Enhancing the performance of waste hemp hurd-based carbons in SIBs through $\text{H}_2\text{SO}_4$-assisted hydrothermal pretreatment

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**Introduction**

Sodium-ion batteries (SIBs) are a promising option due to the wide availability and low cost of sodium. Hard carbons (HCs) are considered as potential anodes in SIBs due to their ability to store Na+ ions, via intercalation into graphitic layers, adsorption on defects and functional groups on surface, as well as pore filling.

In this study, waste hemp hurd (WHH) was as a renewable and sustainable carbon precursor. Hydrothermal carbonization (HTC) of biomass wastes can promote the enlargement of HC pores and the formation of surface nanospheres, thereby improving the reversible capacity of the electrode. Additionally, the HTC process allows the addition of other chemicals to the aqueous solution to facilitate specific decomposition or doping reactions. This study aims to investigate the effect of HTC pretreatment—in water and in $\text{H}_2\text{SO}_4$ aqueous solutions—on the electrochemical performance of the resulting HCs as working electrodes in SIB half-cells.

**Materials and methods**

- **HTC**
  - Temperature: 180 °C (12 h)
  - Solution:
    1. 60 mL distilled water
    2. 60 ml $\text{H}_2\text{SO}_4$ 1 mol dm$^{-3}$
    3. 60 ml $\text{H}_2\text{SO}_4$ 2 mol dm$^{-3}$
    4. 60 ml $\text{H}_2\text{SO}_4$ 4 mol dm$^{-3}$

- **HYDROCHAR CARBONIZATION**
  - Temperature: 800 – 1000 °C
  - Conditions:
    - 5 °C min$^{-1}$ (Ar as carrier gas)

- **Waste Hemp Hurd**

**Results and conclusions**

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**CONCLUSIONS**

- The electrochemical performance of synthesized HCs was significantly affected by both carbonization temperature and hydrothermal medium.
- $\text{H}_2\text{SO}_4$ – assisted HTC
- During the HTC process $\text{H}_2\text{SO}_4$ promotes the hydrolysis, dehydration and decomposition of the organic compounds.
- Microspheres can shorten the diffusion pathway of both electrolyte and Na+ ions. The resulting interparticle voids between the microspheres could provide additional active sites for Na-ion storage.

**Electrochemical results**

- Best performance: HSA2-1000
- Reversible capacity: 459 mA h g$^{-1}$ at 0.1 A g$^{-1}$
  - 185 mA h g$^{-1}$ at 1 A g$^{-1}$
  - 125 mA h g$^{-1}$ at 2 A g$^{-1}$
- HSA1-1000 & HSA4-1000 showed excellent stability over 300 cycles
- Capacity retention = 100 % (when cycled again at 0.1 A g$^{-1}$)