Carbon nanofibers/reduced graphene oxide aerogels – investigations of the nanofibers loading on the electrochemical performance in aqueous electrolyte

Adam Moyseowicz[1], Dagmara Cieślak[1] and Agata Moyseowicz[1]

[1] Department of Process Engineering and Technology of Polymer and Carbon Materials, Faculty of Chemistry, Wrocław University of Science and Technology, Gdańska 7/9, 54-340, Wrocław, Poland

Graphene-based materials have attracted considerable attention in the field of energy storage due to their exceptional physical and electrochemical properties. Among various forms of graphene materials, graphene aerogels have emerged as particularly promising candidates for supercapacitor applications due to their unique structural properties, high specific surface area, and exceptional electrical conductivity [1]. However, the intrinsic limitations of reduced graphene oxide in the form of an aerogel, such as its low volumetric energy density, impede its practical application in energy storage devices. On the other side, carbon nanofibers (CNFs) are well-known carbon nanomaterials with high conductivity and mechanical robustness, though their low specific surface area limits their use in electric double layer capacitors (EDLCs) [2,3].

In this investigation, we prepared a series of carbon-carbon composites composed of CNFs and reduced graphene oxide (rGO) in the form of aerogels, which were synthesized using a simple, one-step hydrothermal method, followed by freeze-drying to produce highly porous and lightweight structures. The resultant graphene aerogel-CNF composites displayed a hierarchical network with enhanced mechanical strength and electrical conductivity.

Porous structure determined by nitrogen sorption at 77 K revealed developed porosity, with a significant contribution of mesopores due to the nature of rGO aerogel. Furthermore, no direct influence of the CNFs loading on the composite porous structure was observed. The specific surface area of the investigated materials was up to almost 500 m^2/g.

We analyzed the composites' electrochemical performance as electrode materials for aqueous alkaline supercapacitors. Measurements were performed in a three-electrode Swagelok® cell in a 6 M KOH electrolyte. Electrochemical measurements revealed that the graphene aerogel-CNFs composites exhibited high specific capacitance and outstanding rate capability. The specific capacitance of the composites was in the range of 170 to 193 F/g at a scan rate of 10 mV/s. Furthermore, the CNF/rGO composite with 15 wt.% of the CNFs exhibited almost 95% of its initial capacitance when the scan rate increased from 0.5 to 100 mV/s. The enhanced performance is attributable to the synergistic effects of the highly conductive CNFs, which facilitate efficient electron and ion transport within the composite structure, and the high surface area of graphene aerogels for electrochemical reactions.

Acknowledgements

The following research was financially supported by a statutory activity subsidy from the Polish Ministry of Science and Higher Education for the Faculty of Chemistry of Wrocław University of Science and Technology

References

[1] Z-S. Wu, Y. Sun, Y-Z. Tan, S. Yang, X. Feng, K. Müllen Journal of American Chemical Society, 134 (2012) 19532-19535.
[2] A. Śliwak, B. Grzyb, J. Ćwikła, G. Gryglewicz Carbon, 64 (2013), 1597–1614
[3] A. Moyseowicz, A.Śliwak, G. Gryglewicz, Journal of Materials Science, 51 (2016), 3431–3439

Dr. Adam Moyseowicz is employed currently at the Department of Process Engineering and Technology of Polymer and Carbon Materials, Faculty of Chemistry, Wrocław University of Science and Technology. He obtained his PhD in 2019. His research interest is related to materials for electrochemical energy storage systems, including supercapacitors and sodium-ion batteries.

Adam Moyseowicz, e-mail: adam.moyseowicz@pwr.edu.pl tel: +48 71 320 62 66