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Towards Sustainable Sodium-Ion Batteries: Bio-Based Anode Materials and Advanced Interface Characterization

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Sodium-ion batteries are emerging as a promising alternative to lithium-ion technology,[1] offering the potential for more sustainable and resource-abundant energy storage. However, achieving truly green systems requires a paradigm shift: we must design full cells from the ground up using sustainable, recyclable, and non-toxic components—eliminating from the start critical or hazardous elements such as cobalt, nickel, and fluorine.[2] At ENEA, we are pursuing this vision through fundamental research that integrates sustainability into every component of the battery architecture, from active materials and electrolytes to binders and separators.

In this talk, I will present our recent work on hard carbon (HC) anodes derived from local Lazio hazelnut shells, produced through controlled pyrolysis.[3] These bio-waste-based materials exhibit electrochemical performance comparable to a commercial petroleum-derived hard carbon (pitch-based), highlighting their potential as low-impact alternatives.[3]

To probe and compare the formation and evolution of the solid electrolyte interphase (SEI) during the first cycle- a key challenge nowadays- we employed high-resolution X-ray spectrometry at the BESSY II synchrotron facility (P. This advanced characterization allowed us to assess the influence of precursor materials on the interfacial chemistry, providing valuable insights into the mechanisms governing SEI formation in sustainable sodium-ion systems.

Our results underline the feasibility of using locally sourced, bio-derived materials in sodium-ion batteries without compromising performance, and emphasize the importance of pairing green material design with advanced operando diagnostics.

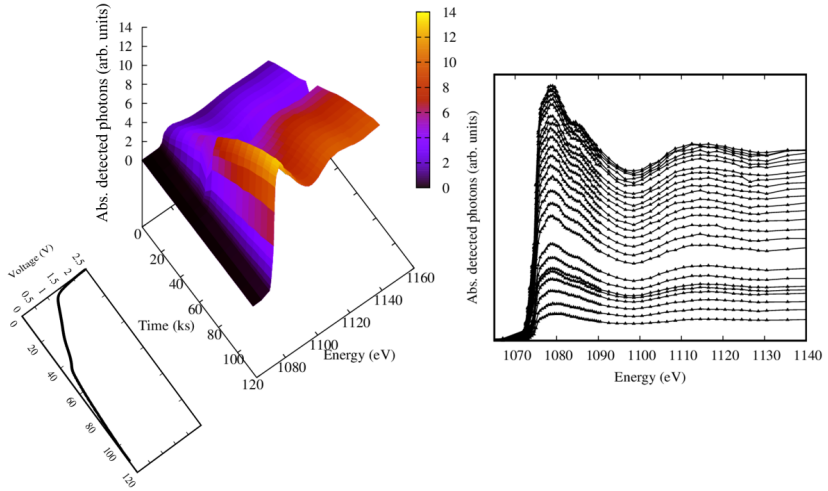

Figure 1 X-ray Absorption Near Edge Structure at Na K-edge of an HC anode surface during the first discharge

(1) *Emerging Battery Technologies to Boost the Clean Energy Transition: Cost, Sustainability, and Performance Analysis | SpringerLink*. https://link.springer.com/book/9783031483585 (accessed 2023-11-28).
(2) Larcher, D.; Tarascon, J. M. Towards Greener and More Sustainable Batteries for Electrical Energy Storage. *Nature Chemistry*. 2015. https://doi.org/10.1038/nchem.2085.
(3) Moon, H.; Innocenti, A.; Liu, H.; Zhang, H.; Weil, M.; Zarrabeitia, M.; Passerini, S. Bio-Waste-Derived Hard Carbon Anodes Through a Sustainable and Cost-Effective Synthesis Process for Sodium-Ion Batteries. *ChemSusChem* **2022**, e202201713. https://doi.org/10.1002/CSSC.202201713.