Proceedings of the 11th World Congress on Electrical Engineering and Computer Systems and Sciences (EECSS'25)
Paris, France – August, 2025
Paper No. ICBES 153
DOI: 10.11159/icbes25.153

Label-Free Antibody Detection Using a Screen-Printed Organic Electrochemical Transistor (OECT) Platform

Riya Wadhwa, Lokesh Kumar, Dipti Gupta*
Department of Metallurgical Engineering and Materials Science,
Indian Institute of Technology Bombay, Mumbai, Powai: 400076
Email: 20003776@iitb.ac.in, lokesh.iitb@iitb.ac.in, diptig@iitb.ac.in*

Extended Abstract

Cancer is one of the leading causes of mortality worldwide, and early detection is critical to improving patient survival rates [1]. Despite progress in diagnostic technologies, identifying cancer at its earliest stages remains a major challenge. Conventional methods such as imaging and biopsies often detect cancer only after it has progressed, limiting treatment options and reducing survival prospects [2]. These techniques are also invasive, time-consuming, and dependent on specialized infrastructure, making them less accessible particularly in low-resource environment. This emphasizes the urgent need for innovative, sensitive, and cost-effective diagnostic tools that can be deployed at the point of care.

In recent years, antibodies have emerged as valuable biomarkers for early diagnosis of cancer, autoimmune disorders, and infectious diseases. Their presence in bodily fluids reflects specific immune responses, often preceding the onset of clinical symptoms [3, 4]. However, commonly used antibody detection techniques such as flow cytometry, Enzyme-linked Immunosorbent assay (ELISA), and Western blotting are typically labelled, labor-intensive, and reliant on centralized laboratory infrastructure [5]. These factors limit their applicability in rapid and decentralized diagnostic settings.

To address these limitations, we have developed a biosensing platform based on Organic Electrochemical Transistors (OECTs) for the selective and label-free detection of antibodies. OECTs offer several advantages for biosensing applications, including high transconductance, low-voltage operation, simple fabrication, and inherent signal amplification [6]. In this study, we demonstrate an OECT-based biosensor designed for the detection of immunoglobulin G (IgG) and immunoglobulin M (IgM) antibodies in phosphate-buffered saline (PBS) solution. The sensor was fabricated by functionalizing the gate electrode with anti-IgG and anti-IgM antibodies to enable selective binding. Upon exposure to target antibodies, specific binding events at the gate interface caused measurable changes in the drain current, which were recorded through amperometric titration. We performed a series of experiments to evaluate the sensor's performance, including the detection of individual antibodies and the assessment of cross-reactivity using mixed samples (IgG + IgM). The biosensor exhibited high sensitivity, excellent selectivity, and effectively distinguishing between antibody isotypes even in the presence of mixed analytes.

This proof-of-concept study highlights the potential of OECTs for real-time, label-free immunoassays. The platform is low-cost, scalable, and adaptable, making it a strong candidate for point-of-care diagnostics and early disease screening. While this work focuses on antibody detection, the sensing approach provides a solid foundation for future development aimed at the selective capture of cancer-associated extracellular vesicles (EVs) through antibody-based recognition.

References

[1] S. Yusuf, P. Joseph, S. Rangarajan, S. Islam, A. Mente, P. Hystad, M. Brauer, V. R. Kutty, R. Gupta, A. Wielgosz, K. F AlHabib, A. Dans, P. L.-Jaramillo, A. Avezum, F. Lanas, A. Oguz, I. M Kruger, R. Diaz, K. Yusoff, P. Mony, J. Chifamba, K. Yeates, R. Kelishadi, A. Yusufali, R. Khatib, O. Rahman, K. Zatonska, R. Iqbal, L. Wei, H. Bo, A. Rosengren, M. Kaur, V. Mohan, S. A Lear, K. K Teo, D. Leong, M. O'Donnell, M. McKee, and G. Dagenais, "Modifiable risk factors, cardiovascular disease, and mortality in 155 722 individuals from 21 high-income, middle-income, and low-income countries (PURE): a prospective cohort study," The Lancet, vol. 395, no. 10226, pp. 795-808, 2020/03/07/ 2020, doi: https://doi.org/10.1016/S0140-6736(19)32008-2.

[2] M. Ferrari, "Cancer nanotechnology: opportunities and challenges," Nature Reviews Cancer, vol. 5, no. 3, pp. 161-171, 2005/03/01 2005, doi: 10.1038/nrc1566.

[3] J. M. Nikoloff, M. A. Saucedo-Espinosa, and P. S. Dittrich, "Microfluidic Platform for Profiling of Extracellular Vesicles from Single Breast Cancer Cells," Analytical Chemistry, vol. 95, no. 3, pp. 1933-1939, 2023/01/24 2023, doi: 10.1021/acs.analchem.2c04106.

[4] H.-Y. Liu, R. Kumar, C. Zhong, S. Gorji, L. Paniushkina, R. Masood, U. A. Wittel, H. Fuchs, I. Nazarenko, and M. Hirtz, "Rapid Capture of Cancer Extracellular Vesicles by Lipid Patch Microarrays," Advanced Materials, vol. 33, no. 35, p. 2008493, 2021/09/01 2021, doi: https://doi.org/10.1002/adma.202008493.

[5] M. Porsch-Özcürümez, N. Kischel, H. Priebe, W. Splettstösser, E.-J. Finke, and R. Grunow, "Comparison of Enzyme-Linked Immunosorbent Assay, Western Blotting, Microagglutination, Indirect Immunofluorescence Assay, and Flow Cytometry for Serological Diagnosis of Tularemia," Clinical and Vaccine Immunology, vol. 11, no. 6, pp. 1008-1015, 2004/11/01 2004, doi: 10.1128/CDLI.11.6.1008-1015.2004.

[6] D. Gupta, R. Anand, L. Kumar, and S. Sahu, "Organic electrochemical transistor based biosensor for the detection of DNA binding proteins and method for preparation Thereof", IN Patent 431170, August 5, 2023