All-polymer chip system for magnetic bead-based solid phase extraction

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INTRODUCTION

Paramagnetic particles or magnetic beads (MBs) are commonly used as the solid phase matrix for magnetic bead-based solid phase extraction (SPE). A variant of MB-based SPE exists, where an immiscible phase is used as a filtering step in order to circumvent the washing steps otherwise needed to perform a successful extraction [1-3]. The principle of the technology is presented in the sketch below.

In this study we present an injection moulded cyclical olefin copolymer (COC) planar chip system that has been bonded together using ultrasonic welding – both techniques that can be readily applied in mass production and it is what sets this system apart from ones previously published. The chip is fitted with geometric capillary micro valves for MB-based SPE using the immiscible phase filtration approach. See figure 1 for a photograph of the chip.

We

- Characterise the chip in regard to carry-over volume and further investigate the influence of surfactants on the efficacy of the system.
- Present initial performance results, by detecting respiratory syncytial virus (RSV) in a mucus sample.

PRINCIPLE OF OPERATION

Figure 1 shows initial results on RNA extraction, comparing the on-chip assay with an off-chip reference.

We find that;

- Reducing the MB amount to one compatible with the chip had no effect on Cq.
- The on-chip extraction performed on par with the off-chip extraction.

RESULTS

The chip was performance tested in regard to volume carry-over and ability to detect RSV. The chip was tested with various surfactants and the carry-over volume was quantified. Figure 2 shows the determination of volume carry-over vs. amount of MyOne SILANE MB magnetic beads for pure water and a typical XNA lysis/binding buffer.

We find that the volume carry-over;

- is proportional to the amount of beads through a linear correlation.
- is the same for Milli-Q water and the typical lysis/binding buffer.

Figure 3 shows initial results on RNA extraction, comparing the on-chip assay with an off-chip reference.

We find that:

- The assembled chip was disc shaped and features a Luer-Slip layout with an inlet channel and outlet channel, all interconnected by geometric capillary micro valves, see Figure 1. The chip was mounted in a setup with a movable magnet situated under the inlet Luer fitting.

METHODS

Off-chip extraction protocol

A reservoir containing solution was added to the inlet channel and a blank solution to the outlet chamber. FC40 oil was then added to the middle channel to complete the loading. Various volumes of MBs was then added to the inlet and transferred from one to another by moving the magnet. The MBs were unaugmented, removed and the outlet volume was transferred to a microcentrifuge tube. The carry-over volume was estimated by analyzing the dye content of the wells. The concentration could then be calculated into a volume by correlating with the dye concentration of the inlet and the respective volumes of the inlet and outlet.

Chip fabrication

The chip consists of two cyclical olefin copolymer parts of the grade ENEX 8510 that were injection moulded main part and a 0.152 mm extruded PMP cluster.

CONCLUSION/OUTLOOK

We have demonstrated a mass-producible all-polymer chip created for MB-based solid phase extraction via immiscible phase filtration. It shows a low volume carry-over and is capable of extracting viral RNA from a mucus sample. Future studies include a more thorough investigation of RNA extraction and a possible switch in polymer type for chip manufacturing. The COC used here is not optimal for a system where you wish to employ surfactants. A polymer with a higher surface energy would be more beneficial.