Paper-Based Microbial Fuel Cells for Self-Powered Sustainable Disease Diagnostics

Zhang, Kendra (School: Jericho High School)

One of today's most pressing healthcare issues is that disease diagnostics are immensely expensive, invasive, painful, and time-consuming. This study developed a paper-based microbial fuel cell (pMFC) for measurement of uric acid (UA) and C-reactive protein (CRP) in saliva, which could be explored as biomarkers of kidney disease and cardiac disease, respectively. pMFCs utilized S. oneidensis to generate current through the oxidation of organic materials in the anodic reservoir, transferring electrons to the anode connected to the cathode via USB-6212. UA-monitoring pMFCs discerned between UA levels at risk for chronic kidney disease and healthy UA levels (70% voltage difference; $p<0.05$). CRP-monitoring pMFCs discerned between CRP levels at risk for cardiac disease and healthy CRP levels in saliva (40% voltage difference; $p<0.05$). Furthermore, reliability of pMFC-based cardiac disease was supported with the addition of clinic-based measurement of fibrinogen in serum. Fibrinogen-monitoring pMFCs fabricated in this study discerned between fibrinogen concentrations at high risk for venous thrombosis, a precursor to cardiac disease, and healthy fibrinogen levels (36% voltage difference; $p<0.05$). Each single-use device costs $0.15 to fabricate and requires a reusable $2 voltmeter to read device output, which is significantly less expensive than traditional diagnostic methods. Overall, the pMFCs developed in this study may give individuals—specifically those with family histories of kidney/cardiac disease—insight into disease biomarker presence before disease onset and possibly increased severity. Future studies will develop pMFCs to detect allergen biomarkers.

Awards Won:

National Aeronautics and Space Administration: Second Award of $750