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Two-dimensional porous carbon nanosheets from exfoliated nanopaper-like biomass

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ABSTRACT

Two-dimensional porous carbon nanosheet materials are of increasing importance. Many examples for their synthesis exist, but they generally show some common requirements, such as rigid reaction conditions, high cost and complicated multiple synthetic steps. Here we report a facile and cost-effective way to prepare porous carbon nanosheets by using an exfoliated nanopaper-like biomass, *i.e.*, melaleuca bark as precursor. It is found that just after a simple carbonization treatment, the nanopaper-like barks can be directly transformed into two-dimensional carbon nanosheets with a unique hierarchical porous structure. A high BET surface area of 1397 m^2/g can be reached for the obtained carbon materials without any extra activation process. Tuning of nanostructures could be facilely accomplished by varying carbonization treatment conditions. The as-prepared porous carbon nanosheet serves well as the sulfur host materials for lithium-sulfur battery.

1. Introduction

Two-dimensional (2D) nanomaterials have received tremendous attention due to their distinctive structural feature of ultimate 2D anisotropy with unique small thickness [1]. Among various 2D nanomaterials, carbonaceous nanosheets, represented by graphene (oxides) and related materials, have garnered particularly considerable interests, not only for their fundamental scientific interest, but also for their technological potential applications [2]. This is motivated by their unique combination of high surface area, excellent electrical conductivity, remarkable thermal and chemical stability.

Despite rapid developments, 2D carbon nanosheets like graphene usually suffer from serious agglomeration and restacking because of strong van der Waals interlayer interaction [3], which inevitably leads to significant compromise or degradation of their specific surface area. Considering the surface area is the most important structural parameter in many applications, numerous efforts have been devoted to prevent the restacking of carbon nanosheets by introduction of spacers such as nanocarbon, conducting polymers and metallic compounds into the interlayer [4,5]. However, these strategies of keeping the carbon nanosheets separated still lead to relatively low surface areas in most cases. Another efficient way is the generation of nanopores on the sheets [6]. These pores on the nanosheets not only provide a large surface area for dispersion of the active sites, but also improve mass transfer rate; therefore, the as-synthesized porous carbon nanosheets exhibit distinct properties from pristine carbon nanosheets, leading to improved performances [7,8]. Many advanced techniques, including nanocasting, activation, helium ion bombardment, electron beam irradiation, and other chemical synthesis, have been developed to fabricate porous carbonaceous nanosheets [6,9]. However, most of these methods have limitations, such as rigid reaction conditions, high cost, and complicated multiple synthetic steps. Hence, establishing an efficient and facile synthesis protocol for 2D porous carbon nanosheet (PCNS) would be of great benefit to their large scale production and broad applications.

Herein we report a facile and cost-effective way to prepare 2D PCNS by using an exfoliated nanopaper-like biomass, *i.e.*, melaleuca bark as precursor. We surprisingly find that the nanopaper-like natural barks can be directly transformed into 2D PCNS after a simple carbonization treatment (Fig. 1a). Meanwhile, numerous nanopores are generated on the carbon sheets, thus forming a unique hierarchical porous structure. The highest surface areas

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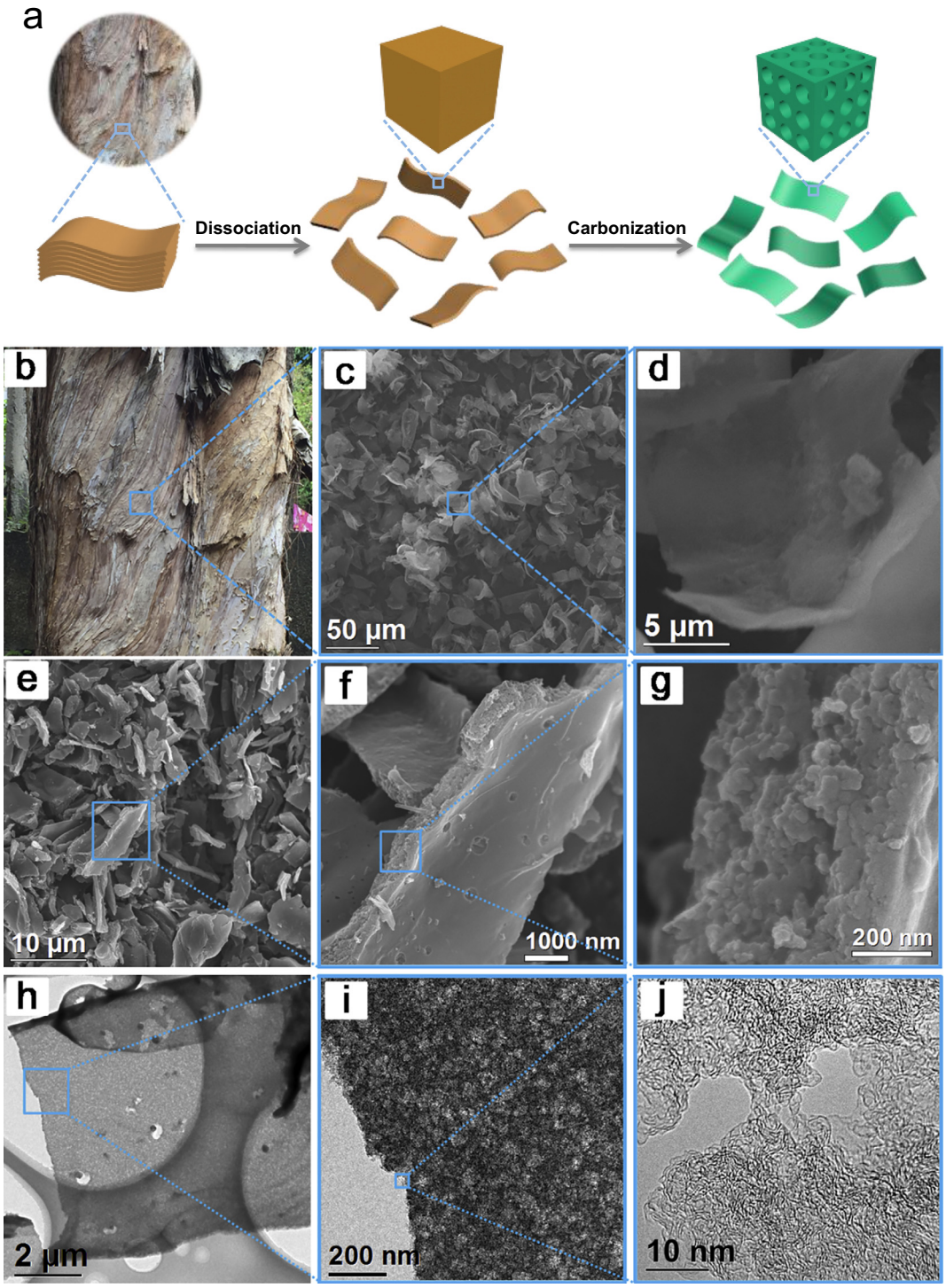

Fig. 1. (a) Schematic illustration of the approach to 2D PCNS by using exfoliated melaleuca bark as precursor. (b) Digital image and (c, d) SEM images of melaleuca barks. (e, f, g) SEM and (h, i, j) TEM images of the PCNS-6H.

can reach 1397 m^2/g without any extra activation process. With combination of the advantages of both porous carbons and 2D nanosheets, the as-prepared PCNS exhibits attractive electrochemical properties when utilized as sulfur host for lithium-sulfur battery. The employment of low-cost and environment friendly melaleuca bark as carbon precursor avoids many chemical/physical processes in normal synthetic procedures of 2D PCNSs, opening new avenues to advanced and sustainable materials.

2. Experimental section

Melaleuca barks were gathered from South China Agricultural University and directly used as the starting material without any pre-treatment. The melaleuca barks were subjected to carbonization by heating at 900 °C for various hours with a heating rate of 5 °C/min in a furnace under N_2 flow, leading to formation of PCNS-*x*H. The *x* was denoted as the carbonization time.