

A Comparison of the Degree of Functionalisation in Graphene oxide

Maria Magro

Daniel Vella, Glenn Cassar

Department of Metallurgy and Materials Engineering, Faculty of Engineering, University of Malta, Msida, Malta

maria.magro@um.edu.mt

Graphene oxide, has an intermediary role in the formation of graphene, but it also has its own applications being in conductive films, electrode materials [1], composite materials [1], [2], and filtration membranes [2].

The introduction of functional groups on a layer of graphene is typically carried out through oxidative processes. The commonly used approach to oxidise graphite is the Hummers' method [3], in which concentrated sulfuric acid acts as an intercalating agent that is able to separate the graphite layers, whereas sodium nitrate(V) together with potassium manganate(VII) act as oxidising agents and introduce several oxygen-containing functional groups [4]. These groups include: hydroxyl (-OH), carbonyl (-C=O), carboxyl (-COOH), and epoxy (-O-). The carboxyl groups are commonly found on the edges, whereas the epoxy and hydroxyl groups reside above and below the plane of a graphene oxide layer[5] as shown in Figure 1.

Two other prominent methods derived from the Hummers' method, namely the Modified Hummers' method and the Improved Hummers' method are used to prepare GO and even graphite oxide (GrO, which is like GO but a few layers thick) from graphite flakes. The difference between the two methods is that in the latter, phosphoric acid is utilised as part of the intercalating agent.

In this review, both methods will be compared by characterising the degree of

functionalisation of the reaction product graphene oxide using an array of techniques such as X-ray Photoelectron Spectroscopy (XPS), Raman, and X-Ray Diffraction (XRD).

References

- [1] A. M. Dimiev and J. M. Tour, *ACS Nano*, vol. 8 no. 3 (2014) pp. 3060–3068.
- [2] A. I. Abd-Elhamid, H. F. Aly, H. A. M. Soliman, and A. A. El-Shanshory, *J. Mol. Liq.*, vol. 265 (2018) pp. 226–237.
- [3] W. S. Hummers and R. E. Offeman, *J. Am. Chem. Soc.*, vol. 80 no. 6 (1958) p. 1339.
- [4] D. C. Marcano, D. V. Kosynkin, J. M. Berlin, A. Sinitskii, Z. Sun, A. Slesarev, L. B. Alemany, W. Lu, and J. M. Tour, *ACS Nano*, vol. 4 no. 8 (2010) pp. 4806–4814.
- [5] K. C. Kemp, V. Georgakilas, M. Otyepka, A. B. Bourlinos, V. Chandra, N. Kim, K. C. Kemp, P. Hobza, R. Zboril, and K. S. Kim, *Chem. Rev.* vol. 112 (2012) pp. 6156–6214.

Figures

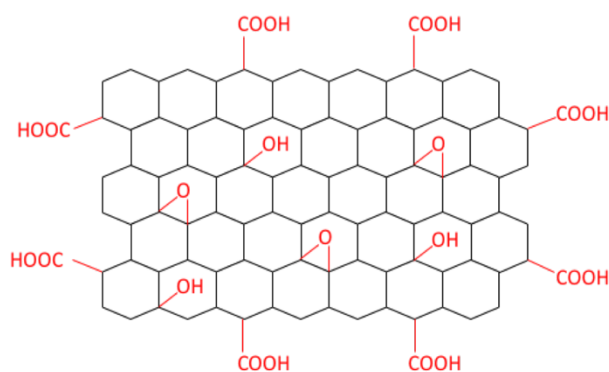


Figure 1: One layer of graphene oxide showing possible functional groups along the plane and edges.