National Institute of Technology Rourkela

Synopsis Seminar

Seminar Title	: Miniaturised Electrochemical Biosensors for Real-Time Bacterial Detection in Aqueous Samples: Design, Development, and Validation
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Venue	: CHEMICAL DEPARTMENT LIBRARY
Date and Time	: 13 May 2025 (11:00 AM)
Abstract	: Bacterial contamination from pathogens like *Escherichia coli* (*E. coli*) and *Staphylococcus aureus* (*S. aureus*) poses a major public health threat, particularly in food and water systems. These bacteria can cause severe infections, requiring detection methods that are rapid, sensitive, and reliable. Traditional microbiological techniques, while accurate, are time-consuming and labour-intensive. Electrochemical biosensors have emerged as effective alternatives due to their high sensitivity, low detection limits, fast response, and cost-effectiveness. However, practical adoption of these biosensors is limited by issues such as low specificity, reduced stability in real samples, and the high cost of conventional electrode materials like gold and platinum. While screen-printed and stencil-printed electrodes provide a more affordable and portable option, the need for expensive nanomaterials and complex fabrication still hampers scalability. This highlights the demand for simple, robust, and cost-effective biosensing platforms suitable for real-time, on-site detection in resource-limited environments. The objective of this study was to develop aptamer-functionalized electrochemical biosensors for rapid, selective, and sensitive detection of bacterial pathogens in food, water, and biological samples. The research focused on optimising electrode fabrication, enhancing sensitivity through surface modification, and validating performance in real sample conditions. Several biosensor platforms were developed. The first used a screen-printed carbon electrode (SPCE) modified with silver nanoparticles (AgNPs) and *E. coli*-specific aptamers, achieving a detection limit (LOD) of 150 CFU/ml. In a second design, porous rhombic dodecahedron-shaped Ag particles electrodeposited at -1.2 V for 180 s enabled a redox-probe-free sensor with an LOD of 50 CFU/ml and linear response (&DeltaI = 4.84 log C + 10.5, R^2 = 0.988). The sensor showed strong selectivity, reproducibility (RSD = 4.98%), and low error (±4%). A lab-fabricated carbon electrode (LCE) further improved performance and was implemented for *E. coli* detection using cyclic voltammetry (CV). The LCE was modified by AgNPs electrodeposition at -1.0 V for 150 s, followed by aptamer immobilisation. This biosensor achieved an LOD of 34 CFU/ml and exhibited high reproducibility (RSD = 1.71%) and accuracy (±5% in water and urine +6.3% in milk). It maintained stability for up to four weeks and showed strong linearity (&DeltaI = 5.71 log C + 2.91, R^2 = 0.987). The final biosensor, developed on stencil-printed electrodes using a graphite-nitrocellulose ink (1:2 w/v) (denoted as NCE), enabled *S. aureus* detection using differential pulse voltammetry (DPV). AgNPs were electrodeposited at -0.15 V for 240 s, and aptamers at optimised concentration (7 µM) were immobilised. The sensor achieved a 10 CFU/ml LOD, with linearity over 10&ndash10^7 CFU/ml (&DeltaI = 1.32 log C + 0.33, R^2 = 0.99), and showed robust performance in PBS and milk (RSD of 4.03%, error ±6%). In summary, this work demonstrates the feasibility of low-cost, easily fabricated, and highly sensitive electrochemical biosensors based on AgNPs-modified stencil printed electrodes. These platforms offer a practical solution for on-site detection of bacterial pathogens and provide a foundation for broader applications in food safety and disease diagnosis.