Simultaneous in-situ graphene oxide reduction and UV curing of acrylic based formulations for inkjet printing

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Because of the high specific surface area, good chemical stability, and outstanding electrical and thermal conductivity, graphene is predicted to be an excellent electrode material candidate for energy-conversion/storage systems [1]. The nanoscale dimensions of graphene-based materials enable them to be solubilized and transferred into inks, which can be exploited for direct printing of electrodes using additive technology, such as inkjet printing [2]. Inks formulation for application to printable electrodes requires large quantities of material, which can be synthesized by wet chemical routes, such as exfoliation of graphene oxide (GO) from bulk graphite [3]. GO may be subsequently reduced to reduced graphene oxide (RGO) using several methods [4-6]. UV irradiation is a promising method for reducing GO, which allows the simultaneous photopolymerization of acrylic resin matrices, such as poly(ethylene glycol) diacrylate (PEGDA), which can be used in the formulation of inks [7].

This work explores the possibility of introducing GO water solutions into a PEGDA matrix, thus creating a conductive printable ink containing UV-reduced GO sheets, of variable viscosity depending on water content.

Commercial GO was purchased from Cheap Tubes Inc. (USA). Starting from a dispersion of GO in deionised water with a photoinitiator, GO/PEGDA nanocomposite samples were prepared as thin films adding the GO dispersion to PEGDA, and subsequently polymerized by irradiation with UV light. I-V characteristics of the irradiated films were measured by means of standard two point contact and resistivity was computed comparing different compositions in order to assess the dispersion effect. The same solutions of GO dispersed in deionised water with photoinitiator were deposited onto a silicon wafer, and subsequently irradiated with UV light. Pristine GO solutions and irradiated samples were analysed by X-ray photoelectron spectroscopy (XPS) and electron energy loss spectroscopy (EELS), in order to evaluate the reduction of oxygen containing groups.

XPS measurements (Figs. 1-2) show that after few minutes of UV irradiationGO was visibly reduced, with a significant decrease of both height and area of C=O and O-C=O peaks, relatively to C-C peak. This tendency was also confirmed by EELS. This behavior was confirmed when GO-aqueous dispersion was added to photocurable PEGDA resin. It was shown an increase in conductivity of PEGDA films containing GO-aqueous by one order of magnitude, from $(5.4\pm0.5) \times 10^7$ Ωcm (PEGDA, UV-cured in air) to $(1.7\pm0.2) \times 10^6$ Ωcm (PEGDA containing an actual content of 1 wt% of GO, UV treated in air).

In order to control the printability of an ink, it is essential to be able to tailor the viscosity. Here we show the possibility of formulating a conductive ink containing UV-reduced graphene oxide, based on PEGDA-water solutions of controllable viscosity. Future work will involve inkjet printing tests of conductive patterns and electrical/morphological characterization of the printed geometries.

References

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Figures

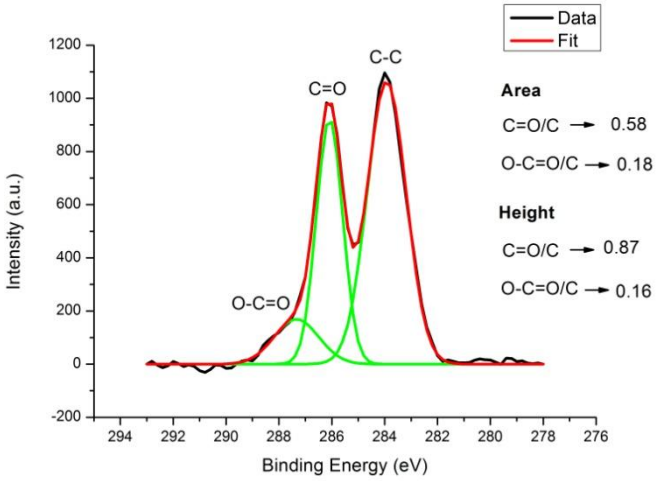

Fig. 1: XPS spectrum of GO before UV curing.

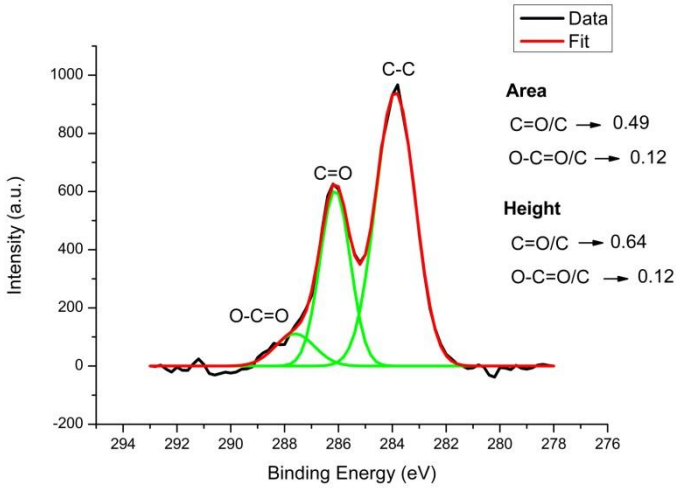

Fig. 2: XPS spectrum of RGO after UV curing.