Amperometric Dual Glucose & Lactate Biosensing for Organ Preservation

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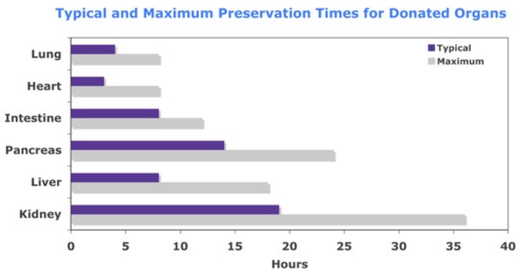
Introduction

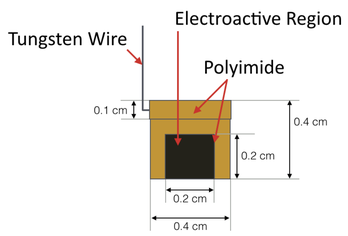
When transporting organs, especially from high risk situations such as military operations on battlefields, prolonging the lifespan of the organ is crucial for a successful transplantation. Maximum preservation time of an organ is approximately between 10 to 30 hours and organ transplantation operations can last anywhere between 2 to 15 hours, depending on the type of organ, allowing for a narrow timeframe for transporting the organ, the receptor, doctors and others involved to the operation location. A chamber is being developed in collaboration with Johns Hopkins University to increase the lifespan of organs by monitoring glucose and lactate, two organic compounds that are excreted by organs that signify decomposition and stress, and adjusting the chamber to better accommodate the organ. Development of amperometric glucose and lactate sensors for the organ chamber will be described.

Organ	Operation Duration (hrs)
Heart	3 - 4
Liver	5 - 8
Kidney	4 - 5
Pancreas	2 - 4
Kidney & Pancreas	5 - 7



Methodology

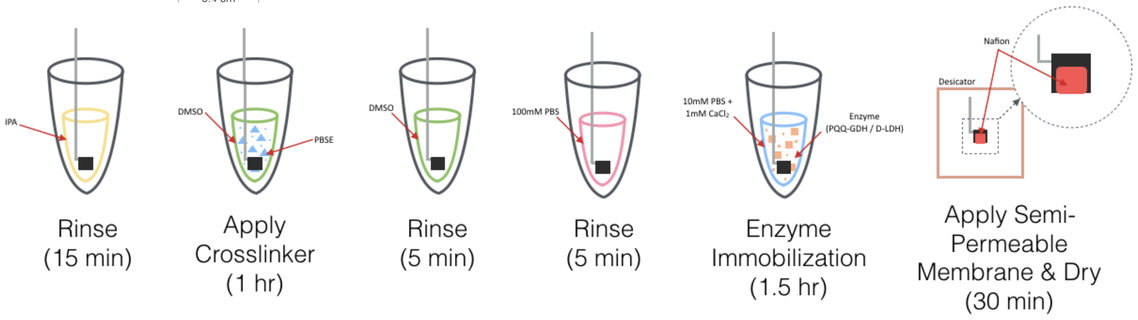
Construction and Functionalization



<u>Enzymes Used:</u>

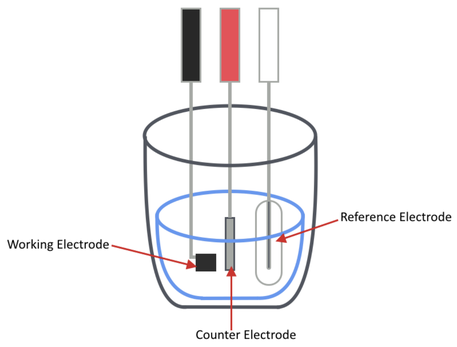
Glucose: Pyrroloquinoline Quinone Glucose Dehydrogenase (PQQ-GDH)

Lactate: D-Lactic Dehydrogenase (DLDH)



$$\text{Glucose} \xrightarrow{\text{PQQ-GDH}} \text{Gluconolactone} + 2H^+ + 2e^-$$

$$\text{Lactic Acid} \xrightarrow{\text{D-LDH}} \text{Pyruvate} + 2H^+ + 2e^-$$



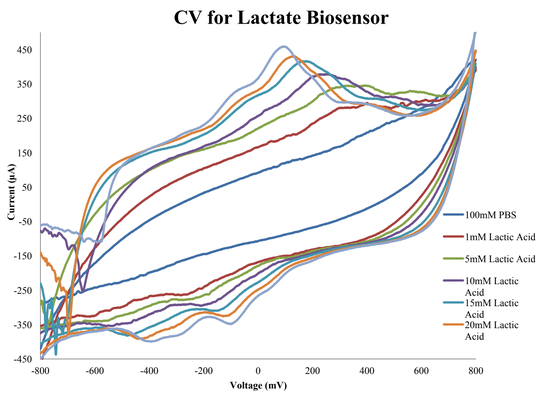
Tests Conducted

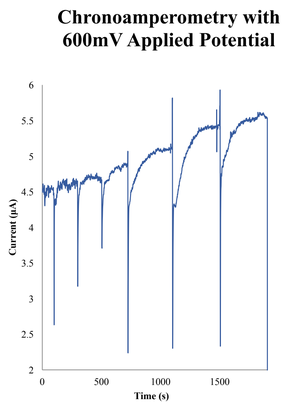
- Cyclic Voltammetry (CV)
- Chronoamperometry
- Potentiostat Circuit Application

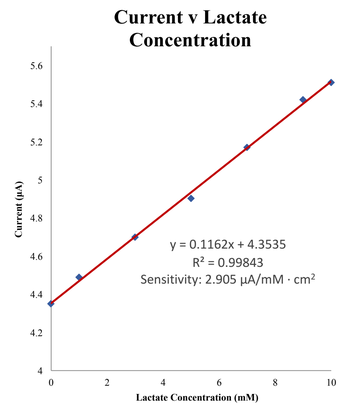
NOTE: All Tests were conducted at physiological conditions (37 °C and pH 7.4)

Results

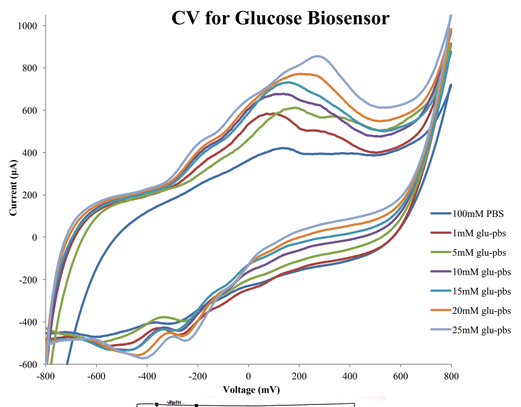
Lactate Biosensor Results

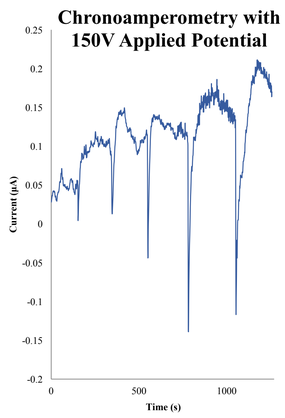


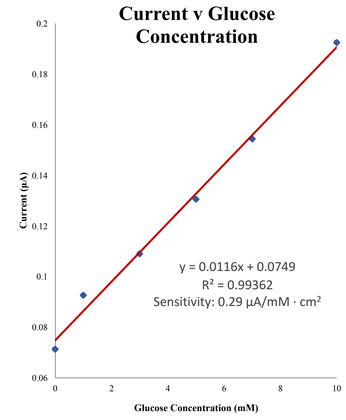


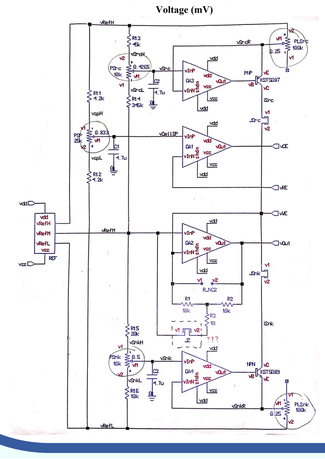


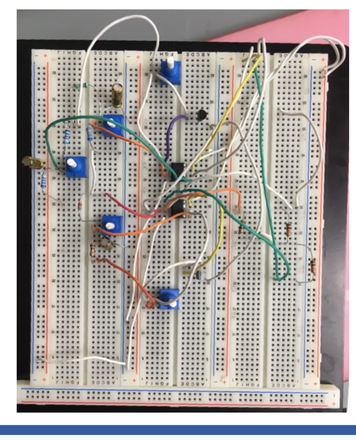
Glucose Biosensor Results

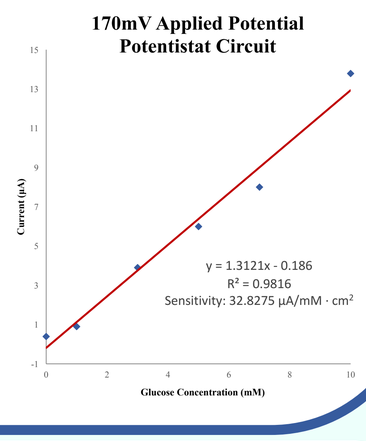






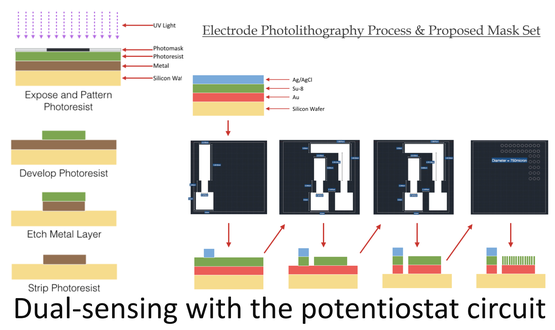






Conclusion & Future Work

- Several working electrodes for glucose and lactate demonstrate a linear relationship between produced current and analyte concentration.
- An operational potentiostat circuit allows current and voltage measurements to be taken over the three-electrode system.
- Sensitivity improved when using the potentiostat circuit; however, linearity decreased.



- Dual-sensing with the potentiostat circuit
- Preparing masks & creating electrodes on silicon wafers in the form of nanoposts

References

"Cyclic-voltammetry-study-of-unmodified-and-Prussian-blue-modified-electrodes." *Research Gate*. N.p., n.d. Web. 29 June 2017.
Guibert, Edgardo E., Alexander Y. Petrenko, Cecilia L. Balaban, Alexander Y. Somov, Joaquín V. Rodriguez, and Barry J. Fuller. "Organ Preservation: Current Concepts and New Strategies for the Next Decade." *Transfusion Medicine and Hemotherapy* 38.2 (2011): 125-42. Web. 30 June 2017.
"Organ Procurement and Transplantation Network." *OPTN: Organ Procurement and TransplantationNetwork - OPTN*. N.p., n.d. Web. 30 June 2017.
Roushani, Mahmoud, and Somayeh Farokhi. "Amperometric Detection of Isoprenaline Based on Glassy Carbon Electrode Modified by Iridium Oxide Nanoparticles." *Journal of the Brazilian Chemical Society*. Brazilian Chemical Society, n.d. Web. 29 June 2017.
Slaughter, Gymama, and Tanmay Kulkarni. "A self-powered glucose biosensing system." *Biosensors and Bioelectronics* 78 (2016): 45-50. Web.
TransWeb.org. N.p., n.d. Web. 29 June 2017.
Tsai, Yu-Chen, Siao-Yun Chen, and Hong-Wei Liaw. "Immobilization of lactate dehydrogenase within multiwalled carbon nanotube-chitosan nanocomposite for application to lactate biosensors." *Sensors and Actuators B: Chemical* 125.2 (2007): 474-81. Web. 29 June 2017.
"What is a kidney transplant? - How long does the transplant operation take?" *How long does the transplant operation take? » National Kidney Federation*. N.p., n.d. Web. 29 June 2017.

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