Developing an Oxygen Detection Device for a Microfluidic Hypoxia Chamber
Design Matrix
October 19th, 2012

Client: *Professor Brenda Ogle, PhD*

Advisor: *Professor Randolph Ashton, PhD*

Team: *Matthew Zanotelli*
Chelsea Bledsoe
Karl Kabarowski
Evan Lange

Oxygen Sensor Format			
Factors	**Thin-Film Sensors**	**Microparticle/ Nanoparticle Sensors**	**Water-Soluble/ Macromolecule Probes**
Accuracy/ Sensitivity (30)	4	5	2
Cost (25)	3	3	1
Ease of Use (20)	5	4	3
Ease of Assembly (15)	4	3	4
Biocompatibility (10)	5	4	2
Total Points	81	78	45

Oxygen-Sensitive Luminescent Materials		
Factors	**Ruthenium-based**	**Metalloporphyrin-based**
Luminescence Properties (25)	5	3
Accuracy/ Sensitivity (30)	2	5
Unquenched Lifetime (10)	2	4
Cost (25)	4	2
Biocompatibility (15)	3	5
Total Points	67	73

Design Alternatives:

Ruthenium-based

- High luminescence quantum yield
- Very photostable
- Short excited-state lifetimes lead to lower sensitivity to oxygen than is necessary in certain applications (esp. low oxygen environments)
- Used in thin film sensor and nanoparticles
    - Thin film sensor – modified to be soluble in silicone films
- Ru(phen)2+ can have phototoxic effects
    - When used as a dye, repeated illumination caused plasma membranes to rupture
- Most are excitable with blue, green, yellow, or orange LEDs

Metalloporphyrin-based

- Phosphoresce rather than fluoresce, which leads to lower luminescent quantum yield
- Longer excited-state lifetime
- Higher sensitivity to oxygen
- Poor photostability
    - Pt- and Pd-OEPK have significantly improved photostability
- Have been used in microfluidics and for inter- and intra-cellular measurements
- Generally encapsulated in a polymer or sol-gel matrix or water-soluble
- No leaching was found from polymer matrices
- Most are excitable with blue, green, yellow, or orange LEDs

Thin-film sensor

- Encapsulating the sensor in polymer or sol-gel matrix reduces likelihood of unwanted interactions
- Typically fabricated by either pipetting or spinning solutions of the indicator and encapsulation medium onto a substrate of interest such as glass slides, polymers, or polyester foils
- Successfully used with microfluidics already
- Usually excited with either trans- or epi-illumination

Microparticle/Nanoparticles

- Encapsulating the sensor in polymer or sol-gel matrix reduces likelihood of unwanted interactions
- Fabricated by doping polymer or silica beads with luminescent indicator dye or by grinding indicator-doped ormosil
- Used directly or embedded in another material such as silicone or hydrogel
- Can add particles to silicone or hydrogel thin-films within the channels

Macroparticles/water-soluble

- More expensive (need to change media over course of the experiment)
- Water-soluble probes, which may be bound to albumin or other molecs to improve sensor characteristics
- Very versatile
- Likely to interfere with their environment
- Difficult to control sensor parameter
- May allow 3D mapping

Final Design:

- Metalloporphyrin-based thin-film sensor
    - Ideally will use PdOEPK if cost appropriate otherwise PtOEPK