Performance of thermally reduced holey graphene oxide binder

Hanna Bukovska[2*]
Monica Giovannucci[1]
Shoayb Mojtahedi[1]
Francesca Soavi[1]
María Belén Gómez Mancebo[2]
María Isabel Rucandio Sáez[2]
[1]University of Bologna, Department of Chemistry "Giacomo Ciamician", Via Selmi, 2, 40126, Bologna, Italy
[2]CIEMAT, Department of Technology, Av. Complutense, 40, 28040, Madrid, Spain
Hanna.Bukovska@ciemat.es

Graphene-based materials (GBMs) are potential candidates for applications in the energy sector, such as hydrogen storage[1], batteries[2], supercapacitors[3] or as a binder for active materials in different devices[4], due to properties such as high specific surface area (SSA), porosity and electrical conductivity. Binders are used in the electrodes of supercapacitors as a glue, to create a bond between the active material and the current collector. The aim of this work is to study a GBM, graphene oxide with reduced holes, as a binder in activated carbon (AC) electrodes. The presence of edges and high conductivity on the electrode favours the formation of electrical double layers, increasing its efficiency. However, most of the chemical syntheses used to obtain GBM are based on graphene oxide (GO) as the starting reagent. This material has a low electrical conductivity due to the presence of oxygenated functional groups and a low SSA and porosity. In this work, hollow reduced graphene oxide has been synthesised from GO, and its behaviour as a binder was studied, both in a single supercapacitor electrode and in a complete device. For this purpose, a previously synthesised GO[5] was hydrothermally treated with H_2O_2 to form graphene oxide with holes (HGO), favouring the increase of edges[6]. Subsequently, the HGO has been thermally reduced at 450° C in a furnace to remove the oxygenated functional groups in the form of CO_2 gas in an explosive process. In this step, the HGO on the one hand recovers part of the electrical conductivity of the graphene sheets, and on the other hand undergoes an exfoliation, increasing its SSA. The obtained material (T450_Red_HGO) has been characterised corroborating the improvements respect to the non-reduced HGO. Then, the performance of T450_Red_HGO has been studied both, as a binder on single electrode for supercapacitors and in a symmetrical complete device assembly, using H_2SO_4 solution as electrolyte and CA as active material in both cases. Finally, a complete device with a polymeric binder (Polyvinyl alcohol, PVA), which is commonly used, has been prepared under the same conditions, and the results have been compared with those corresponding to the complete device with 450_Tred_HGO binder.

References

1. Shiraz, H.G. and O. Tavakoli, *Investigation of graphene-based systems for hydrogen storage.* Renewable and Sustainable Energy Reviews, 2017. **74**: p. 104-109.
2. Yu, M., et al., *Graphene materials for lithium–sulfur batteries.* Energy Storage Materials, 2015. **1**: p. 51-73.
3. Velasco, A., et al., *Recent trends in graphene supercapacitors: from large area to microsupercapacitors.* Sustainable Energy & Fuels, 2021. **5**(5): p. 1235-1254.
4. Zhu, Z., et al., *Effects of Various Binders on Supercapacitor Performances.* International Journal of Electrochemical Science, 2016. **11**(10): p. 8270-8279.
5. Bukovska, H., et al., *Evaluation and Optimization of Tour Method for Synthesis of Graphite Oxide with High Specific Surface Area.* C, 2023. **9**(3): p. 65.
6. Mikhraliieva, A., et al., *Mesoporous Nitrogen-Doped Holey Reduced Graphene Oxide: Preparation, Purification, and Application for Metal-Free Electrochemical Sensing of Dopamine.* Small, 2024.

Acknowledgements: This research was supported by REGRAP-2D project, Grants PID2020-114234RB-C21 and C22 funded by MCIN/ AEI/ 10.13039/501100011033