A 3-D Diagnostic Device Based on Paper-Based Microfluidics

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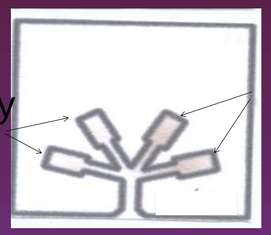
Introduction

The purpose of this research is to create a diagnostic device that keeps the complication level low, the cost low, and efficiency high. With these parameters the research focused on Paper-Based Microfluidic Analytical Devices (µPADs). Using a method called wax printing, a layer of wax in printed on paper. The device is then put in a heating device at 150 ^{O} C for two minutes. This allows the wax to melt into the Whatman no. 1 Chromatory paper both vertically and horizontally forming a hydrophobic barrier to control the flow.

2-D µPADs

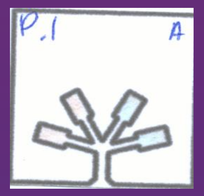
This is a two- dimensional design that flows only in the x and y direction. In this design, .01 µL of the assay is placed in each branch (either protein or glucose assays). The assay kits were purchased from Sigma-Aldrich. The glucose assays dries clear, while the protein dries brown.

Glucose Assay



Protein Assay

After the assays dry, synthetic urine with known amounts of glucose and or protein are entered into the system at the entrance point which then flows into each branch mixing with the assay but not within other branches. The amount of protein or glucose determines the color change. The larger the amount means a greater change in color. Glucose changes form clear to brown. Protein changes from brown to blue.

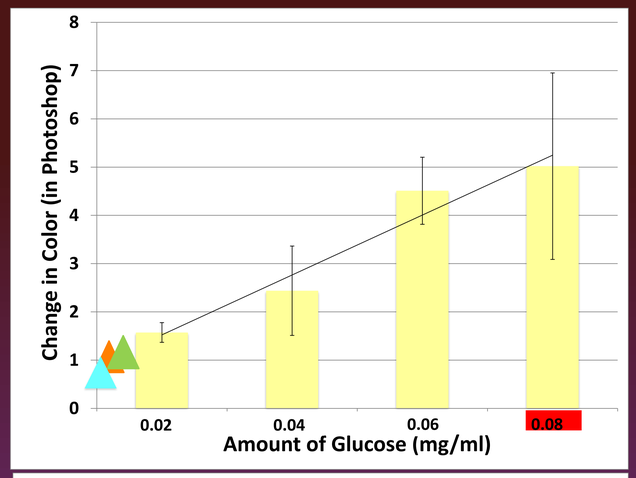


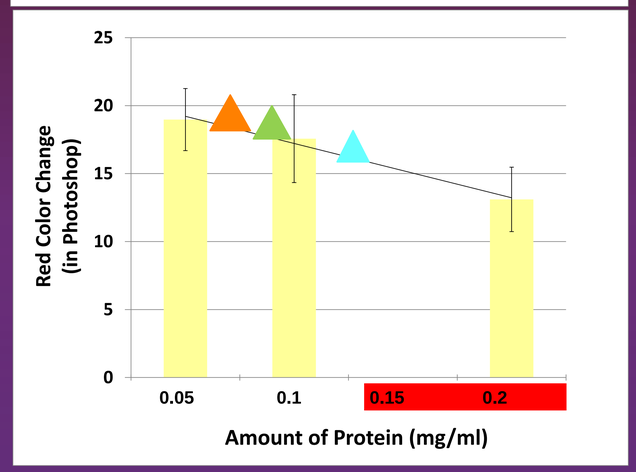
Example with .1 mg/ml of protein

Results

The images were captured with a scanner before and after applying urine with at a resolution of 600 dpi. The pictures are then uploaded to Photoshop. In Photoshop, the pictures are analyzed using the histogram tool, which analyzes color in the selected area by graphing the amount of darkness or brightness in the section. That means that the color change can be measured. The graphs in this poster show the relationship between the change in the color and how much protein or glucose in the synthetic urine.

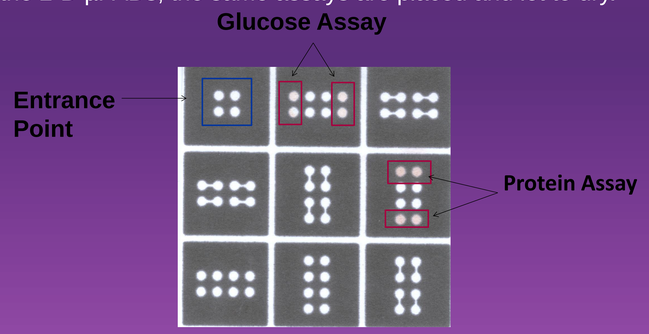
The abnormal zones are in red. Protein in urine can be a sign of kidney disease. Signs of glucose can be the detection of diabetes.



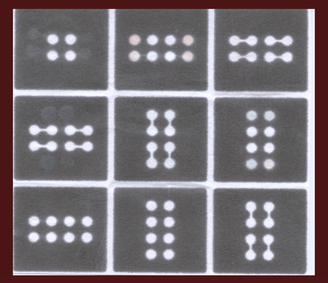


3-D µPADs

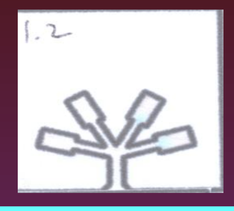
The next design is three-dimensional, using an origami technique by folding the device to create the prototype. This allows multiple detection points on a small footprint. Similar to the 2-D µPADs, the same assays are placed and let to dry.



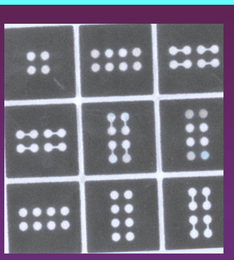
The urine flows through and mixes with the assay like in the 2-D device giving off a color change.



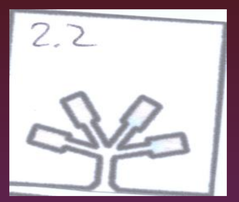
Assay of Human Urine



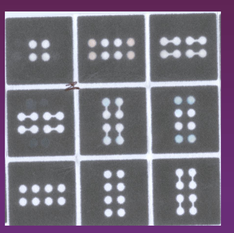
Volunteer #1



Average color change for
Glucose: 0.195
Protein: 15.945

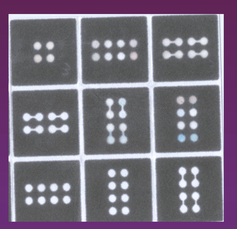


Volunteer #2



Average color change for
Glucose: 0.57
Protein: 17.365

Volunteer #3



Average color change for
Glucose: 0.525
Protein: 18.825

In an experiment, 3 volunteers were chosen. The same method was used but the volunteer's urine was added into the system. Using a graph we obtained from known amount of protein or glucose, an estimation of where the volunteer's protein and glucose levels land. The volunteers are between the ages of 17-18, with two samples male, one female and a weight range of 100 pounds. All three volunteers fell under the healthy ranges for both Glucose and Protein.

Acknowledgements

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References

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