Journal of Diabetes Science and Technology
Volume 4, Issue 2, March 2010

ORIGINAL ARTICLES

A Disposable Tear Glucose Biosensor—Part 1: Design and Concept Testing

Daniel K. Bishop, B.S.E.,[1,2] Jeffrey T. La Belle, Ph.D.,[1,2] Stephen R. Vossler, B.S.E.,[1,2] Dharmendra R. Patel, M.D.,[3] and Curtiss B. Cook, M.D.[4]

Abstract

Background:

Tear glucose has been suggested previously as a potential approach for the noninvasive estimation of blood glucose. While the topic remains unresolved, an overview of previous studies suggests the importance of a tear sampling approach and warrants new technology development. A concept device is presented that meets the needs of a tear glucose biosensor.

Methods:

Three approaches to chronoamperometric glucose sensing were evaluated, including glucose oxidase mediated by potassium ferricyanide or oxygen with a hydrogen peroxide catalyst, Prussian blue, and potassium ferricyanide-mediated glucose dehydrogenase. For tear sampling, calcium alginate, poly(2-hydroxyethyl methacrylate), and polyurethane foam were screened as an absorbent tear sampling material. A quantitative model based on the proposed function of concept device was created.

Results:

For glucose sensing, it was found that potassium ferricyanide with glucose dehydrogenase was ideal, featuring oxygen insensitivity, long-term stability, and a lower limit of detection of 2 μ*M* glucose. Polyurethane foam possessed all of the required characteristics for tear sampling, including reproducible sampling from a hydrogel-simulated, eye surface (4.2 ± 0.5 μl; $n = 8$). It is estimated that 100 μ*M* of glucose tear fluid would yield 135 nA (14.9% relative standard deviation).

Conclusion:

A novel concept device for tear glucose sampling was presented, and the key functions of this device were tested and used to model the performance of the final device. Based on these promising initial results, the device is achievable and within reach of current technical capabilities, setting the stage for prototype development.

J Diabetes Sci Technol 2010;4(2):299-306

Author Affiliations: [1]Biodesign Institute, Arizona State University, Tempe, Arizona; [2]Harrington Department of Bioengineering, Arizona State University, Tempe, Arizona; [3]Department of Ophthalmology, Mayo Clinic, Scottsdale, Arizona; and [4]Division of Endocrinology, Mayo Clinic, Scottsdale, Arizona

Abbreviations: (DM) diabetes mellitus, (GDH) glucose dehydrogenase, (GDH-FAD) glucose dehydrogenase with flavin adenine dinucleotide, (GO_x) glucose oxidase, (LLD) lower limit of detection, (PBS) phosphate-buffered saline, (pHEMA) poly(2-hydroxyethyl methacrylate), (PB) Prussian blue, (RSD) relative standard deviation, (SMBG) self-monitoring of blood glucose, (TG) tear glucose

Keywords: biosensor, diabetes mellitus, glucose monitoring, tear glucose monitoring

Corresponding Author: Jeffrey T. La Belle, Ph.D., The Biodesign Institute, 1001 S. McAllister Ave., P.O. Box 875801, Tempe, AZ 85287-5801; email address *jeffrey.labelle@asu.edu*