Photoreduction of Graphene Oxide with Photosystem I

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Introduction

•Green plants have been the premier producer of solar energy for millennia. This is due to the presence of Photosystem I (**PSI**), a photoactive protein that excites an electron from the P_{700} reaction center to an iron-sulfur complex (F_B).

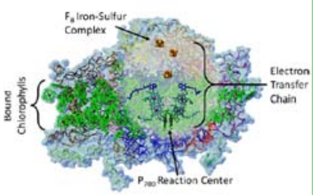


Figure adapted from source [1] with permission.

•Graphene (a single layer of carbon atoms) has shown potential in electronic devices due to its transparency and conductivity.

•Graphene can be produced through the oxidation of graphite, producing graphene oxide (**GO**) followed by thermochemical reduction to reduced graphene oxide (**rGO**).

Objectives

•Photoreduce prepared **GO** with **PSI** in solution.

•Combine **PSI** and **rGO** to produce an integrated.

•Deposit the composite film on various electrode materials.

•Characterize the composite using various techniques.

Methods

Graphite Unpurified GO

•Above is a synthesis adapted from Marcano et al.[2]

•**GO** was purified through filtrations, dialysis, sonication, and centrifugation.

•For photoreduction, **PSI** and **GO** were mixed in solution and exposed to red light for various durations of time.

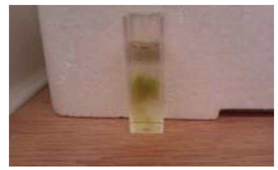
•**PSI-rGO** aggregates were deposited into films on various electrodes and substrates. These films were characterized by UV-Vis spectrophotometry, Raman spectroscopy, and common electrochemical techniques, (chronoamperometry, cyclic voltammetry, and potentiometry).

Results and Discussion

•**GO** and **PSI** mix homogenously in aqueous solutions prior to red light exposure.

0 minutes

•After 15 minutes of exposure, aggregation begins.

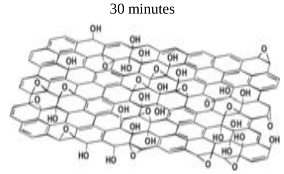


15 minutes

•Aggregations continues through 30 minutes of exposure.

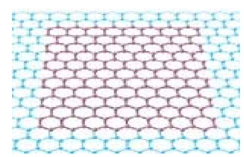
30 minutes

•The contents of the mixture showed a decrease in solubility, which we attributed to the partial reduction of **GO** to **rGO**.

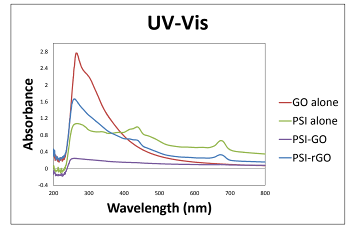


Schematic of **GO** adapted from source [3].

•The loss of oxygen functionalities (hydroxides and epoxides) that occurs in reduction from **GO** to graphene decreases aqueous solubility, due to the loss of hydrogen bonding sites.

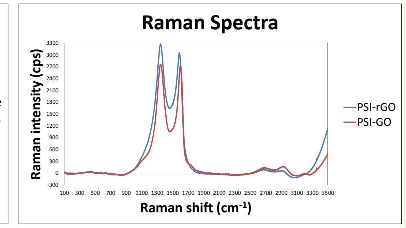


Schematic of graphene adapted from source [4].

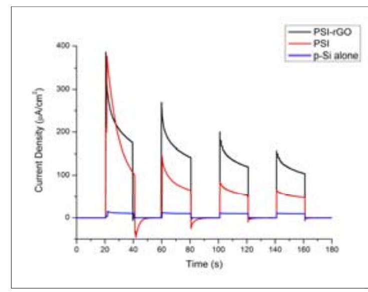


•UV-Vis spectra of the composite before and after light exposure, along with the two starting materials themselves.

•Note the peak at 260 nm, which is characteristic of graphene, but it is present in all samples.

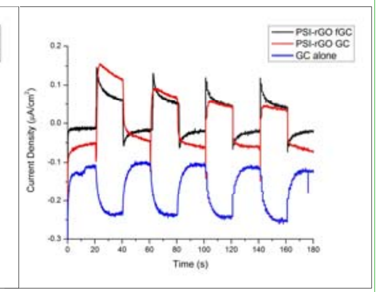


•Raman spectra of the composite before and after exposure to light show a slight difference in peak height ratio at 1300:1600 cm^{-1} (1.1 in **PSI-rGO** vs. 1.0 in **PSI-GO**).



•The sample was exposed to light for 20 second intervals, starting at 20 seconds.

•The composite generates significantly higher photocurrent density than p-doped silicon alone & p-doped silicon with **PSI**.



•i-t curve of a **PSI-rGO** film deposited on a glassy carbon electrodes (hydroxyl functionalized & unfunctionalized)

•Note: Both electrodes with the composite showed opposite photocurrent directions than the electrode by itself.

Conclusion & Future Directions

PSI can be used to photoreduce **GO** in solution making a **PSI-rGO** biohybrid composite. This composite can be deposited on many electrode materials while still maintaining photoactivity greater than **PSI** alone. We were also able to use our own **GO**, which makes this a very low-cost, simple procedure. Our characterization methods do show difference between starting material and the finished product.

This composite has numerous applications , such as, photodetection devices and inexpensive solar energy conversion cells.

References and Acknowledgements

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