Electrode materials from alternative sources for supercapacitors

Francesca A. SCARAMUZZO – *Sapienza University of Rome*

According to the International Energy Agency (IEA), energy demand has been supplied for decades up to 80% by fossil fuels. Such an impressive percentage is currently slowly decreasing, while investment in clean energy has risen by 40% since 2020, and the International Renewable Energy Agency actually predicts that, by 2050, two-thirds of the world's energy will be sourced from renewable energy. [1] However, energy transition can be effective only if coupled to (i) sustainable energy conversion and storage systems and (ii) the development of efficient materials through green processes. [2] For this reason, the exploitation of secondary raw materials, such as industrial or agricultural wastes, represents a virtuous goal. Agricultural wastes actually constitute eco friendly sources of carbon with different morphology and structure at micro- and nanoscale, and could be highly appealing starting matrices for the development of waste-to-energy processes and materials. [3] Among the most common agricultural wastes, the outer covering of the rice kernel, i.e. rice husk (RH), is particularly promising and has already been used for several energy applications, e.g. biochar, carbon capture, fabrication of electrodes for lithium-ion batteries (either as such and in composites with silicon), and capacitors. [4] Here, we present some of our most recent results concerning the use of RH for the synthesis of light, stable and highly conductive carbon aerogels (CAs) used as electrodes for supercapacitors. The first part of the work focused on the optimization of the synthetic strategy, which allowed to evaluate the actual impact of each step on morphology, structure, and electrochemical performances of the obtained materials. Obtaining the cellulose was a two-step pre-treatment removing lignin, hemicellulose, and silica. Subsequent gelation, drying, and carbonization converted the resulting product into CAs. A full morphological and structural characterization, including scanning electron microscopy, energy-dispersive X-ray spectroscopy, X-ray diffraction, Raman spectroscopy, X-ray tomography, and Brunauer-Emmett-Teller analysis, was performed. The electrochemical performances of CAs were evaluated via cyclic voltammetry (CV) and galvanostatic charge/discharge measurements in T-cells assembled in symmetrical configuration, using alkaline electrolytes at different concentrations. The obtained results demonstrate that some of the CAs in the optimized experimental conditions exhibit promising performances as supercapacitor electrode. Moreover, they display exceptional stability, with a capacitance retention up to 81.2% after 10,000 cycles. [5]

References

[1] P. Tzeremes, E. Dogan, N.K. Alavijeh "Analyzing the nexus between energy transition, environment and ICT: A step towards COP26 targets", Journal of Environmental Management 326 (2023): 116598
[2] X. Shao, Y. Zhong, W. Liu, R.Y.M. Li, "Modeling the effect of green technology innovation and renewable energy on carbon neutrality in N-11 countries? Evidence from advance panel estimations", Journal of Environmental Manage 296 (2021): 113189
[3] M. Saleem, "Possibility of utilizing agriculture biomass as a renewable and sustainable future energy source", Heliyon 8 (2022): e08905
[4] G. Jyothsna, A. Bahurudeen, P.K. Sahu, "Sustainable utilisation of rice husk for cleaner energy: A circular economy between agricultural, energy and construction sectors", Materials Today Sustainability 25 (2024): 100667
[5] P. Atanasio, R. Zampiva, A. Fornari, C. Mancini, M. Rossi, M. Pasquali, and F.A. Scaramuzzo, "Innovative and green synthesis of carbon aerogels for advanced supercapacitors", under review.

Acknowledgments: This work has been financed by the Research Fund for the Italian Electrical System under the Three Year Research Plan 2022-2024 (DM MITE n. 337, 15.09.2022), in compliance with the Decree of April 16th, 2018".