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Engineering the Electrical and Optical Properties of Graphene Oxide via Simultaneous Alkali Metal Doping and Thermal Annealing

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Introduction

In order to extend the application of graphene oxide (GO) in the area of electronic industries, enhancing the electrical properties of GO as a cost-effective alternative for graphene seems mandatory. Engineering the electrical properties of GO can be achieved in two different approaches the oxygen functional group reduction and doping GO with chemical dopants. Here, both approaches were utilized to tune the electrical properties of GO toward its application as cathode; first, GO was doped with alkali metal dopants, and later, the doped samples were thermally reduced. Energy-dispersive X-ray spectroscopy (EDX) and X-ray photoelectron spectroscopy were utilized to study the chemical composition of the doped samples [1].

After the dilemmas regarding the costly methods of producing graphene, difficulties of transferring methods, and small scale of production, graphene oxide was introduced as a low-cost two-dimensional alternative that could fit well into the different application demands via variable tuning techniques [2]. Easy and cost-effective producing methods of GO and its hydrophilic characteristics introduced it as a relevant material that can efficiently be utilized as a coating or thin film on an industrial scale via the conventional water-based deposition techniques. utilized a spray coating approach for depositing a large-scale film of GO for use in electronic devices. used spin coating as a simple solution-based method for depositing GO on silicon oxide substrate as an active material for molecular sensors. deposited GO on an aluminum surface via electrophoretic deposition to take advantage of the chemical stability of the coating and its corrosion barrier characteristics in saline solutions.

Description

X-ray photoelectron spectroscopy (XPS)

To further investigate the doped-GO samples and analyze their elemental composition, XPS was utilized before and after thermal annealing. The XPS survey spectra of the samples before and after thermal annealing is presented in and the detail information are presented in , which provides useful evidence about the atomic composition and carbon to oxygen (C/O) ratios of the samples [3]. The survey spectra of the doped samples have pronounced alkali metal peaks, indicating successful doping of GO. From the atomic composition results presented in , it can be concluded that the ratio of carbon to oxygen (C/O) of the GO was increased after alkali metal doping that was in accordance with the results presented for EDX The suggested results were due to partial reduction of the GO and also the functional groups of GO were replaced via the alkali metal elements .

Raman

To recognize the number of graphene layers, presence of defects and disorders, and the effect of doping and thermal reduction on the graphene structure, Raman spectroscopy as a non-destructive method can be useful. To identify GO via Raman technique, two prominent Raman features of GO, D band at 1350 cm^{-1} (the defects or edges) and G band at about 1584 cm^{-1} (the first order scattering of the E_{2g} mode) are beneficial. Here the GO layers were doped with alkali metals and later were thermally reduced [4]. Therefore, by studying the Raman pattern of the samples, first, we identify the success of the doping process and its effect on the structure of GO regarding the defects. Moreover, we investigate the effect of thermal reduction on the doped samples.

Sheet resistance

The sheet resistance of GO and alkali metal doped-GO samples was measured from three different points on the samples' surface in ambient conditions utilizing a four-point probe system. Based on the different researches, doping graphene with alkali metals (that are n-type dopants) slightly increase the sheet resistance of the graphene layers in comparison with the p-dopants that decrease the sheet resistance while in the case of GO, n-doping reduces the sheet resistance of the GO layers Additionally, the oxygen functional groups cover the GO layers, which by eliminating these groups, the sheet resistance of the rGO decreases dramatically [5].

Conclusion

As a cost-effective alternative for graphene in advanced optoelectronic and electronic applications, graphene oxide(GO) needs to be enhanced electrically. In the current project, the GO was doped with alkali metal elements and the doped samples were thermally reduced to improve their electrical properties for cathode application. The chemical composition of the samples before and after the doping process and thermal reduction were studied via EDX, XPS, and Raman. The results suggested the successful doping of the GO sample with alkali metal elements, the partial reduction of GO via doping, and the stability of the dopants after thermal annealing at high temperatures.

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Conflict of Interest

The authors declare that they are no conflict of interest.

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