

# AN IMPLANTABLE BIOCHIP FOR TELEMETERED MONITORING OF GLUCOSE AND LACTATE IN THE COMBAT TRAUMA VICTIM

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## ABSTRACT

The design, fabrication and assembly of a fully integrated amperometric biochip for the continuous *in vivo* (subcutaneous) measurement and telemetered reporting of physiological analytes, lactate and glucose, is described. The 2mm x 4mm x 0.5mm biotransducer comprises two "electrochemical-cells-on-a-chip", each comprising a platinum microdisc array (37 discs, each 50  $\mu\text{m}$  diameter) that serves as a working enzyme electrode and is complemented by a large area platinized platinum counter electrode and a silver reference electrode [1]. This configuration permits either simultaneous dual analyte (lactate and glucose) sensing or a differential response methodology for a single analyte. The biorecognition layer was fabricated from an ca. 1.0  $\mu\text{m}$  thick, spun-applied, UV-polymerized, composite membrane of principally tetraethylene glycol (TEGDA) cross-linked poly(2-hydroxyethyl methacrylate) (HEMA) that contained a methacrylate-derivatized polypyrrole component and two biomimetic methacrylate components, one with poly(ethyleneglycol)(110) chains and the other with phosphorylcholine moieties, both pendant to the polymer backbone. These additional components were introduced to provide interference screening [2] and *in vivo* biocompatibility [3] respectively. Within the membrane were immobilized PEGylated glucose oxidase and/or PEGylated lactate oxidase, which were then used to assay for *in vitro* glucose and lactate, respectively. The glucose biosensor exhibited a dynamic linear range of 0.10 - 13.0 mM glucose with a response time ( $t_{95}$ ) of 50 s. The immobilized glucose oxidase within the hydrogel yielded a  $K_{m(\text{app})}$  of 35 mM, not significantly different from that for the native, solution-borne enzyme (33 mM). The microdisc biosensor displayed linearity for assayed lactate up to 90 mM, which represents a 30-fold increase in linear dynamic range compared to biosensors using planar electrode formats. Operational stability revealed 80% of the initial biosensor response after 5 days of continuous operation in buffer under physiologic conditions of pH and temperature.

1. **Anthony Guiseppi-Elie**, Sean Brahim, Gymama Slaughter and Kevin R. Ward "Design of a Subcutaneous Implantable Biochip for Monitoring of Glucose and Lactate" *IEEE Sensors Journal* (2005), 5(3), 345-355.
2. Sean I. Brahim and **Anthony Guiseppi-Elie** "Electroconductive Hydrogels: Electrical and Electrochemical Properties of Polypyrrole-Poly(HEMA) Composites" *Electroanalysis* (2005) 17(7) 556-570.
3. Sheena Abraham, Sean Brahim, Kazuhiko Ishihara and **Anthony Guiseppi-Elie** "Molecularly engineered hydrogels for implant biocompatibility" *Biomaterials* (2005), 26(23), 4767-4778.