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Facile and novel hydrothermal preparation of functionalised carbon microspheres from glucose by using graphene sheets as a substrate

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ABSTRACT

We report for the first time a facile and efficient strategy to prepare carbon microspheres by the polymerization of glucose in the presence of graphene under hydrothermal carbonization. The morphologies characterizations of the as-synthesized products confirmed that the technique in this paper acted as a good strategy. A great deal of carbon microspheres with good morphology and uniform diameter were prepared. The structure characterizations indicated that there were many functional groups on the surface while the spheres were mostly amorphous structure. A formation mechanism was proposed that involved curved graphene sheets as a substrate for microsphere formation. As this route is low-cost, green and simple, and the experimental parameters are very easy to control, it may provide a great convenience to study properties and applications of carbon microspheres.

1. Introduction

Among different forms of carbon materials, carbon microspheres (CMSs) have attracted considerable attention, owing to their potential wide variety of applications [1]. Though many approaches have been developed towards these microstructure carbons, such as chemical vapor deposition [2], pyrolysis of carbon sources and catalyst [3,4], mixed-valence oxide-catalytic carbonization [5] and so on, each of these methods has its own advantages and limitations. To our knowledge, to get the narrower particle size distributions, controlling the time and temperature, as well as the concentration of the process accurately are required. So it is also worth to develop simpler and low-cost procedures to obtain CMSs under mild conditions.

Graphene has attracted much interest because of its structure and specific properties. One possibility is the use of graphene sheets as a substrate agent for assisting the development of 0D and 1D structure of materials [6]. Initially, our purpose is to introduce carbon nanoparticles to load on exfoliating surface area of graphene oxide (GO). But surprisingly, when the reaction time was over at 24 h under 160 °C, the results of several careful characterizations reveal that the as-prepared sample are all CMSs and the graphene disappear. So, here we first describe a noble and easy strategy to get CMSs by investigating glucose as precursors and graphene sheets as a substrate for the production of highly functionalised products through hydrothermal carbonization (HTC).

2. Experimental section

GO was obtained by modified Hummers method [7]. In a typical procedure: 5.0 g glucose and 0.1 g Vitamin C (Vc) was dispersed in 40 mL of GO solution (0.1 g) under vigorous magnetic stirring. Then the mixture solution was put into a Teflon-lined steel autoclave with a volume capacity of 50 mL. Finally, the container was closed and maintained at 160 °C for 24 h. After that, the autoclave was cooled down to room temperature naturally. For discussing the mechanism, another sample prepared at 160 °C for 8 h was acted as a parallel sample. The as-synthesized products were obtained by filtering, rinsing, and drying. Scanning electron microscopy (SEM) was performed with a Philips XL30 FEG FE-SEM instrument. Transmission electron microscopy (TEM) images were taken on a JEOL 2010F (JEOL Ltd., Japan). Fourier transform infrared spectroscopy (FTIR) spectra were recorded on a Nicolet IS10 spectrometer. Raman spectra were recorded on a Dilor LABRAM-1B multichannel confocal microspectrometer with 514 nm laser excitation.

3. Results and discussion

SEM and TEM images in Fig. 1 show the general morphology of the CMSs. Fig. 1a and b reveal that the sample consists of many uniform microspheres with diameter of about 4.8 ± 1.5 μm and the morphological yield of CMSs is approximately 98%. Most

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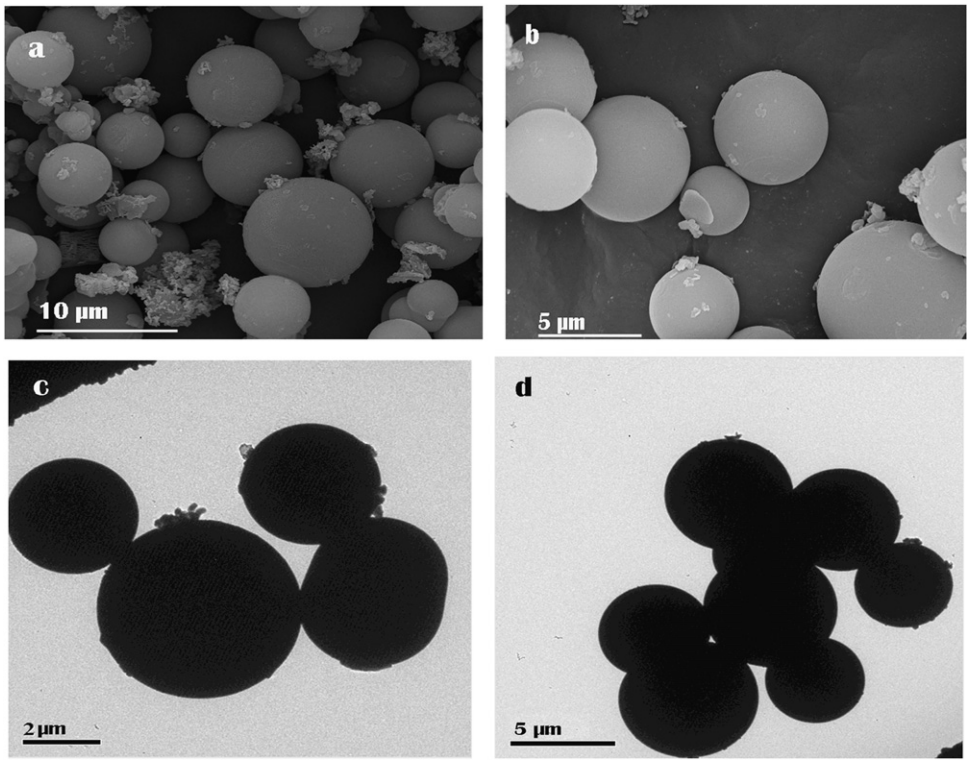

Fig. 1. SEM (a–b) and TEM (c–d) images of CMSs.

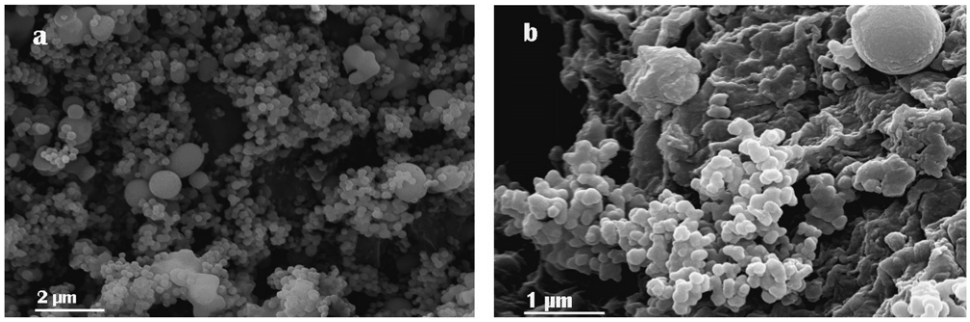

Fig. 2. SEM images of carbon spheres by HTC from (a) glucose solution and (b) MMT/glucose solution.

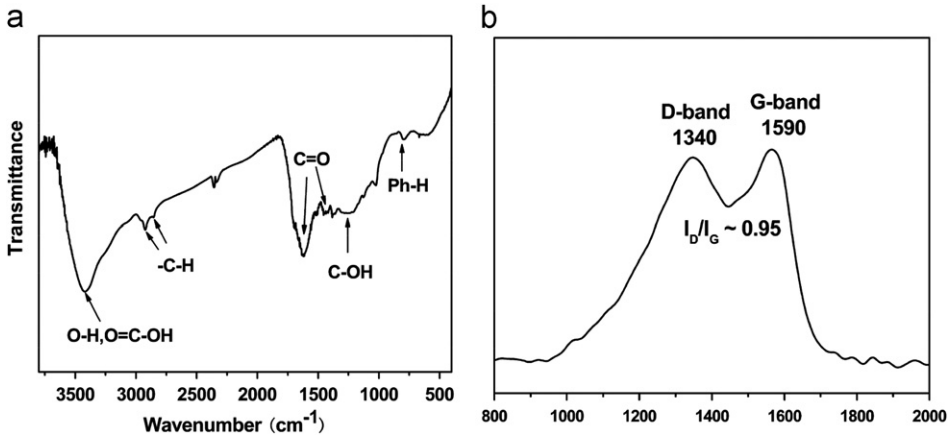

Fig. 3. FTIR (a) and Raman (b) patterns of CMS.

particles are single spheres and agglomerations are almost invisible, showing the perfect spherical morphology of the CMSs with smooth surface. Fig. 1c and d present the TEM images of the as-obtained CMSs. It can be observed that the CMSs are monodisperse and have a narrow size distribution with a diameter of 2–5 μm. This result is in perfect good agreement with those of the