Optical-Based Fluorophore Microparticle Sensors

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Introduction

- Current methods of studying cancer cells fail to simulate conditions in human bodies. Results are poorly translated to humans.
- The amount of oxygen is probably the most important factor when it comes to regulating the tumor-microenvironment.
- Controlling/Monitoring the oxygen levels precisely is one of the most important factors in simulating conditions in the human body. In order to do so, a sensor that can sense the amounts of oxygen and express that amount is needed.
- Our goal is to build a sensor that can accurately convey the amount of oxygen in a confined area by using oxygen insensitive fluorophores and oxygen sensitive luminophores, and find the sensor response time of the sensor: the delay in sensing the levels of oxygen.

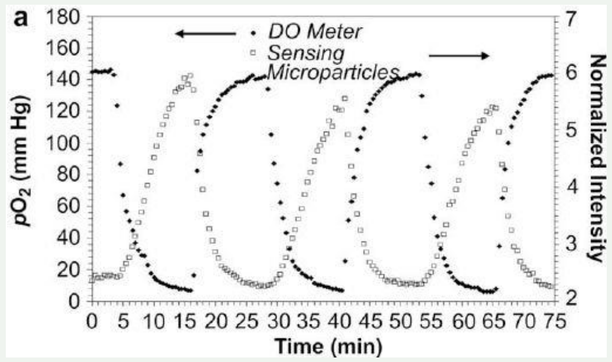

Figure 1: Sensor Response Time

Methods

Making PDMS with the sensor particle

- PDMS (polydimethylsiloxane) is a biocompatible, clear, gel-like substance that can be cured (heated) to turn the gel into a solid form
- Mix the prepolymer and curing agent together in a 10:1 ratio. Place in Thinky machine
- Put sensor particles in the PDMS, mix/stir gently. Place in Thinky machine again.

Spin coating sensor particle with PDMS

- Place a coverslip in the spin coater machine.
- Place a drop of the sensor particle with PDMS in the center of the coverslip.
- Start the spin coating process.

Image acquisition and analysis

- Observe the coverslips under the microscope using an inverted fluorescent microscope.
- Analyze the images on the computer using MATLAB after exposing it to Cal 0 water (water with no oxygen, simulating hypoxic conditions) and regular water (serving as the control).

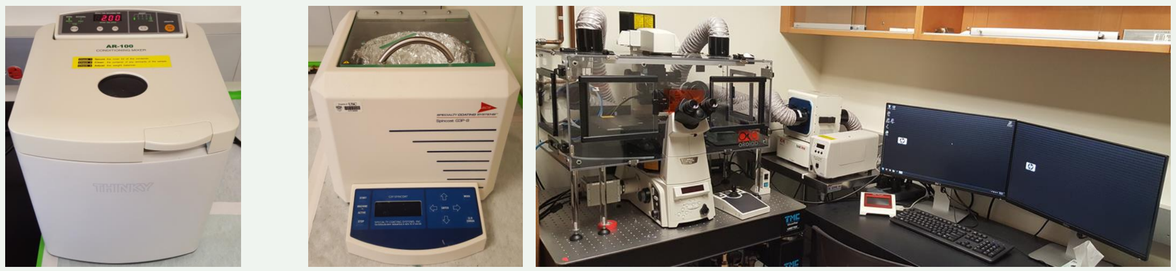

Figure 2, 3, & 4: (from left to right) Thinky Machine, Spin Coating Machine, and Fluorescent Microscope

Research Results

- In the graph on the top, it looked like the sensor response time is around 2 minutes.
- In the graph on the bottom, the sensor response time seems to be around 20 minutes, since it reaches a plateau. A little longer than the expected 10-15 minutes, Areas to improve: repeat the experiment for a longer period of time, or optimizing our procedures so that the Cal 0 water stays 0% oxygen until the end.

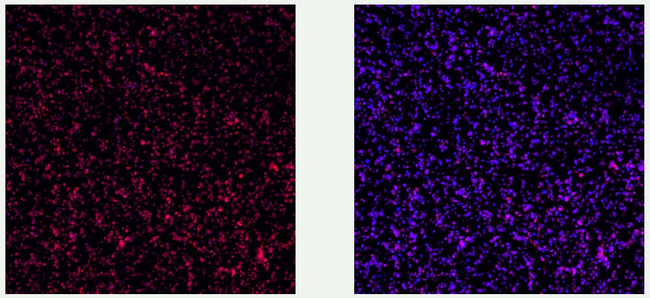

Figure 5 & 6: (left to right) Nile Blue Chloride in regular water and Ruthenium Complex in Cal 0 water

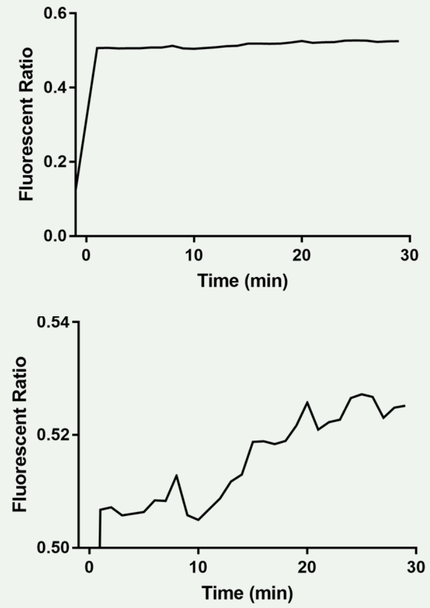

Figure 7 & 8: (top to bottom) Relationship between Fluorescent Ratio and Time (unfocused & focused, respectively)

Next Steps

- Uniform distribution of sensor particles. Look for microparticle that distributes better. Increase sensor particle to PDMS ratio.
- Localization of testing on the coverslip.
- Determining size differences between the sensor particles.
- Simulate human body environments better.

References

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2. Acosta, M. A., Ymele-Leki, P., Kostov, Y. V., & Leach, J. B. (2009). Fluorescent microparticles for sensing cell microenvironment oxygen levels within 3D scaffolds. *Biomaterials*, 30(17), 3068-3074.

Acknowledgement

I would like to thank my PhD mentor Yuta Ando for supporting me through the whole process of research and answering any questions I have. In addition, I would like to thank Professor Shen and all the people in the three labs for being so kind and helpful to me. Also, I would like to thank Dr. Mills, Manny, Deepika, and Ethan for the events they have hosted and the wonderful lunches they have provided every Friday. Most importantly, I would like to thank my parents for encouraging me to attend the SHINE program and doing whatever they can so I can concentrate on research.