INVESTIGATION OF GRAPHENE/POLYPYRROLE COMPOSITES AND THEIR APPLICATION IN ELECTROCHEMICAL DOPAMINE SENSORS

Gintarė Rimkutė[1], Rasa Pauliukaitė[2], Gediminas Niaura[2], Jurgis Barkauskas[1], Justina Gaidukevič[1,2]

[1]Faculty of Chemistry and Geosciences, Vilnius University, Vilnius, Lithuania
[2]Center for Physical Sciences and Technology (FTMC), Vilnius, Lithuania
gintare.rimkute@chgf.vu.lt

The global sensor market is proliferating every year and is expected to reach $345.77 billion by 2028 [1]. However, several issues still prevent the widespread impact and application of electrochemical sensors. It is mainly related to the materials used in these devices, which often lack the sensitivity and selectivity required for the detection of target analytes [2]. For this reason, current research is often focused on nanostructured carbon materials, which have many unique properties, including high electrical conductivity, biocompatibility, enzyme mimicking activity, and can be easily obtained using low-cost preparation methods [3].

The purpose of this work was to produce graphene-polypyrrole (GP) composites, characterize them, and investigate their sensitivity in the non-enzymatic detection of dopamine (DA). Three different graphite precursors with grain sizes of $<50\ \mu$m, ≥ 150, $\leq 830\ \mu$m and $\leq 2000\ \mu$m were intercalated with sulfuric acid and thermally treated to obtain exfoliated graphite (EG). EG samples were further modified with conductive polymer polypyrrole. The acquired samples were characterized using SEM, XPS, and Raman spectroscopy techniques. Electrochemical investigations were conducted using differential pulse voltammetry (DPV). Additionally, the potential application of the prepared GP nanocomposites for highly sensitive non-enzymatic DA sensors was explored.

Structural analysis showed that the sample obtained from the medium-size graphite grains (GP_2) had the lowest number of defects (ID/IG = 0.483) and the highest elemental nitrogen content (5.12 at.%) with 15.16 at.% as graphitic-N, known to improve electrocatalytic activity. Electrochemical investigations demonstrated that all GP samples were prospective for DA sensing. However, the electrode modified with the GP_2 showed the best performance. The sensitivity of this sensor was 2180 $\mu A \cdot mM^{-1} \cdot cm^{-2}$ and the limit of detection was 78 nM.

[1] I. O'Connell, S. Chevella, G.M. Salgado, D. O'Hare, Precision Voltage Sensing in Deep Sub-micron and Its Challenges, in: Analog Circuits for Machine Learning, Current/Voltage/Temperature Sensors, and High-Speed Communication, Springer International Publishing, 137–163 (2022).
[2] C. Ferrag, K. Kerman, Grand Challenges in Nanomaterial-Based Electrochemical Sensors, Frontiers in Sensors, 1 (2020).
[3] Y. He, C. Hu, Z. Li, C. Wu, Y. Zeng, C. Peng, Multifunctional carbon nanomaterials for diagnostic applications in infectious diseases and tumors, Mater Today Bio, 14 (2022).