Green reductants for graphene fabrication via liquid chemical exfoliation process

Volodymyr Khranovskyy
Ivan Shtepliuk, Rositsa Yakimova
Department of Physics, Chemistry and Biology (IFM) Linköping University, SE-581 83, Linköping, Sweden
volkh@ifm.liu.se
Igor Wlasny, Piotr Kazmierczak and Andrzej Wysmolek
Institute of Experimental Physics, Faculty of Physics, University of Warsaw, Pasteura 5, 02-093, Warsaw, Poland
Zbigniew Klusek
Department of Solid State Physics, Faculty of Physics and Applied Informatics, University of Lodz, Pomorska 149/153, 90-236, Lodz, Poland
Kateryna Shavanova, Andrii Tencha
National University of Life and Environmental Sciences of Ukraine, 03041 Kiev, Ukraine

Modern liquid chemical exfoliation processes of graphene fabrication involves use of toxic and dangerous chemicals i. e. hydrazine for reduction purposes. These chemicals can be substituted by non-toxic, environment and human-friendly "green" chemicals, such as ascorbic acid (vitamin C), glucose, caffeic acid or even fruits juice extracts. Their exact influence on the graphene oxide (GO) is not well known yet and deserves detailed study for future application in graphene industrial production.

For this purpose we have synthesised GO by modified Hummers method and investigated it in comparison to commercially available GO. Both materials demonstrated D and G bands, as well as 2D line on Raman spectra, peculiar for 2D carbon materials. The presence of carbonyl (40%), carboxyl (17%), epoxy (3%) and oxygen substitution functional groups was identified and quantified on GO surface using XPS spectroscopy (Fig. 2top). Upon reaction with "green" reductants (Glucose, Vitamin C, Caffeic Acid and Blueberry juice) it was revealed that Vitamin C has the best reducing performance. It turned out, however, that it creates most defects in the reduced material, accordingly to the D/G lines ratio. While Glucose was observed to be the best green reductant in terms of least defects in rGO and best oxygen content decrease performance. Detailed data analysis allows us to claim that glucose as environmentally friendly and non-toxic "green" reductant can be used in the liquid chemical exfoliation processes for graphene production.

Figures

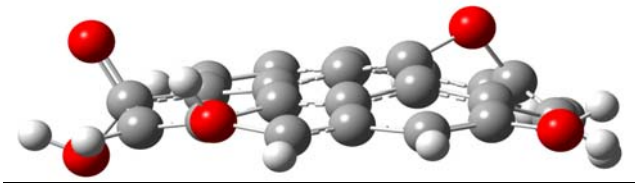

Figure 1: Model representation of the presence of different functional groups on Graphene surface: black balls - C atoms, grey – H, red – O.

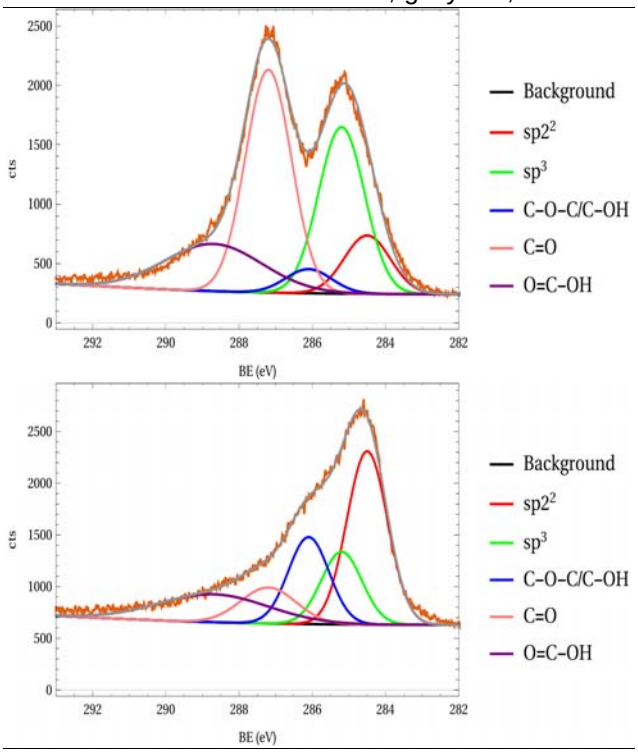

Figure 2: XPS data of functional groups available on Graphene surface before (top) and after reduction by glucose (bottom).