Microfluidic sample concentrator

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SUMMARY

We present a rapid, point-of-care microfluidic chip that concentrates water-based samples several orders of magnitude. This reduces the demands of the analysis system and enables the detection of analytes whose concentration would otherwise be lower than the detection limit.

KEYWORDS: Microfluidic, Concentration, Point-of-care.

INTRODUCTION

Much effort is done to improve the sensitivity of chemical analysis systems in order to enhance the signal [1]. However, even the most sophisticated miniaturized systems are limited by a concentration below which no signal is obtained. A sample can be concentrated orders or magnitude prior to performing the analysis, leading to higher accuracy and enabling the detection of a target even if its initial concentration is lower than the detection limit of the system [2].

We present a microfluidic chip that concentrates water-based samples by reducing the overall volume several orders of magnitude and positioning the analytes into a small chamber, e.g. 1 ml sample is reduced and positioned into a 1 µl chamber.

The chip consists of microfluidics channels where one of the walls is substituted by a porous hydrophobic membrane. The bulk sample remains in the channels while water vapour can go through the membrane, which turns into an increase in the concentration.

To enhance the speed of the evaporation process, the sample is spread over parallel microfluidic channels increasing the interface air-sample, the temperature is raised and a stream of air is forced to prevent moisture accumulation.

Finally, thanks to the design, the enriched sample is trapped into a chamber.

EXPERIMENTAL

The microchannels (100 µm deep) were fabricated with polydimethilsyloxane (PDMS) and a Teflon (PTFE) porous membrane.

The master for the channels was fabricated with SU-8 on a silicon wafer with UV-lithography.

The membrane was glued to the channels with silicone glue: the glue was laminated, the PDMS channels stamped on it and transferred to the membrane.

To concentrate, the chips were fed through a tube from an open reservoir and a stream of hot air was forced towards the membrane. Once the reservoir was empty, an extra volume of DI water was fed during 5 minutes in order to rinse the channels, confining all analytes into the chamber.

RESULTS AND DISCUSSION

The rate of evaporation was 50 µl/min at 45 ºC for a chip with a membrane area of 410 mm^2.

As evaporation took place, the concentration increased exponentially along the channel, with a maximum in the final chamber. To clean the channels and gather all analytes, DI water had to be fed.

Increasing the temperature to 60 ºC led to 75 µl/min. However, the nature of the sample sets a limit for temperature, e.g. proteins will coagulate if it is too high.

This technology is restricted to samples where water is the solvent, although it admits other solvents to a certain extent as long as the membrane is not penetrated.

While the chip works with an excellent efficiency for molecular solutions, larger particles seem to be pushed towards the membrane, preventing their concentration.

CONCLUSION

In this work, we have successfully developed simple, point-of-care sample concentrator that can be combined with different analysis systems to decrease the limit of detection orders of magnitude.

The chip costs below 20 cent euro and it is easy to operate.

Furthermore, a sensor could be integrated at the concentration chamber for a direct read out or a valve would allow the concentrated sample to be extracted.

ACKNOWLEDGEMENTS

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REFERENCES

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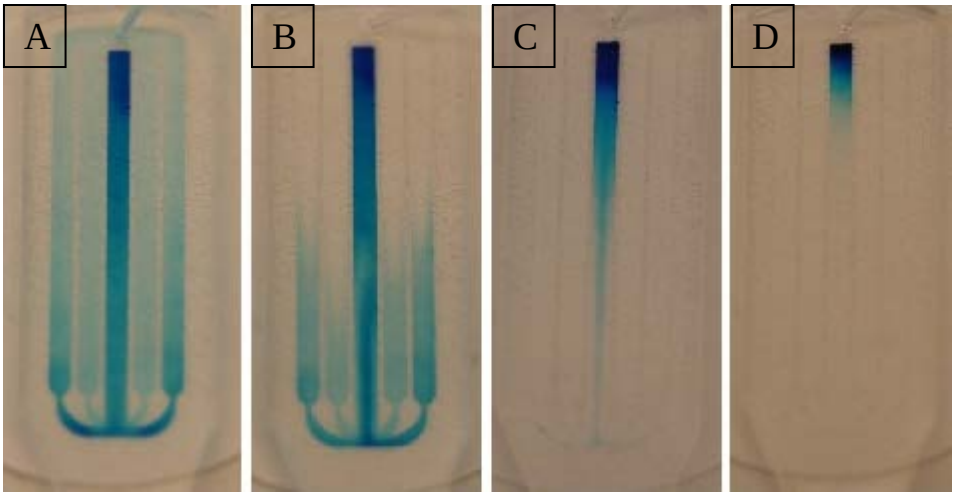

Figure 1. Process of concentration. (A) Analyte concentration while the sample is fed. (B), (C) and (D) Analyte concentration and rinse step while clean water is fed.

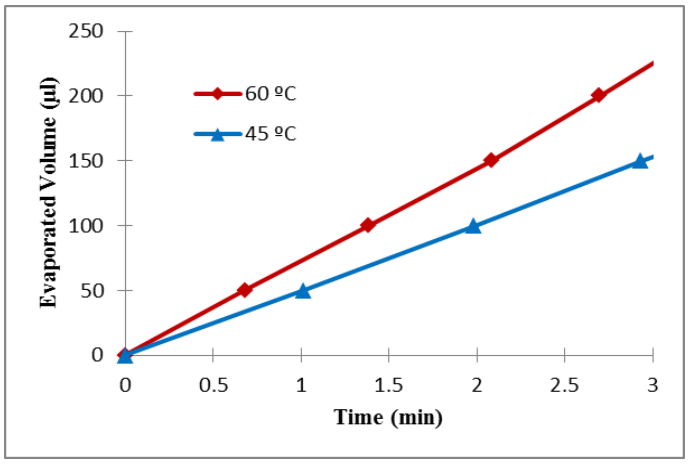

Figure 2. Evaporation rate of a microfluidic chip with a surface of 410 mm^2.

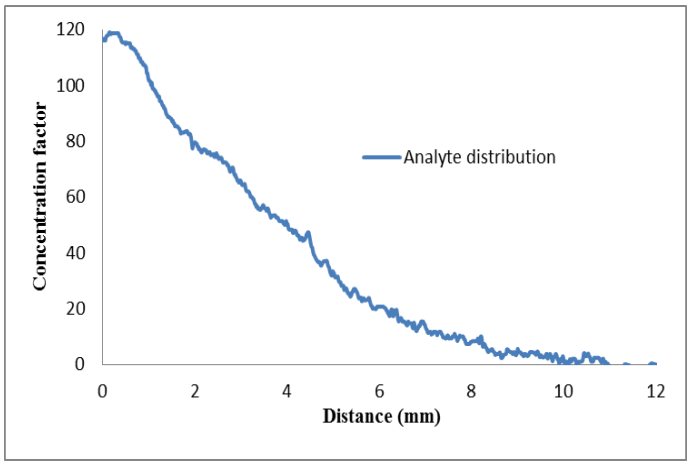

Figure 3. Distribution of the analyte on the concentration chamber. The origin in X axis refers to the concentrating chamber.