Graphene-Integrated Portable Biosensing Concept for Next-Generation Diagnostic Applications

Prity Kumari[1], Amritha Binod[2], Siddharth J S[2], Nancy Antony[2], Binu R. Chandran[1] and Prof. Alex P James[1,2]

[1]India- Graphene Engineering & Innovation Center, Thiruvananthapuram, Kerala– 695317, India
[2]Kerala University of Digital Sciences, Innovation and Technology (DUK) Technopark Phase IV, Pallipuram, Thiruvananthapuram, Kerala – 695317, India
pkumari@igeic.org

Abstract

This work presents a versatile biosensing concept designed for rapid and user-friendly detection of biological analytes using a disposable test strip paired with compact, low-power electronics. The graphene-based sensing interface enhances sensitivity and signal strength, enabling accurate detection from very small sample volumes and supporting reliable performance in point-of-care settings [1-3] The platform is broadly adaptable and capable of detecting a wide range of targets, including small molecules such as glucose, proteins, and nucleic acids like DNA [4]. During development, hemin is used as a model analyte due to its stable redox properties and relevance in catalytic and biochemical systems [5]. Its well-defined behaviour allows the sensor to be evaluated and optimized in a controlled manner, facilitating future translation to other biomarkers. Designed with practicality and accessibility in mind, the system emphasizes portability, simplicity, and ease of operation.

The one-step test-strip format minimizes user involvement and eliminates the need for specialized laboratory equipment, making the approach particularly suitable for resource-limited environments, remote diagnostic scenarios, and field applications. Compatibility with portable devices further supports widespread adoption in a variety of real-world settings. Overall, this biosensing approach provides a strong foundation for next - generation point-of-care devices, combining graphene-enabled sensitivity with an easy-to-use format to deliver reliable and scalable diagnostic solution.

References

[1] P. Kumari, S. Adeloju, Fabrication of DNA-based Biosensors Driven by Electrostatic Attractions on Electrodes Modified with Reduced Graphene Oxide and Multi-walled Carbon Nanotubes, ChemNanoMat 8 (2022).

[2] M.G. Gopika, Sreelekshmi, B. Saraswathyamma, Recent advancements in the detection of amino acids using graphene-oxide-based electrochemical sensors, Graphene-Based Sensors, IOP Publishing, 2023, pp. 13-1-13-23.

[3] A. Elgamouz, A.-N. Kawde, I.A. Shehadi, S. Sayari, S.A. Abdullah Mohammed, A. Abdelrazeq, C.N. Nassab, A.A. Abdel Hamid, K. Hasan, Modified Graphite Pencil Electrode Based on Graphene Oxide - Modified Fe3O4 for Ferrocene-Mediated Electrochemical Detection of Hemoglobin, ACS Omega 8(13) (2023) 11880-11888.

[4] Y. Zhao, F. Chen, Q. Li, L. Wang, C. Fan, Isothermal Amplification of Nucleic Acids, Chemical reviews 115(22) (2015) 12491-545.

[5] H. Xie, J. Liu, H.A. Yones, Y. Niu, Y. Zhao, Y. Xi, X. Li, G. Li, W. Sun, X. Wang, Fe3O4 Decorated Reduced Graphene Oxide Modified Electrode for Electrochemistry of Hemoglobin and Its Application as Trichloroacetic acid and Nitrite Sensor, International Journal of Electrochemical Science 14(9) (2019) 9141-9149.

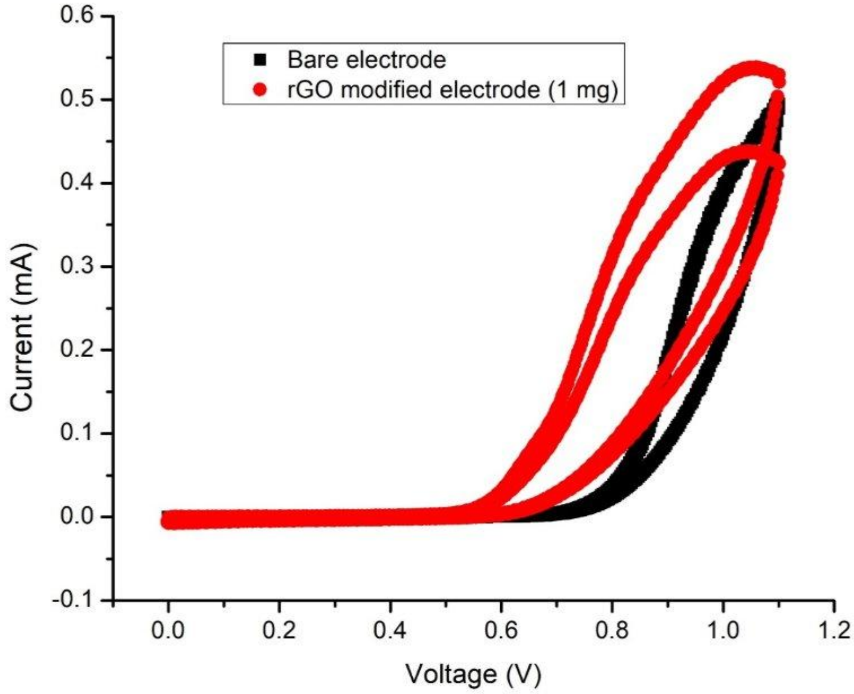

Figure 1: Screen-printed electrode modified with reduced graphene oxide (rGO, 1 mg/mL) in the presence of sodium nitrite ($NaNO_2$), with a scan rate of 50 mV/s

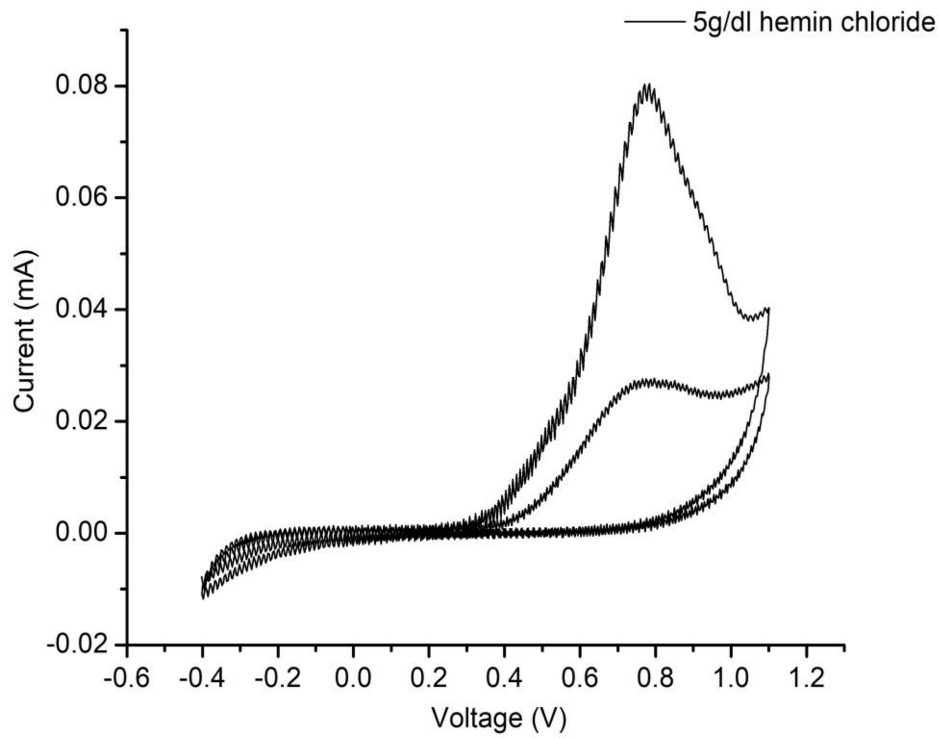

Figure 1: Screen-printed electrode modified with Hemin Chloride, with a scan rate of 50 mV/s