A Paper-Based Microbial Fuel Cell for Glucose Monitoring in Saliva

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Present-day blood glucose monitoring test kits are antiquated, requiring a finger prick to draw blood. This study's purpose was to develop a paper-based microbial fuel cell (pMFC) for glucose monitoring in saliva, a noninvasive indicator of systemic glucose levels (GL) compared to blood ($R^2 = 0.823$). pMFC performance was recorded via a customized LabVIEW interface (NI USB-6212). Each experiment was performed using 8 devices, each with glucose concentrations ranging from 0.0 mg/dL to 19.68 mg/dL using the bacterial species S. oneidensis. All experiments were performed 5x. In the first phase of this study, a 3-layer pMFC (3-pMFC) and a 2-layer pMFC (2-pMFC) were designed to determine optimal efficiency. The 3-pMFC prototype consisted of 3 distinct layers: (i) the anode, (ii) the anodic reservoir/wax membrane, and (iii) the air-cathode; the 2-pMFC consisted of 2 distinct layers: (i) the anode, and (ii) the anodic reservoir/cathode. The 3-pMFC showed 58% higher sensitivity than the 2-pMFC to distinguish between average diabetic (D) and average nondiabetic (ND) salivary GL, and was used for the remainder of this study. There was a 72% voltage difference between D and ND voltage levels after 5 minutes ($p<0.0001$). The 3-pMFC showed a linear range of voltage output ($R^2 = 0.93$) and distinguished GL ±0.2 mg/dL ($p<0.005$). The 3-pMFC's current increased linearly during a 16-day longevity test, signifying that bacteria proliferated for 16 days post-inoculation. This study fabricated an accurate pMFC to detect and monitor salivary GL. Future studies will investigate the use of wastewater as the device's reducing agent.

Awards Won:
Intel ISEF Best of Category Award of $5,000
Air Force Research Laboratory on behalf of the United States Air Force: First Award of $750 in each Intel ISEF Category