Marine mucilage-based SiO_2/C nanocomposite for supercapacitors: transforming untapped bioresources into value-added products

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Sustainable electrode materials are often made from agricultural feedstock. Alternative biomass sources include micro- and macroalgae found in the marine environment. These organisms have a high growth rate and do not require agricultural land, freshwater or human activity. In recent years, temperature anomalies caused by climate change have led to harmful but nontoxic marine events, including mucilage outbreaks and algal blooms. Considering the huge amount of biowaste generated by such natural phenomena, turning this untapped resource into value-added products can yield remarkable environmental and economic benefits. Moreover, marine mucilage undergoes a self-activation process due to the abundance of natural seawater salts in its structure, avoiding the cost and environmental impact of an additional activation process.

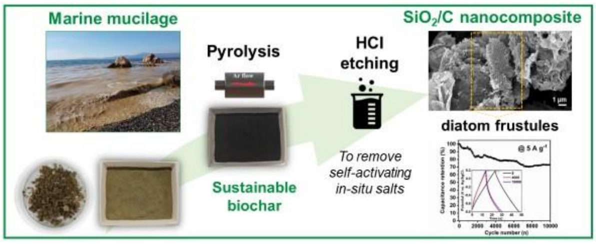

Figure 1. Synthetic process of SiO_2/C nanocomposite.

Diatoms, with their unique biosilica (SiO_2) cell walls known as frustules, are major marine organisms suspected to be involved in mucilage outbreaks. Despite being electrochemically inactive and non-conductive, SiO_2 contributes to the electrical double layer capacitance by its inherent surface potential, resulting in a very high differential capacitance of 180 $\mu F\ cm^{-2}$ [1], exceeding the typical double-layer capacitance of carbon electrodes (10–20 $\mu F\ cm^{-2}$). Consequently, in recent years, efforts have been focused on employing inexpensive and environmentally benign SiO_2 for energy-storage applications.

Here, the marine mucilage (collected from the Marmara Sea, Turkey) was converted to SiO_2/Carbon composite via pyrolysis and acid etching (Figure 1) [2]. The composite exhibited a capacitance of 210 $F\ g^{-1}$ at 0.5 $A\ g^{-1}$ in 1M Na_2SO_4. The porous silica skeleton enhanced capacitance by enlarging the electrode/electrolyte interface, while the hierarchically connected pores ensured high electrochemical stability. The SiO_2/Carbon exhibited outstanding long-term cycling stability, retaining 70% of its capacitance after 10,000 cycles at 5 $A\ g^{-1}$.

References

[1] Abendroth, R. P. (1970). Journal of Colloid and Interface Science, 34(4), 591-596.

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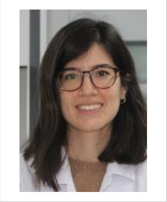

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