Development of biomimetic paper-based lab-on-chip

Vreys F.[12], Daniels K[1], Oudebrouckx G.[12], Vandenryt T.[12], Thoelen R.[12]

frederik.vreys@uhasselt.be

[1]Institute for Materials Research(IMO), Hasselt University,
Wetenschapspark 1, 3590 Diepenbeek, Belgium
[2]IMEC vzw – Division IMOMEC,
Wetenschapspark 1, 3590 Diepenbeek, Belgium

Abstract: A biomimetic paper-based lab-on-chip device based on the heat transfer method(HTM) was developed. This work applied molecularly imprinted polymers(MIPs) as a biomimetic functional interface. In order to deliver the sample to the functional interface an optimal wick design is needed. Several designs were tested to determine the flow rate, flow duration and amount of volume needed. HTM and camera recording were used to acquire test results. The final wick design allows for easy integration of the biomimetic layer. The paper-based lab-on-chip will allow the rapid on-site testing of potentially polluted fluids.

Keywords: paper-based, microfluidics, molecularly imprinted polymers, MIPs, HTM

Introduction

Ongoing research of biomimetic sensors based on the heat transfer method often focus on the development of online sensors or dip sensors. This is also the case for sensors functionalized with molecularly imprinted polymers(MIPs). Peeters M. et al. performed these measurements with bulk MIPs [1].

However, this work focuses on the development of paper-based microfluidics. Paper-based micro-fluidics do not require actively driven pumps as they have the advantage of the capillary forces of the paper fibres. Paper-based sensors also require less fluid which in turn leads to less stabilization time. This severely decreases the duration of a measurement. Paper-based microfluidics also enable sample pre-treatment. Indeed, the pore size distribution filters out the unwanted large molecules.

Materials

Keeping the final application in mind, water and milk will be used to test the capillary action of the paper. Indeed, the final application will test xenobiotics in milk.

Different types of wicking papers were tested. Normal printer paper has a pore size which is too dense because milk was not absorbed. Whatman nr.1 filter paper possessed a good absorption for water and milk. Kapton tape was used to laminate the wicking paper. A heat sealer has also been tested to laminate the wicking paper, but the thermal resistance of laminating plastic is much higher than Kapton tape, hence a bigger barrier. A printed circuit board(PCB) with a meander trace was used to perform the sensing part.

Methods

The design was cut out with a laser cutter (Trotec Speedy 100R). Care has to be taken when cutting the paper because when the focal point of the laser is only slightly higher than the surface, the paper will be burned on the cutting lines.

The design has a paper-based pump with a capacity of 110µL.[2] This way the same amount of fluid has passed the sensor area as the amount of fluid in a flow cell chamber[1].

Results and Discussion

Measurements were performed to detect the amount of fat in water, semi-skimmed and full milk. The results show an increase in thermal resistance respectively.

The wicking paper requires a pump past the sensing area. Indeed, otherwise non-specific molecules would accumulate on the sensing area. This would always lead to a false positive result.

Conclusion

A wick design has been optimized for the development of a rapid, small test giving lab assistants an indication about the potential pollution of the test fluid.

References

[1] Peeters M. et al.: AnalBioanalChem 2016, 20, 6453-6460
[2] Brian M. Cummins et al.: Technology 05, 2017, 21, 1-10

Acknowledgements

I gladly acknowledge the Special Research Funds BOF of Hasselt University. Also many thanks to De Weyer T. for showing me the optimal settings for laser cutting the wicking paper.

IMO-IMOMEC
UHASSELT imec