Carbon materials for post Li-ion batteries: Na- and K-ions batteries

Camélia MATEI GHIMBEU [1,2]

[1] *Institut de Science des Matériaux de Mulhouse, UMR 7361 CNRS-UHA, France*
[2] *Réseau sur le Stockage Electrochimique de l'Energie, CNRS FR3459, Amiens, France*

* camelia.ghimbeu@uha.fr

The increase in demand for Li-ion batteries (LIBs), along with the scarcity of lithium resources and their specific localization over the planet, generated intense research in the last decade to find new alternative energy storage systems. Among them, sodium and potassium ion batteries (SIBs and KIBs) have emerged as potential candidates due to their large abundance and availability, which might ensure a long-term and cost-effective technology to satisfy incessant growing demands. The anode materials used to store energy in LIBs is graphite (G). However, for NIBs, hard carbon (HC) materials proved to be more suitable anodes than graphite, mainly due to their large disordered structure and large graphitic interlayer distance, which favour Na-ion insertion-extraction. In the case of KIBs, both disordered carbon materials, such as HC and ordered graphitic materials (soft carbon, SC and graphite) can be used, although the ideal choice needs to be determined.

In recent years, our work has been focused on the design of HC materials with controlled properties *via* the development of novel synthesis pathways. Several sustainable and renewable precursors were explored, leading to the design of hard carbons with different properties and electrochemical performance. The objective of this work is to provide a broad overview of the impact of the synthesis conditions (precursors, temperature, and process) on hard carbon characteristics (porosity, surface chemistry, morphology, and structure) [1-2]. Moreover, valuable correlations between HC properties and their performance (initial Coulombic efficiency, capacity, and cycle stability) in NIBs and KIBs will be presented [3,4]. Finally, insights on the sodium and potassium storage mechanism in hard carbon will be provided [3, 5, 6]. These works allowed us to progressively improve the carbon performance in these novel battery systems, although some challenges still need to be addressed.

Acknowledgements:

I thank all the students and collaborators that contribute to these works.

References:

[1] CM Ghimbeu, B Zhang, AM de Yuso, B Réty, JM Tarascon, Valorizing low cost and renewable lignin as hard carbon for Na-ion batteries: Impact of lignin grade, *Carbon* **153** (2019) 634
[2] J Conder, C Vaulot, C Marino, C Villevieille, CM Ghimbeu, Chitin and chitosan—Structurally related precursors of dissimilar hard carbons for Na-ion battery, *ACS Appl Energ Mater* **2** (2019) 4841
[3] CM Ghimbeu, J Górka, V Simone, L Simonin, S Martinet, C Vix-Guterl, Insights on the Na+ ion storage mechanism in hard carbon: Discrimination between the porosity, surface functional groups and defects, *NanoEnergy*, **44** (2018) 327
[4] A Beda, F Rabuel, M Morcrette, S Knopf, PL Taberna, P Simon, CM Ghimbeu, Hard carbon key properties allow for the achievement of high Coulombic efficiency and high volumetric capacity in Na-ion batteries, *J Mater Chem* A **9** (2021) 1743
[5] B Zhang, CM Ghimbeu, C Laberty, C Vix-Guterl, J Tarascon, Correlation between microstructure and Na storage behavior in hard carbon, *Adv Energy Mater* **6**, 1501588
[6] L Larbi, B Larhrib, A Beda, L Madec, L Monconduit, C M Ghimbeu, Impact of hard carbon properties on their performance in potassium-ion batteries, ACS Appl Energ Mater, ACS Appl. Energy Mater., **6** (2023) 5274