ABSTRACT

Sodium-ion batteries (SIBs) are the frontrunner to displace lithium-ion batteries (LIBs) in stationary storage applications, due to sodium's abundance and even distribution around the globe, consequently reducing the strain on lithium resources. Non-graphitizable carbons are currently utilized as negative electrodes in most common SIB configurations, because of their high storage capacities, low cost, and the ability to produce them from waste biomass. However, a general consensus regarding the sodium storage mechanism is yet to be achieved, despite several studies proposing various mechanisms. Moreover, high storage capacities of non-graphitizable carbons still do not satisfy the energy market demands, therefore further improvement of their performance is necessary.

This work focused on two aspects of non-graphitizable carbons: the investigation of the sodium storage mechanism, followed by strategies for improvement of charge storage capacities of non-graphitizable carbons.

Based on correlations established between the structural evolution at various pyrolysis temperatures and the electrochemical behavior of corncob-derived non-graphitizable carbons, we propose a sodium storage mechanism, endorsing the "adsorption – intercalation – pore filling" model.

We demonstrate the effect of the organic precursor on the closed porosity volume of non-graphitizable carbons. Sequential testing with sodium and lithium elucidated the impact of the closed porosity volume on the electrochemical performance.

We synthesized a series of heteroatom-doped non-graphitizable carbons to study the influence of introduced heteroatoms on sodium ion diffusivity.

Finally, the addition of Bi_2S_3 nanoparticles on the surface of non-graphitizable carbons was performed to boost the charge storage capacity and improve the cycling stability of non-graphitizable carbons. Based on the employed characterization techniques, we propose a sodium storage mechanism in Bi_2S_3 nanoparticle decorated non-graphitizable carbons.

Keywords: sodium-ion batteries, non-graphitizable carbons, sodium storage mechanism, organic precursor, closed porosity, pore filling, heteroatom doping, Bi_2S_3 nanoparticles.