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ORIGINAL ARTICLE

Enhancing the Sensitivity of Needle-Implantable Electrochemical Glucose Sensors via Surface Rebuilding

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Abstract

Objective:

Needle-implantable sensors have shown to provide reliable continuous glucose monitoring for diabetes management. In order to reduce tissue injury during sensor implantation, there is a constant need for device size reduction, which imposes challenges in terms of sensitivity and reliability, as part of decreasing signal-to-noise and increasing layer complexity. Herein, we report sensitivity enhancement *via* electrochemical surface rebuilding of the working electrode (WE), which creates a three-dimensional nanoporous configuration with increased surface area.

Methods:

The gold WE was electrochemically rebuilt to render its surface nanoporous followed by decoration with platinum nanoparticles. The efficacy of such process was studied using sensor sensitivity against hydrogen peroxide (H_2O_2). For glucose detection, the WE was further coated with five layers, namely, (1) polyphenol, (2) glucose oxidase, (3) polyurethane, (4) catalase, and (5) dexamethasone-releasing poly(vinyl alcohol)/poly(lactic-co-glycolic acid) composite. The amperometric response of the glucose sensor was noted *in vitro* and *in vivo*.

Results:

Scanning electron microscopy revealed that electrochemical rebuilding of the WE produced a nanoporous morphology that resulted in a 20-fold enhancement in H_2O_2 sensitivity, while retaining >98% selectivity. This afforded a 4–5-fold increase in overall glucose response of the glucose sensor when compared with a control sensor with no surface rebuilding and fittable only within an 18 G needle. The sensor was able to reproducibly track *in vivo* glycemic events, despite the large background currents typically encountered during animal testing.

Conclusion:

Enhanced sensor performance in terms of sensitivity and large signal-to-noise ratio has been attained *via* electrochemical rebuilding of the WE. This approach also bypasses the need for conventional and nanostructured mediators currently employed to enhance sensor performance.

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Abbreviations: (AgCl) silver chloride, (CV) cyclic voltammetry, (FBR) foreign body response, (GO_x) glucose oxidase, (H_2O_2) hydrogen peroxide, ($K_3Fe[CN]_6$) potassium ferricyanide, (KCl) potassium chloride, (NP) nanoparticle, (PLGA) poly(lactic-co-glycolic acid), (PPh) polyphenol, (PVA) poly(vinyl alcohol), (SC) subcutaneous, (WE) working electrode

Keywords: electrochemical, implantable glucose sensor, membranes, needle-implantable, sensitivity, surface etching

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