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Synthesis of nanoporous carbon with new activating agent for high-performance supercapacitor

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Highlights

- First time we have reported nanoporous carbon from Kapok shells.
- New molten salt (NaCl-KCl) is used as an activation agent for the synthesis.
- The surface area and capacitance of carbon is found to be 1260 $m^2 g^{-1}$ and 169 $F g^{-1}$.
- The energy and powder density of carbon is found to be 12.5 $Wh kg^{-1}$ and 1.9 $kW kg^{-1}$.

Abstract

In the present work, we report a new activating agent (NaCl:KCl) (1:1) for the synthesis of nanoporous carbon from Java Kapok tree shell (1:1) with different controlled temperature under inert atmosphere. Additionally, surface morphology, physico-chemical and electrochemical properties of the nanoporous carbon are characterized. The obtained Kapok shell derived nanoporous carbon possessed a large surface area of 1260 $m^2\ g^{-1}$, pore volume of 0.439 $cm^3\ g^{-1}$, pore size of 1.241 nm, and microspore volume of 0.314 $cm^3\ g^{-1}$. The nanoporous carbon-based electrode material exhibited higher capacitance of 169 $F\ g^{-1}$ with 97% capacity retention after 10,000 cycles at 1 $A\ g^{-1}$. We believe that this new activation agent can be significant contribution in the new carbon technology for energy storage materials.

Graphical abstract

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Introduction

In general, porous activated carbon, CNT, graphene are prepared by carbonization of carbon precursor and sequential chemical activation (KOH, NaOH, K_2CO_3, HCl, Mg/Zn, $ZnCl_2$ or H_3PO_4 etc.,) and physical activation (CO_2, NO_2, Ar, H_2O, air or microwave etc.,) [1], [2]. Due to large specific surface area, high porosity, conductivity, energy, long cycle and temperature stability [3], the activated carbon is usually applied in many fields, such as supercapacitors [4], [5] lithium ion anodes [6], sodium ion anodes and CO_2 capture [7]. Amongst many varieties of carbon precursor, the biomass-derived activated carbon is a kind of economical and advantageous material because of low cost, environmentally friendly and high performance. Because of its high surface area, extensive porosity and the profuse surface functional groups, the porous activated carbon can make the electrode material store more counter-ions electrostatically in the diffuse layer formed next to the surface and lead to a higher electrical double layer

capacitance [8].

In this present work, we consider the environmental solicitude and mainly focus on the consumption of energy from bio-waste. The nanoporous carbon from the biomass of Java kapok, (Ceiba pentandra), also called Java cotton. Kapok tree shell was obtained from fruit of the kapok and it is a cheap, most abundant, sustainable biological resource. The synthesis of molten salt solution is based on multi-salts with low melting point. In this work, new activating agent, molten salt (NaCl:KCl) solution with low melting point of 657 °C is employed for the synthesis of highly nanoporous carbon from biomass. To the best of our knowledge, influence of molten salt as activating agents on the surface morphology and electrochemical properties of activated carbon made from kapok has not been investigated. The major objective of this study is to synthesis nanoporous carbon with novel activating agent from kapok.

Section snippets

Experimental

The received Kapok tree shell was first washed to remove all cottons, seeds, mud and impurities. The Kapok tree shell was then carbonization at 300 °C for 2 h in the muffle furnace. Further it was cooled for 24 h and thus the carbonized powder was crushed into fine powders by ball milling and collected for further activation. In the next process, sodium chloride (NaCl) and potassium chloride (KCl) salt (molten salt) is mixed at the ratio of 1:1.This molten salt solution was used as solvent and

Results and discussion

The TGA/DTA curves are shown in Fig. 1(a). The TGA curves of kapok shell raw material, carbonized Kapok shell at 300 °C and KNPC 1000 respectively were compared. The TGA curves reveal a higher weight loss (55%) between 230 °C to and 350 °C which represents the degradation of volatile substances and removal of oxygen functional groups from the surface. Hence, 300 °C kept as the standard temperature for carbonization. For 300 °C carbon, the activation appeared around 550 °C and after that there

Conclusion

The activated carbon from the Java Kapok tree waste is prepared with new activating

agent of molten salt (NaCl-KCl) with high specific surface area of 1260 $m^2 g^{-1}$. The specific capacitance was found to be 169 F g^{-1} with the capacitance retention greater than 97% after 10,000 cycles. This novel activated carbon can be more economical and breakthrough technology for carbon materials and applications.

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Molten salt induced nitrogen-doped biochar nanosheets as highly efficient peroxymonosulfate catalyst for organic pollutant degradation

2020, Environmental Pollution

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> ...For example, Hou's research found that the loss of nitrogen from N-doped mesoporous carbon was up to 70% when thermal treatment temperature increased from 700 °C to 1000 °C (Hou et al., 2018). Recent studies showed non-toxic molten salt (NaCl/KCl) (1:1 by molar ratio) with low melting point of 657 °C could function as protection and activation media for preparing carbon nanosheets (Thileep Kumar et al., 2018; Wang et al., 2018). Biomass is carbonized in molten salt medium and the sp3 C–X bonds (X = C, H, or O) can be converted to sp2–bonded graphene-like carbon network sheets (Liu et al., 2014)....

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