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Communication

Effect of carboxylic acid groups on the supercapacitive performance of functional carbon frameworks derived from bacterial cellulose

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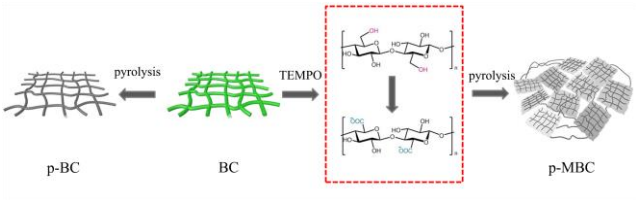
Graphical abstract



We proposed a method by using a renewable biomass of modified BC as a precursor to prepare functional carbon frameworks.

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ABSTRACT

Three-dimensional (3D) carbonaceous materials derived from bacterial cellulose (BC) has been introduced as electrode for supercapacitors in recent. Here, we report a simple strategy for the synthesis of functional carbon frameworks through 2,2,6,6-tetramethylpilperidine l-oxyl radical (TEMPO) -mediated oxidation of bacterial cellulose (BC) followed by carbonization. TEMPO-mediated oxidation can efficiently convert the hydroxyls on the surface of BC to carboxylate groups to improve electrochemical activity. Because of its high porosity, good hydrophilicity, rich oxygen groups, and continuous ion transport in-between sheet-like porous network, the TEMPO-oxidized BC delivers a much higher gravimetric capacitance (137.3 F g^{-1}) at low annealing temperature of 500 °C than that of pyrolysis BC (31 F g^{-1}) at the same annealing temperature. The pyrolysis modified BC obtained at 900 °C shows specific capacitance (160.2 F g^{-1}), large current stability and long-term stability (84.2% of its initial capacitance retention after 10,000 cycles).

Increasing interests in developing renewable and environment friendly electrodes has driven researchers for several years [1-3]. Nanocellulose has attracted great attentions as electrode materials because of low cost, large specific surface area, high porosity and broad chemical-modification capacity [4, 5]. Bacterial cellulose (BC) is one of the families of nanocellulose and it features not only common cellulosic properties but also other useful properties as ultrafine fiber network structure and rich hydrogen bonds [6]. Thus, it shows the potential applications as electrodes in electrochemical supercapacitors.

Significant efforts have been made to fabricate BC-based composite electrodes, such as carbonization [7, 8], electro-deposition [9] and chemical polymerization [10]. Among these methods, one-step carbonization has shown the advantage of convenient, environment friendly and potential of large scale synthesis. For BC carbonization, the specific capacitances of electrodes prepared from pristine BC increase because of the enhanced specific surface area with the increase in carbonization temperature [7]. In this work, we found that the specific capacitances of pyrolysis BC (p-BC) increased first and then decreased in a KOH electrolyte with the increase of carbonization temperature, exhibiting the maximum capacitance value of ~149.1 F g^{-1} at the current density of 1 A g^{-1} at 900 °C. Further increase of the temperature above 900 °C, the specific capacitances of p-BC declined sharply. It indicates that there is a