

# SYNTHESIS AND INVESTIGATION OF REDUCED GRAPHENE OXIDE MODIFIED WITH PHOSPHOROUS AND GRAPHITIC CARBON NITRIDE

Modestas Aušra<sup>1</sup>, Rūta Rasikė<sup>1</sup>, Justina Gaidukevič<sup>1,2</sup>

<sup>1</sup>Vilnius University, Faculty of Chemistry and Geosciences, Institute of Chemistry, Naugarduko Str. 24, LT-03225, Vilnius, Lithuania

<sup>2</sup>Center for Physical Sciences and Technology, Department of Nanoengineering, Savanorių Ave. 231, LT-02300, Vilnius, Lithuania

[modestas.ausra@chgf.stud.vu.lt](mailto:modestas.ausra@chgf.stud.vu.lt)

Reduced graphene oxide (rGO) has attracted significant attention as a conductive, high-surface area carbon platform for electrochemical (bio)sensing applications due to its large specific surface area, tunable surface chemistry and good charge transport properties. However, the performance of rGO-based materials in electrochemical devices strongly depends on the control of defect density, functional groups and heteroatom doping, which govern electron transfer and interfacial interactions with biomolecules [1,2]. Coupling rGO with graphitic carbon nitride (g-C<sub>3</sub>N<sub>4</sub>) and phosphorus-containing species offers an effective strategy to modify both the electronic structure and surface chemistry, thereby improving charge separation, enhancing active site density and enabling more sensitive electrochemical responses [1,3].

g-C<sub>3</sub>N<sub>4</sub> is a nitrogen-rich semiconductor with a conjugated polymeric structure that has been widely investigated in photocatalysis and (bio)electrochemical sensing owing to its visible-light activity, decent stability and abundance of lone-pair containing nitrogen sites [1,3]. When combined with graphene-based materials, g-C<sub>3</sub>N<sub>4</sub> can form heterostructures that facilitate interfacial charge transfer and increase the effective electrochemically active surface area, as demonstrated for g-C<sub>3</sub>N<sub>4</sub>/graphene oxide nanocomposites in ultrasensitive pesticide and biomarker detection [1,2]. In parallel, phosphorus-modified rGO has been shown to exhibit increased defect density, modified charge distribution, and improved electrocatalytic activity due to the introduction of electron-rich P sites into the sp<sup>2</sup> carbon framework [3].

The aim of this work is to synthesize and characterize a series of rGO-based materials modified with phosphorus and g-C<sub>3</sub>N<sub>4</sub>, with potential application as electrochemically active components in sensor devices. g-C<sub>3</sub>N<sub>4</sub> is obtained via thermal decomposition of urea at 500 °C temperature in the air for 2 hours. Graphene oxide (GO) is prepared via a two-step oxidation route, involving the formation of a chromium(VI)-oxidized graphite intermediate followed by a modified Hummers' method [4]. The resulting GO is then used to prepare four types of samples by hydrothermal treatment in aqueous media at 180 °C temperature for 20 h: rGO (GO only), P-rGO (GO with H<sub>3</sub>PO<sub>4</sub>), rGO/g-C<sub>3</sub>N<sub>4</sub> (GO with g-C<sub>3</sub>N<sub>4</sub>), and P-rGO/g-C<sub>3</sub>N<sub>4</sub> (GO with both H<sub>3</sub>PO<sub>4</sub> and g-C<sub>3</sub>N<sub>4</sub>). After the treatment, all samples are frozen in distilled water and freeze-dried to increase the surface area. The structural, morphological, textural, and chemical features of the resulting materials are systematically investigated using scanning electron microscopy with energy-dispersive X-ray spectroscopy, Raman spectroscopy, Fourier-transform infrared spectroscopy, and nitrogen adsorption-desorption measurements at 77 K.

- 
- [1] Monkathok J, Janphuang P, Suphachiaraphan S, et al. Enhancing Glucose Biosensing with Graphene Oxide and Ferrocene-Modified Linear Poly(ethylenimine). *Biosensors* 2024; 14; 161.
- [2] Cai Z, Rong M, Zhao T, et al. Solar-induced photoelectrochemical sensing for dopamine based on TiO<sub>2</sub> nanoparticles on g-C<sub>3</sub>N<sub>4</sub> decorated graphene nanosheets. *Journal of Electroanalytical Chemistry* 2015; 759; 32–7.
- [3] Qiao X, Liao S, You C, et al. Phosphorus and Nitrogen Dual Doped and Simultaneously Reduced Graphene Oxide with High Surface Area as Efficient Metal-Free Electrocatalyst for Oxygen Reduction. *Catalysts* 2015; 5; 981–91.
- [4] Gaidukevic J, Aukstakojyte R, Navickas T, et al. A novel approach to prepare highly oxidized graphene oxide: structural and electrochemical investigations. *Applied Surface Science* 2021; 567; 150883.