Developing a Condensation-Based Biosensor for Non-Invasive, Open Air Cancer Monitoring

Ethan Abbott, Marian High School, Mishawaka, Indiana, USA

Research Question

- Over 400 people suffer from diabetes while lung and liver cancer are the leading causes of cancer deaths. Many of the cancer diagnoses are when it is too late.
- Can I develop a device that can one day be used for earlier cancer detection by condensing exhaled breath and analyzing the biomarkers in it?

Methodology

1. Practice 3D modeling on SolidEdge
2. Model pieces for other versions of ABLE
3. Design a new segmented version of ABLE for longer collections
4. Model the segments of the new ABLE on SolidEdge
5. Print the segments on a PLA printer
6. Make adjustments to the segments so they would all fit
7. Analyze evaporation times of different biomarkers with an optical contact angle microscope
8. Test new ABLE with controlled concentrations of glucose & water vapor for 10 minutes
9. Measure amount of sample collected
10. Calculate color change on a glucose test strip using the L.a.b. formula $(E = L2 + a2 + b2)$ where E is the color, L is lightness, a is red/green, and b is yellow/blue
11. Repeat tests and analysis with concentrations of ethanol

Data

Color Change Graph for Different Concentrations of Ethanol
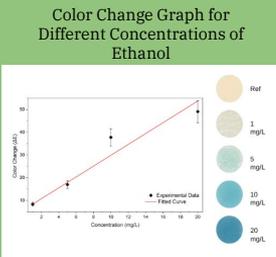
The above figure shows the color change on the ethanol test strips from samples collected with the new ABLE device. Created by Yamin Mansur with OriginLab.
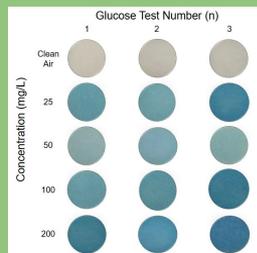
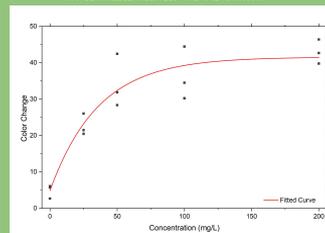The above figure shows the color change on the glucose test strips from samples collected with the new ABLE device. Created by Yamin Mansur with OriginLab.

Color Change Curve for Different Concentrations of Glucose

The above figure was made based on color change calculated from three (3) collections at each of the different concentrations of glucose. Created by Amio Ritwik with OriginLab.

Glucose ANOVA Test

Source	DF	Sum of Square	Mean Square	F Statistic	P-value
Groups (between groups)	4	2692.1077	673.0269	25.8102	0.00002985
Error (within groups)	10	260.7604	26.076		
Total	14	2952.8681	210.9192		

The table above shows the results of an ANOVA test done on the glucose color change. Made by Ethan Abbott with a ANOVA calculator.

Conclusion

Glucose solutions were tested to validate performance, with results showing reliable sample collection and detection through color analysis. The color change curve was compared to one made by Dr. Jingcheng Ma, one of my mentors, and they had the same trend. To do research on condensed biomarkers from exhaled breath we need to figure out a way to analyze them as soon as they condense. Acetone has been identified by other researchers as a potential indicator of certain cancers, however it evaporates in less than thirty (30) seconds.

ABLE is a device which can one day aid in the detection of cancer without forcing you to go to the doctor. People everywhere will be able to directly benefit from the development and production of ABLE. This version of the ABLE device has proved that it works just as well as the first version. With this new version it is possible to do longer collections to get more sample to study and learn from. The next steps for this model would be to continue testing with glucose and ethanol solutions until collection amounts are consistent. After that, experiments would run for longer periods of time which would show the device's full capabilities. I would then figure out a way to integrate a sensor that can analyze samples as they condense, not giving any of the biomarkers time to evaporate. Finally I would start collecting exhaled breath sample from human to get a baseline for different biomarkers.