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Partially graphitic nanoporous activated carbon prepared from biomass for supercapacitor application

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Highlights

- First time reported partially graphitic nanoporous carbon derived from biomass.
- The capacitance of carbon-F was found to be 173.2 F g^{-1}, 164 F g^{-1}, 156 F g^{-1} and 148 F g^{-1}.
- The carbon-F has energy density 12.8 Wh kg^{-1}, 12.2 Wh kg^{-1}, 12.1 Wh kg^{-1} and 12.6 Wh kg^{-1}.
- The carbon and carbon-F was found to have retention of 89% and 95%.

Abstract

In this present work, the preparation of partially graphitic nanoporous carbon from biomass (bamboo bagasse) is carried out using potassium ferrocyanide and -KOH as activating agent with controlled temperature and gas flow rates. The physico-chemical properties of biomass-derived graphitic nano-porous carbon were characterized by X-ray Diffraction (XRD), Fourier Transform Infra-Red Spectroscopy (FTIR), Thermal Gravimetric Analysis (TGA), Raman spectroscopy, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM) and electrochemical measurements. It is interesting that the activation with the iron salts plays a significant role in the formation of graphitic structures. The graphitic nanoporous carbonaceous materials show high specific surface area of 1360 $m^2\ g^{-1}$, low impedance, large pore volume and high specific capacitance. Thus, the iron-catalyzed graphitic carbon is excellent candidate for the supercapacitor applications. This contemporary- novel method to synthesis of nanoporous carbon represents a great potential for apparent and diversified applications in energy storage materials.

Introduction

Supercapacitors/ultracapacitors/electrochemical capacitors play a vital role in energy storage technology by providing high power and cycling performances. The current state of art in the field of supercapacitor is it has good power density, good reversibility and it is extensively used in high power applications such as grid applications, high power electronics, etc. Carbon-based materials are of interest because of their properties like high specific surface area, tunable porous structures and other distinguished properties. The most common form of carbon from the renewable energy is the biomass [1], [2], [3], [4].

The major objective is to prepare low cost, high conducting, and abundant electrodes for supercapacitor with stable cycling performances and also to synthesize partially graphitic nanoporous carbon from biomass [5]. This study for the first time preparation of partially graphitic carbon is carried out to overcome the limitations. This facile, easy method with abundant source, eco-friendly, and low-cost can be suitable for supercapacitor applications [6].

Section snippets

Carbonization and activation of bamboo bagasse

All chemicals used in this experiements are of analytical grade (AR). The physicochemical characterization of the material was carried out with TGA, XRD, Raman spectroscopy, FTIR, SEM (HitachiS-4800), TEM and electrochemical measurements (Biologic SP300). Small pieces of bamboo bagasse was treated into the muffle furnace (Hot King Instruments Company) at 300 °C for 2 h and cooled for 24 h and thus the carbonized bamboo bagasse was obtained [7], [8], [9]. The carbonized BB was then homogeneously

Results and discussion

Fig. 1(a) represents the TGA of raw material, 300 °C carbon at and 800 °C carbon. The TGA curves were taken in N_2 atmosphere at a heating rate of 15 °C/min. The raw material curve reveals that the decomposition (carbonization) starts from 260 °C. Hence, 300 °C was kept as the standard for the carbonization of the raw material. For 300 °C carbon, the activation appeared around 400 °C to –600 °C and after that there is certain amount decrease in the weight, thus few functional groups may be

Conclusion

The partially graphitic activated carbon from biomass was successfully prepared. The carbon-F reveals the high specific capacitance and efficient rate capability for high-performance electro-chemical electrical double layer capacitor. It is concluded that biomass derived-iron catalyzed carbon is highly porous in nature. It was also found that carbon-F electrodes obtained 35% higher capacitance, higher current density of 10 A g^{-1}, energy density of 12.8 Wh kg^{-1}, 12.2 Wh kg^{-1}, 12.1 Wh kg^{-1} and

Acknowledgments

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Recent progress on porous carbon and its derivatives from plants as advanced electrode materials for supercapacitors

2022, Journal of Power Sources

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Recent advances and challenges in biomass-derived porous carbon nanomaterials for supercapacitors

2020, Chemical Engineering Journal

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> …In recent years, the demand for high-performance electrodes has led to the further

development of research and synthesis technologies for BDPC. A large amount of woody biomass has been studied as electrode materials for supercapacitors, such as walnut shells [109], bamboo bagasse [110], raw cotton [80], corn silk [93], pistachio nutshell [111], rice husks [58], oil palm shell [70], coconut shells [103], broad bean shells [112], Acacia tree bark [113], onions [68], cornstalk [114], coconut shell [115], shiitake mushroom [72], bamboo [116], etc. Woody biomass is mainly composed of cellulose, hemicellulose and lignin.…

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2019, Journal of Energy Chemistry

Citation Excerpt :

…Considering from the practical application, it is essential to develop a cost-effective way to fabricate functional carbon electrode materials with high capacity. In this regard, biomass derived carbons (BDCs) have long been the hot research topics and a large variety of biomass has been employed as initial materials by synthesis of functional carbons via carbonization/KOH-activation method or ZnCl2-activation method [17–41]. However, the supercapacitor performance of most BDCs remains poor (usually low to 200–300 F/g) mainly on account of the low content of electrochemical-active functionalities resulting from the traditional high-temperature carbonization/activation [42,43].…

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