Paper-Based Microfluidic Devices: Innovation in Diagnostics of Infectious Diseases

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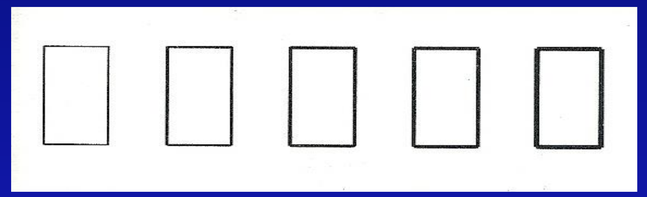
Introduction

The goal of this research is to develop a method of diagnosing disease that is simple, affordable, and easily transported. Paper-Based Microfluidic Devices (μPADs) were chosen as the best option for this. From a variety of ways to produce μPADs we found wax printing to be the best option for our standards. With wax printing channels are created by printing wax on paper. The wax is then melted, causing it to spread not only horizontally on the surface of the paper, but also vertically through it creating a hydrophobic barrier.

Chromatography Paper (Whatman, 1CHR, 100 μm thick) was used for the device. Device patterns were created using SolidWorks. These patterns were then printed on the paper with wax instead of ink (Xerox ColorQube 8570DN). The devices were then placed in an oven and melted for 120 seconds at approximately 150° Celsius.

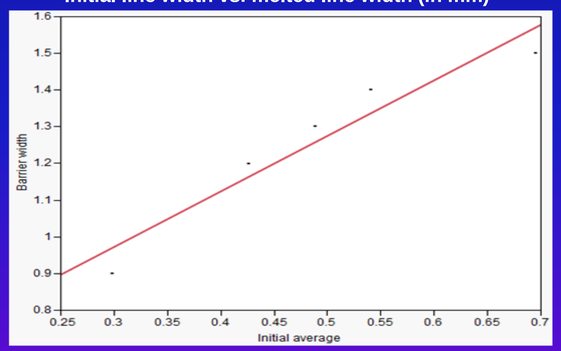
Wax Spreading

A device was first designed to measure the necessary width of line required to create a fully hydrophobic barrier. The device consisted of 5 rectangles of the same size with different beginning line widths.

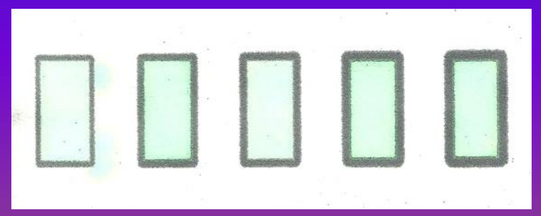


The devices were then melted and the line width was measured. Water colored with green food coloring was then placed in the center of the rectangles and allowed to spread throughout the paper to test the ability of the channels to hold in fluids. It was found that the smallest original line width of 400 μm worked as a barrier after melting (about 1000 μm wide).

Initial line width vs. melted line width (in mm)



Channels with red coloring

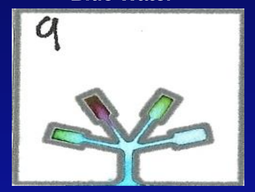


2D μPAD

The first μPAD design produced was a 2D figure that had an entrance point which then divided the liquid down 4 different paths allowing 4 different detectors to be used with only one sample of fluid. The ability of this device was then tested by adding a small drop of a different color of food coloring at the end of each channel. Water was then places at the entrance and allowed to flow through the device. The water spread evenly and colors remained within their own channels. A second test was done starting with the same original locations for the colors only a water sample dyed with blue food coloring was used to show how the sample mixes with what's at the end of the channel.

Plain Water

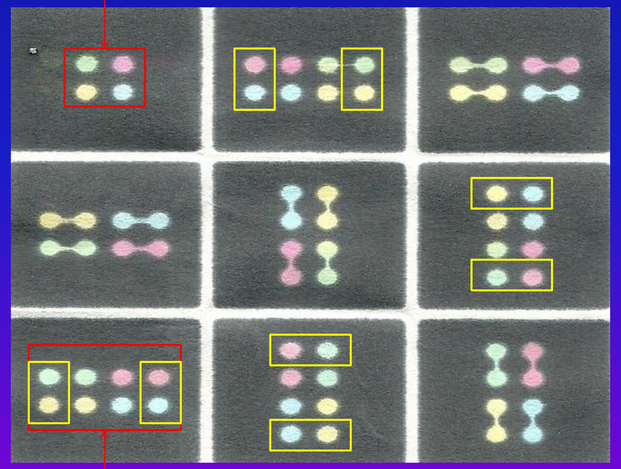
Blue Water



3D μPAD

A second design was produced, this time with the ability to be folded into a 3D device. This device has many channels where assays may be placed. Red, blue, yellow, and green colored water was placed in each of the four entrance locations. The liquid again flowed evenly through the paper and the colors did not mix within the device.

Entrance

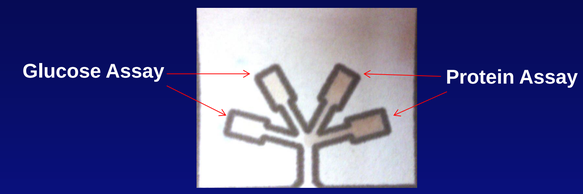


End

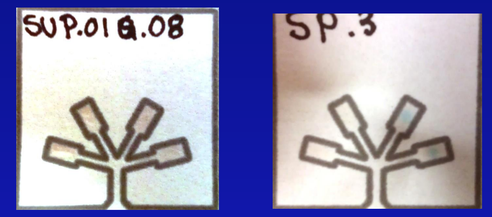
Areas for assays are surrounded by a yellow box.

Assays

To test the devices ability to be used for disease detection Protein (TP0100) and Glucose (GAGO-20) Assay kits were purchased from Sigma-Aldrich. The assays were prepared and each was placed at the end of two channels on the 2D μPAD and then allowed to dry.



The samples used were a synthetic urine each containing different known amounts of Protein and Glucose. Once the devices were dry each sample was added to the device. After these had dried the devices were examined for a change in color in the detection reservoirs.



The change of colorless to a light brown in the left picture indicates the presence of Glucose in the solution. The change from brown to blue in the right picture indicates the presence of Protein in that sample. As the amount of Glucose or Protein in a sample increases so will the intensity of the color change. Being able to detect the amount of not only Glucose and Protein but many other things providing a cheap and effective way of diagnosing disease.

Acknowledgements

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References

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