DEVELOPMENT OF AN ECONOMIC, MOBILE DUAL OXYGEN AND PH SENSOR

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Introduction

- Fluorescent and phosphorescent dyes have been used to determine pH values and oxygen concentrations in a variety of systems.[1]
- The goal of this project is to develop a small, self-contained, cheaply processed dual pH/oxygen sensor (Figure 1). Such an instrument could potentially be taken to various environments and quickly and easily provide readings.
- A platinum-porphyrin dye was used based upon its long emission time, high sensitivity, and short response time[2].
- The Stern-Volmer Equation ($I_0/I = 1+k^{*}P_{O2}$, where I_0 is phosphorescence intensity in the absence of oxygen, I is the phosphorescence intensity, and k is a rate constant), can be used to determine the concentration of oxygen from the intensity of the emitted light.[3]
- This project is focused on the development of the oxygen-sensing component of the device.

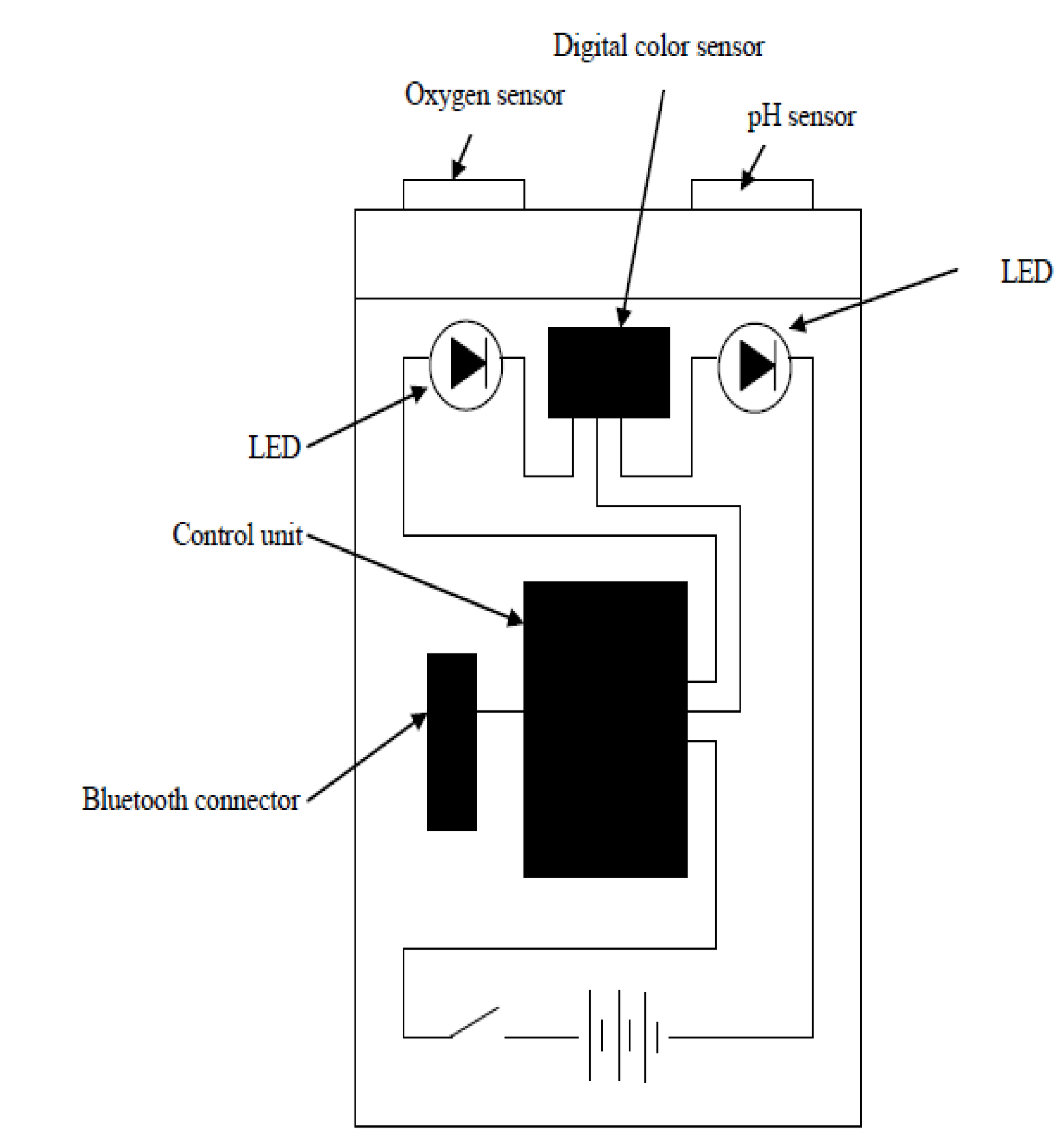

Figure 1. Schematic of optical pH/oxygen sensor.

Methodology

- Platinum (II) meso-tetrakis (2,3,4,5,6 –pentafluorophenyl) porphyrin (PtTFPP) (Figure 2) was dissolved in a suspension of polystyrene and titanium dioxide in toluene. This produced a thin, oxygen-sensitive membrane when placed on a surface and allowed to dry (Figure 3).

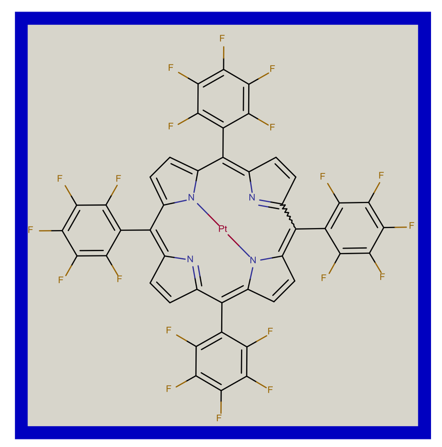

Figure 2. Platinum (II) meso-tetrakis (2,3,4,5,6 – penta-fluorophenyl) porphyrin (PtTFPP)

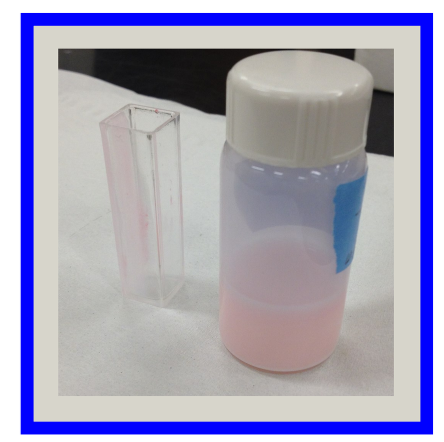

Figure 3. Cuvette with one surface covered in a layer of PtTFFP paint (left). Vial of PtTFFP paint (right) used to coat the surface of the cuvette.

- An Arduino Uno® microcontroller was programmed using open-source software to control a 405 nm LED and a Hamamatsu Digital Color Sensor S11012-01CR (Figure 4).

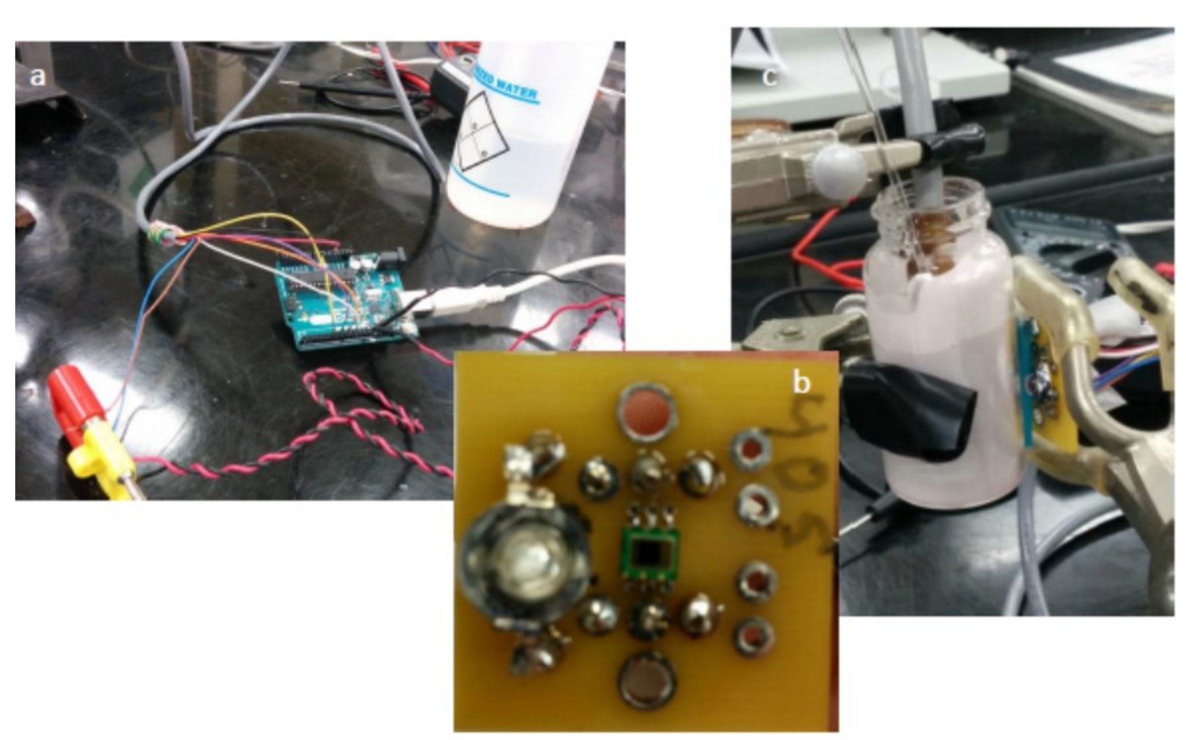

Figure 4. Set-up of oxygen- sensing component. Arduino board (a) attached to Hamamatsu Digital Color Sensor (b). LED emits 405 nm wavelength light onto PtTFPP-painted vial (c).

Data and Analysis

- The PtTFPP paint showed an increase in emission intensity at low oxygen levels when compared to high oxygen levels during a yeast-depletion study (Figure 5).

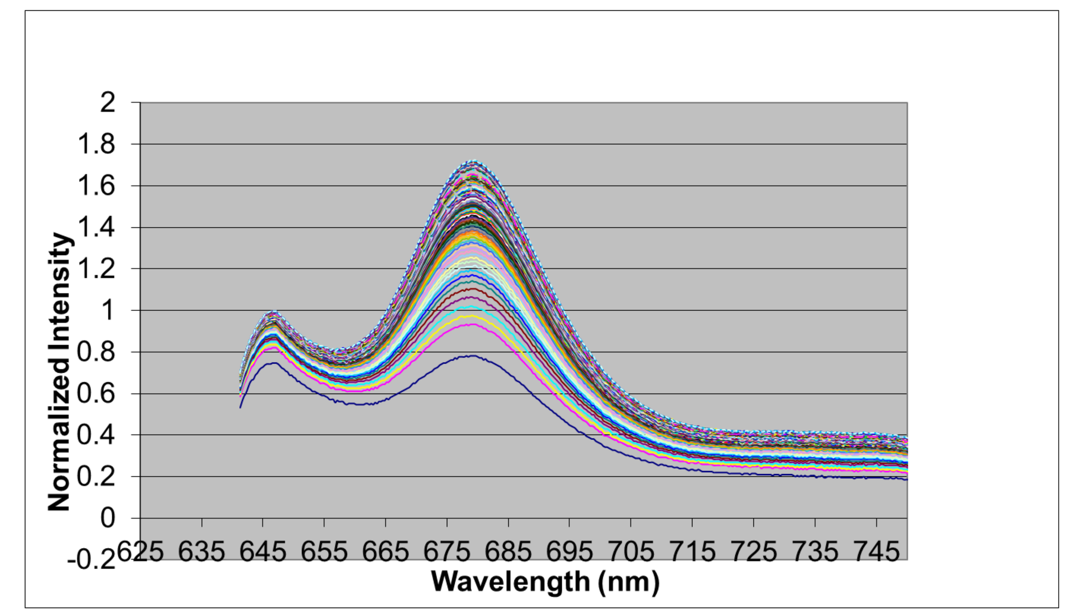

Figure 5. Emission Spectra of PtTFPP-containing paint over twenty minutes from air saturated (low amplitude, t = 0 s), to zero oxygen (high amplitude, t=1200 s).

- Code written for the Arduino Uno® and Hamamatsu Digital Color Sensor, was used to control an LED and determine the percentage air saturation of a sample (Figures 6, and 7). Data was collected simultaneously by a Clark oxygen sensing probe (Figure 8).

Figure 6. Phosphorescence of PtTFPP-painted vial. Shows emission in the red region.

You are on trial number:5
Red emission: 1883
Green emission: 1991
Red to Green emission ratio:0.95
gtc value: 428
Sum of RtoG values: 4.56
Average RtoG ratio values from air saturation trials: 0.91
RGS ratio: 0.91
Percentage Air Saturation of Sample: 101.64

Figure 7. Sample Arduino Uno® data output on serial monitor used to determine percent air saturation.

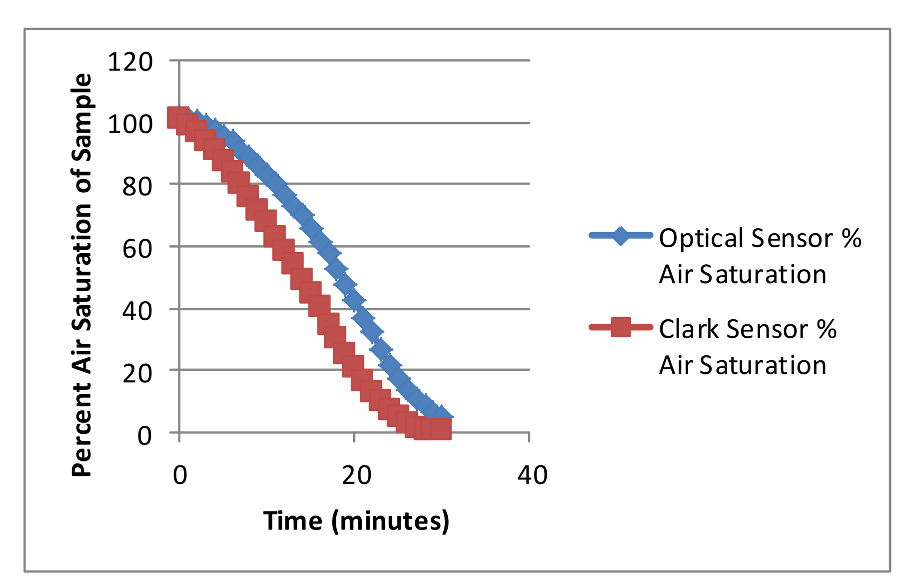

Figure 8. Percent air saturation of sample over 30 minutes during oxygen depletion by yeast. Shows values given by our optical sensor (PtTFPP) and Clark electrode.

Data and Analysis Continued

- A power law fit curve, comparing the percent air saturation values of the Clark sensor to the optical sensor, was applied using Excel® (Figure 9).

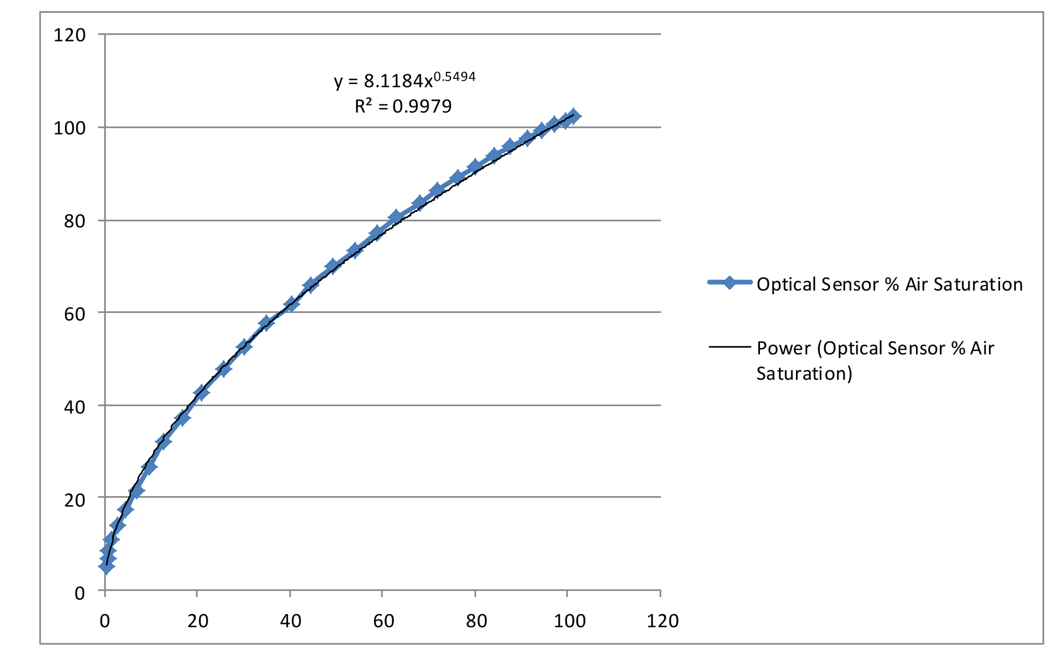

Figure 9. Power law fit curve between the percent air saturation values given by the Clark sensor and the optical oxygen sensor.

Discussion

- The oxygen-sensing film containing PtTFPP, showed sensitivity to oxygen, with an increase in emission intensity corresponding to a decrease in oxygen in the sample (Figure 5).
- A successful code was written for an Arudino Uno® microcontroller, 405 nm LED, and Hamamutsu Digital Color Sensor, which allowed for the determination of the percentage oxygen in a sample.
- When a power-law fit curve was applied to the percentage air saturation between a Clark oxygen sensor and our optical sensor, the optical oxygen sensor showed excellent oxygen sensitivity.

Literature Cited

[1] Tian, Y. Shumway, B., Youngbull, A., Li, Y., Jen, A., Johnson, R., & Meldrum, D. (2010). *Sens Actuators B Chem. 147*(2): 714-722.

[2] Mills, A., Tommons, C., Bailey, R.T., Crilly, P., & Tedford, M.C. (2011). *Analytica Chimica Acta. 702*: 269-273

[3] Adler, A. D., L. Sklar, F. R. Longo, J. D. Finarelli, & Finarelli, M.G. (1968). *Journal of Heterocyclic Chemistry. 5:* 669–678.

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