Optical Detection of Glucose Using 3D-Printed Microfluidic Platform

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Introduction

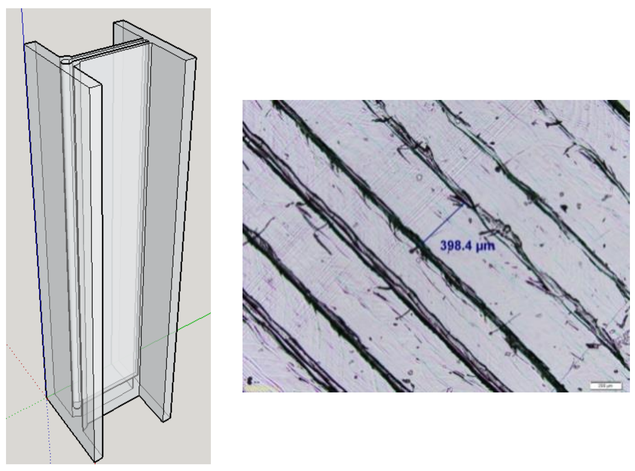
An aging population in combination with an obesity and diabetes epidemic is placing huge burden on health care services and increasing the need for point-of-care testing for serious pathologies. The advance of solid freeform fabrication techniques such as 3D-printing has significantly improved the ability to prepare solid structures with precise geometries; this provides a means for rapid device development for point-of-care devices. However, 3D-printed optical assay platforms can suffer from the poor optical properties and performance of polymers available.

- To develop a cheap disposable 3D-printed microfluidic optical device.
- Improve optical transparency of the devices such that optical colourimetric assays can be performed within.
- Produce calibration curve of colourimetric glucose assay performed within device.

Methodology

A Microfluidic device was designed using CAD software and fabricated using an Ultimaker 2+ 3D-printer. Optical transparency was improved using optimisation techniques of the printer and print conditions. Further optical improvement has been achieved with solvent vapour treatment. A colourimetric glucose assay was performed within the device and the absorbance determined via a spectrometer.

The glucose assay utilized an enzymatic cascade of glucose oxidase and horseradish-peroxidase was used for the oxidative coupling of 4-aminoantipyrine and chromotropic acid to produce a blue quinoneimine dye. The assay was performed in a the 3D-printed prototype, the absorbance was quantified and a glucose concentration curve was successfully produced.



(A) (B)

Figure 1: (A) CAD design of microfluidic device. Channel diameter 500 µm. (B) Image of plastic sample.

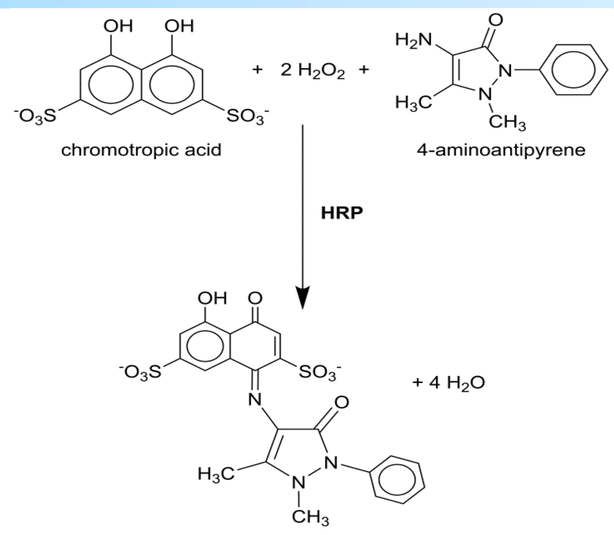


Figure 2: Proposed mechanism for peroxidase-catalysed formation of a quinoneimine dye.

Results

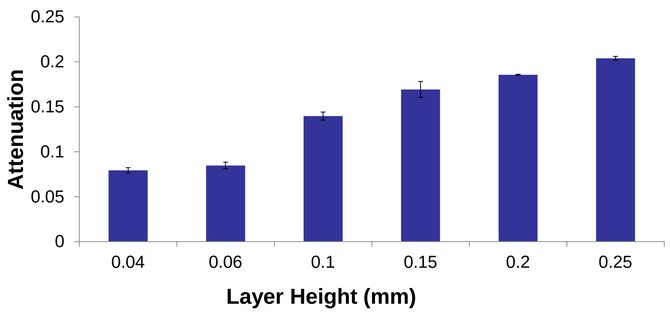


Figure 3: The effect of print resolution/layer height on optical transparency.

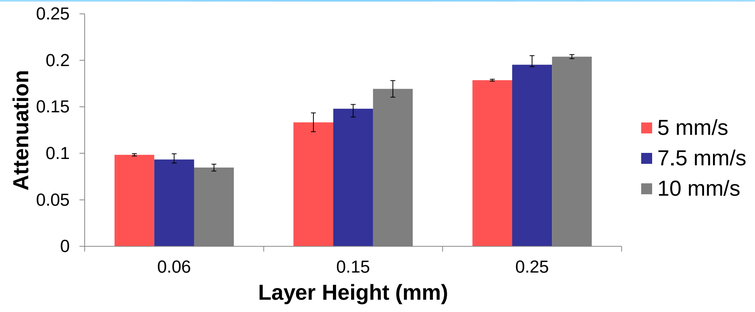


Figure 4: The effect of print speed on optical transparency.

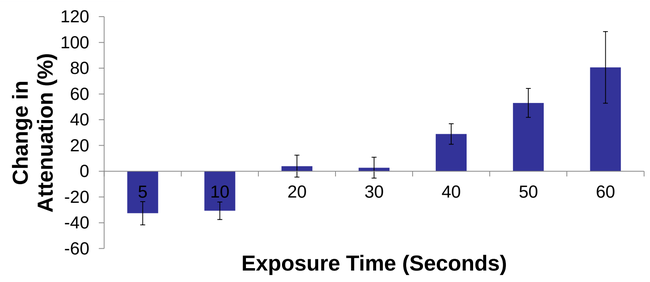


Figure 5: The effect of acetone vapour treatment on improving optical transparency.

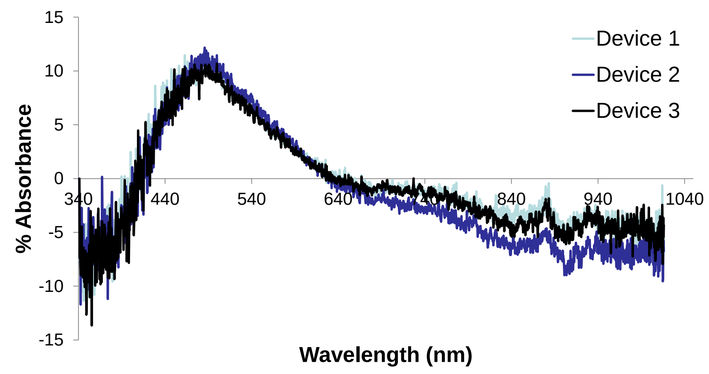


Figure 6: Variability of printed devices.

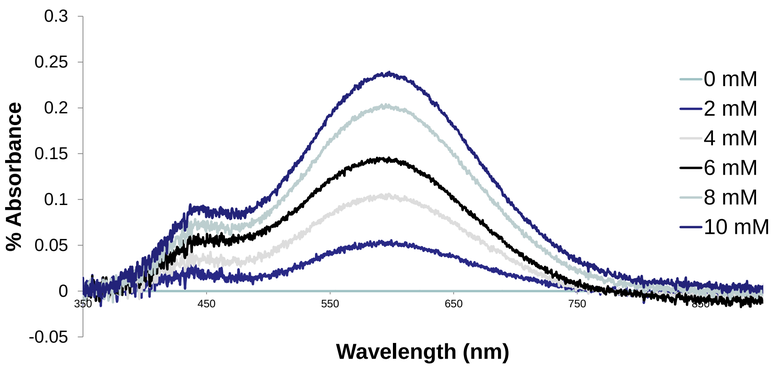


Figure 7: Absorbance spectra of quinoneimine dye produced by assay in 3D-printed device.

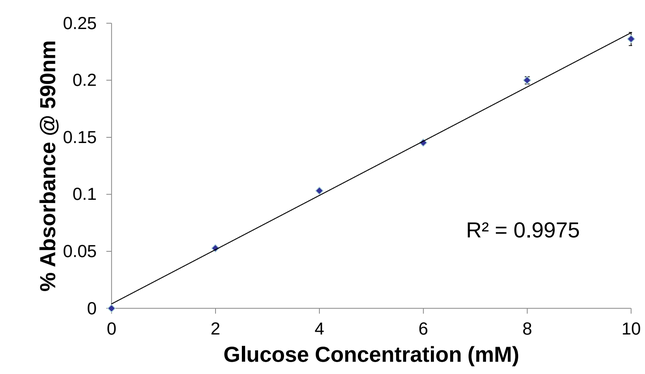


Figure 8: Quinoneimine dye absorbance at 590 nm. CV 2.4%.

Conclusions

The current work demonstrated that with proper optimisation of equipment and operating parameters, it is possible to produce microfluidic devices suitable for point- of-care testing using a 3D-printer. The optical transparency of the devices was improved using various techniques during and after manufacture to such a point that optical colourimetric assays can be performed in the device. The data gathered shows that excellent assay reproducibility is possible in the 3D-printed device. Future work focuses on blood and urine analysis and complex 3D-printed devices such as lab-on-a-disc assay platforms, providing mobile diagnostic information efficiently and cheaply for personal health monitoring.

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Microfluidic Device Download Link

Poster/Data Download Link