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## Biomass-based hard carbon as negative electrode for sodium-ion batteries

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### Abstract

Sodium-ion batteries are a promising technology to respond to the critical availability of lithium. The most suitable material for negative electrode is hard-carbon, which can be obtained from biomass. Usually, it is synthesized by two pyrolysis steps at low (about 450°C) and high temperature (1500°C), which requires a dry starting material. Unlike pyrolysis, hydrothermal carbonization (HTC) has the advantage of immersing the material in water: there is no need in drying the biomass before processing. Furthermore, during the process, inorganics tend to leach in the liquid phase, which is can be positive for the resulting electrochemical properties of hard-carbon. It makes HTC an interesting alternative to the first low temperature pyrolysis. The objective of this work is to understand the influence of initial feedstock composition, both on the material properties after HTC and the high-temperature pyrolysis and on the final battery performances in order to optimize the chain feedstock/process/product. Elemental compositions were characterized at the different steps by CHNS analysis, ICP-OES and UV-visible spectroscopy, and crystalline structure was characterized by XRD. As expected, the inorganic elements leached to a large extent to the liquid phase during HTC, however in different proportions depending on the feedstock tested. The resulting hard carbons contained therefore little impurities and showed very good performances when tested in batteries, both in terms of initial columbic efficiency, cyclability among 100 cycles and specific capacity. These performances are promising since they are similar to graphite in lithium-ion batteries.

Keywords: biomass-based hard carbon, energy storage, sodium-ion battery, inorganic elements