Polymelamine-Modified Graphene Electrodes for Enhanced Claudin18.2 Detection

Kanagavalli Pandiaraj and Shimaa Eissa*

Department of Chemistry, Khalifa University of Science and Technology, Abu Dhabi, P.O. Box 127788, United Arab Emirates
Contact: kanagavalli.pandiaraj@ku.ac.ae

Abstract

Recent advancements in nanotechnology have led to the development of carbon-based nanomaterials, including graphene (Gr), graphene oxide (GO), and carbon nanotubes (CNT), which significantly enhance the performance of electrochemical biosensors[1]. Their high surface area, mechanical strength, and excellent electrical conductivity make them ideal candidates for diagnostic and environmental applications[2]. This study investigates polymelamine (PM) electrodeposition on screen-printed electrodes (SPEs) modified with various carbon-based materials, such as carbon (C), Gr, GO, CNT, and carbon nanofibers (CNF). While PM has been previously explored on substrates like graphene-doped carbon paste, there is a lack of comprehensive comparisons among these commercial carbon nanomaterials. Cyclic voltammetry (CV) was utilized to assess the electron transfer properties. Defect density, and chemical composition of the modified electrodes were characterized with the support from Raman spectroscopy and X-ray photoelectron spectroscopy (XPS). Figure 1 presents scanning electron microscopy images of the bare Gr and PM-Gr modified electrodes, showing the polymer layer coating the electrode surface. PM-modified Gr and CNT/SPEs exhibited pronounced and stable redox behaviour in phosphate-buffered saline (PBS). The presence of terminal amine functionalities on the PM-modified electrodes enabled the effective immobilization of anti-CLDN18.2 antibodies via EDC-NHS chemistry. This facilitated the sensitive detection of Claudin18.2 (CLDN18.2), a critical biomarker frequently overexpressed in gastrointestinal and oesophageal cancers[3,4]. The detection limits achieved were 7.9 pg/mL for PM-modified Gr/SPE and 0.104 ng/mL for PM-CNT/SPE, indicating the superior sensitivity of these electrodes. The PM-modified electrodes also exhibited reagentless signalling capabilities, demonstrating exceptional performance in CLDN18.2 detection. Overall, this research offers a promising approach for the early diagnosis of gastric cancer, effectively addressing a pressing clinical need in cancer detection and management.

References

[1] L. Cui, Y. Li, M. Lu, B. Tang, C Zhang, Biosens. Bioelectron., 99 (2018) 1–7.
[2] S. Eissa, G.C. Jimenez, F. Mahvash, A. Guermoune, C. Tlili, T. Szkopek, M. Zourob, M. Siaj, Nano Res., 8 (2015) 1698–1709.
[3] R. Inamoto, N. Takahashi, Y. Yamada, Cancers, 15 (2023) 5742-5763.
[4] C. Qi, C. Lic, J. Gong, D. Liu, X. Wang, P. Zhang, Y. Qin, M. Zhang, Z. Peng, J. Zhou. Nat. Med. 3 (2024), 1-1.

Figures

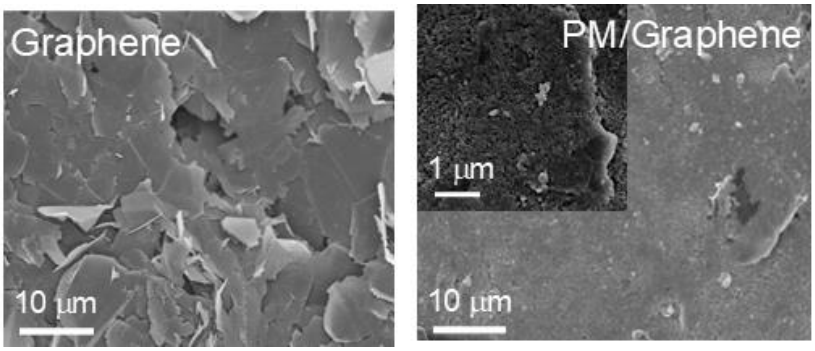

Figure. 1 SEM images of graphene and polymelamine modified graphene electrodes