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ELECTROCHEMICAL SENSORS BASED ON TRACK-ETCHED MEMBRANES FOR GLUCOSE DETERMINATION

Glucose is the most prevalent natural saccharide, playing a crucial role in our bodies as the primary energy source for living cells [1]. Deviations from normal glucose levels can lead to hypoglycemia or hyperglycemia, negatively impacting health. Diabetes, a serious chronic disease, poses a significant global health challenge, affecting approximately 537 million people worldwide and causing 6.7 million deaths [2]. Early diagnosis and careful monitoring of blood glucose levels are essential for managing diabetes effectively and maintaining a good quality of life. Additionally, the determination of glucose levels in food serves as an indicator of its quality. Accurate, rapid, simple, and real-time glucose measurement is crucial for clinical diagnostics, the food industry, and other sectors. Glucose sensors can be classified into enzymatic and non-enzymatic types based on their operating principle, with non-enzymatic sensors gaining considerable research attention in recent years [3,4]. These sensors offer superior long-term stability, resistance to external factors, and lower maintenance costs compared to enzymatic counterparts. Track-etched membranes (TeMs) are highly versatile materials extensively studied for applications ranging from water filtration and cell cultivation to membrane distillation and catalysis. Due to their excellent mechanical and chemical properties, narrow pore size distribution, thinness, and flexibility, TeMs are also suitable for developing electrochemical sensors.

We present the use of modified PET TeMs as sensors for non-enzymatic glucose detection. The membranes were functionalized through graft polymerization with 2-hydroxyethylmethacrylate (HEMA) and modified with poly(allylamine) (PAlAm) to form polyelectrolyte complexes. Subsequently, the membranes were treated with 4-mercaptophenylboronic acid (MPBA) to enhance sensitivity and stability by forming bonds with the hydroxyl groups of grafted PHEMA via B-OH groups. The -SH groups of MPBA reacted with gold nanoparticles produced via magnetron sputtering, forming Au-S bonds to further improve sensor stability and reproducibility. The TeMs were characterized using attenuated total reflection FTIR spectroscopy (ATR-FTIR), scanning electron microscopy coupled with energy-dispersive X-ray spectroscopy (SEM-EDX), and gas permeability tests.

The sensors developed were tested for glucose detection using square wave voltammetry (SWV), demonstrating a wide linear range (0.1 mM to 8 mM), low detection limit (0.1 mM), good reproducibility, and excellent stability. Stability testing in a 4 mM glucose solution showed consistent performance over 80 measurements, with the sensors retaining >97% of their initial response after 50 measurements. Selectivity tests using urea, ascorbic acid (AA), and various ions (K+, Ca2+, Mg2+) from bovine serum confirmed the selectivity of sensors towards glucose. These substances are due to coexistence with glucose in human serum and juice. There is no significant change in analytical signal on the addition of AA, K+, Ca2+, Mg2+ ions that proves the selective nature of sensors towards glucose. However, the presence of serum albumin in human serum led to contamination of TeMs pores, resulting in a reduced recovery rate for glucose detection in this medium.

Following optimization, the electrochemical glucose sensors were applied to measure glucose concentrations in apple juice and human blood serum, achieving recovery values of 100.8% for apple juice. Despite the lower recovery rate (84%) in human serum, the sensors demonstrated practical potential and significant utility in biological and food industry applications.

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