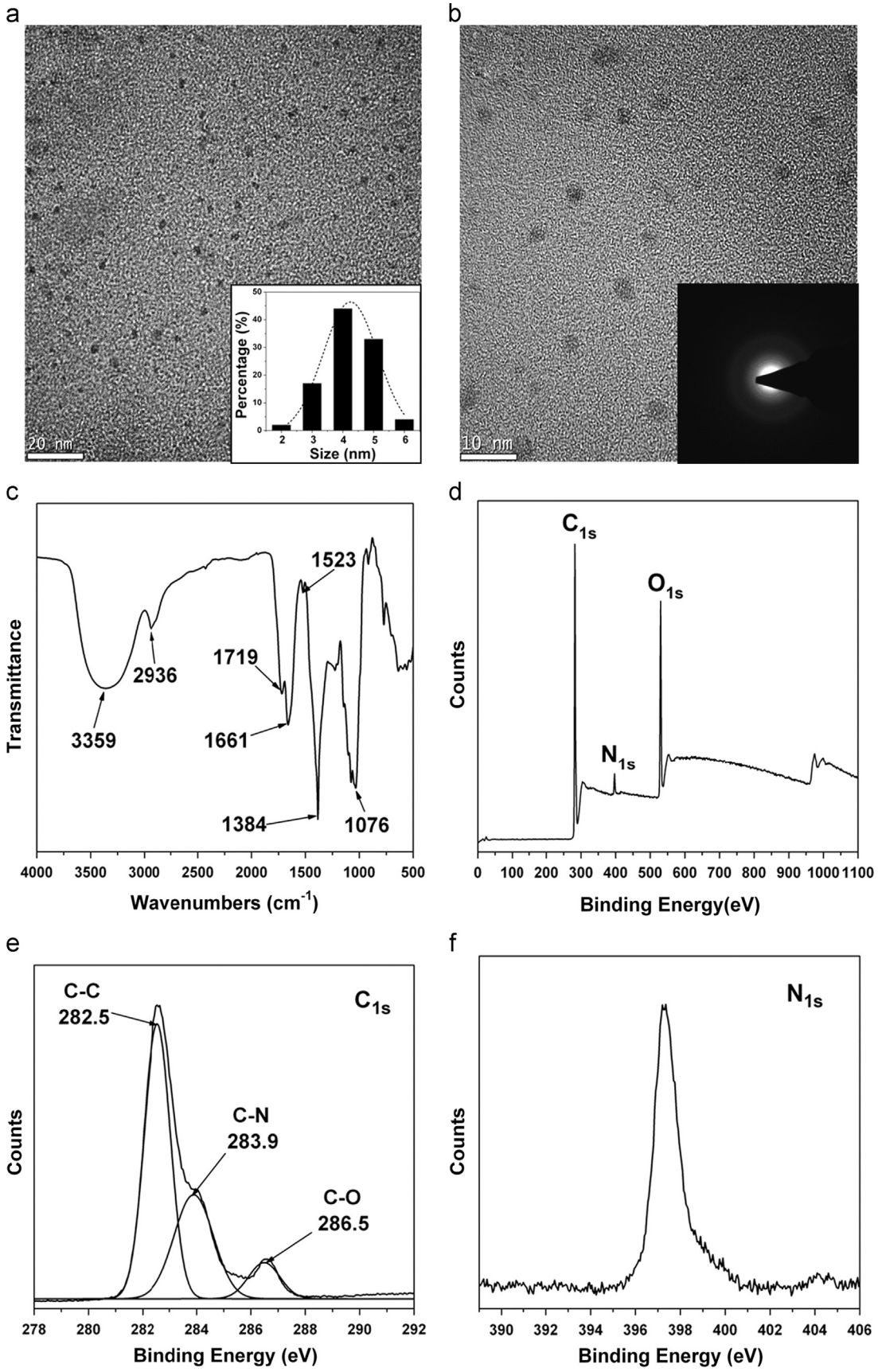

Fig. 1. Morphology and component characterization of CDs: (a) TEM image, inset: size distribution ($n=100$); (b) HRTEM images, inset: SAED pattern; (c) FTIR spectrum; (d) XPS, (e) C_{1s} and (f) N_{1s} spectra.