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SYMPOSIUM

Design and Fabrication of a High-Performance Electrochemical Glucose Sensor

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Abstract

Objective:

Development of electrochemical sensors for continuous glucose monitoring is currently hindered by a variety of problems associated with low selectivity, low sensitivity, narrow linearities, delayed response times, hysteresis, biofouling, and tissue inflammation. We present an optimized sensor architecture based on layer stratification, which provides solutions that help address the aforementioned issues.

Method:

The working electrode of the electrochemical glucose sensors is sequentially coated with five layers containing: (1) electropolymerized polyphenol (PPh), (2) glutaraldehyde-immobilized glucose oxidase (GO_x) enzyme, (3) dip-coated polyurethane (PU), (4) glutaraldehyde-immobilized catalase enzyme, and (5) a physically cross linked polyvinyl alcohol (PVA) hydrogel membrane. The response of these sensors to glucose and electroactive interference agents (i.e., acetaminophen) was investigated following application of the various layers. Sensor hysteresis (i.e., the difference in current for a particular glucose concentration during ascending and descending cycles after 200 s) was also investigated.

Results:

The inner PPh membrane improved sensor selectivity via elimination of electrochemical interferences, while the third PU layer afforded high linearity by decreasing the glucose-to-O_2 ratio. The fourth catalase layer improved sensor response time and eliminated hysteresis through active withdrawal of GO_x-generated H_2O_2 from the inner sensory compartments. The outer PVA hydrogel provided mechanical support and a continuous pathway for diffusion of various participating species while acting as a host matrix for drug-eluting microspheres.

Conclusions:

Optimal sensor performance has been achieved through a five-layer stratification, where each coating layer works complementarily with the others. The versatility of the sensor design together with the ease of fabrication renders it a powerful tool for continuous glucose monitoring.

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Abbreviations: (AP) acetaminophen, (BSA) bovine serum albumin, (FAD) flavin adenine dinucleotide, (GO_x) glucose oxidase, (PBS) phosphate-buffered saline, (PPh) polyphenol, (PU) polyurethane, (PVA) polyvinyl alcohol

Keywords: bienzymatic, biosensor lag time, drug delivery coatings, foreign body response, implantable glucose sensors, outer membranes, selectivity

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