Power-free sequential injection for microchip immunoassay toward point-of-care testing

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Electronic Supplementary Information

Preservation of the ready-to-use microchip in a portable air-tight package

This document reports the results of preliminary experiments on preservation of the pumping activity of the microchip in a portable air-tight package.

Methods

The portable air-tight package was fabricated in-house by modifying a 100-mL glass bottle (SCHOTT; Mainz, Germany). In the center of the polypropylene screw cap, a 2-mm-diameter hole was bored. The hole was covered with a 0.04-mm-thick transparent polyethylene film, which functioned as a flap of a check valve (Figure S1). An edge of the flap was fixed to the cap with adhesive tape. The interface between the flap and the cap was wetted with a few drops of poly(ethylene glycol) (PEG, Mw = 200, Wako Pure Chemical Industries; Osaka, Japan).

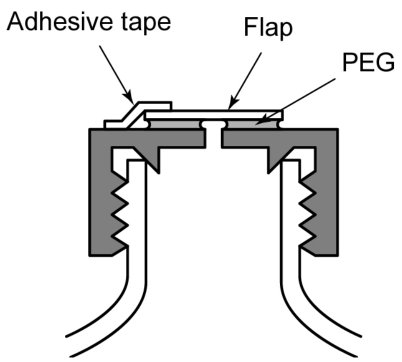

Figure S1. Cross-sectional view of the modified screw cap.

Fabrication of the microchip is detailed in the main text (*Microchip Design and Fabrication*). The microchip was degassed at 10 kPa for 1 h in a vacuum desiccator (model VS, As One; Osaka, Japan). Immediately after the degassing, a piece of adhesive tape was attached onto the top of the microchip. The microchip was put into the bottle, and the bottle was firmly closed with the modified screw cap. The bottle was placed in the vacuum desiccator. During the reduction of air pressure in the desiccator, we were able to observe air escaping out of the hole by pushing aside the PEG. When the pressure in the desiccator became stable at 10 kPa, the air passage was automatically closed by the surface tension of PEG. This indicated the isolation of 10-kPa air in the bottle. After ventilation of the desiccator, the top of the cap was coated with epoxy adhesive (Araldite, Huntsman; Salt Lake City, UT, USA) to ensure the sealing (Figure S2). Three or seven days later, we opened the bottle. After a 2-min interval, power-free sequential injection (PFSI) of deionized (DI) water was started as described in the main text (*Flow Characterization*).

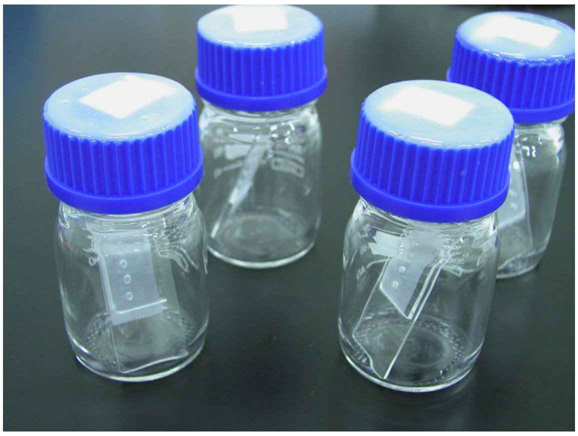

Figure S2. The finished air-tight packaging bottles.

Results and Discussion

PFSI was successfully conducted. Figure S3 shows the flow times of the aliquots in the cases of 3- and 7-days preservation. There is no significant difference between the two cases. The preservation of the active microchip was fairly stable.

Interestingly, the flow became faster (the microchip became more active) than the immediate use (Figure 4 in the main text) by 30–50%, although the qualitative tendency was unchanged. We suppose that this additional activation was caused by the degassing in the bottle. In the experiments in the main text, we attached the tape immediately (~1 min) after the degassing. During this short period, a significant amount of air may dissolve into PDMS. Preservation in the vacuum bottle for a long period can evacuate this air.

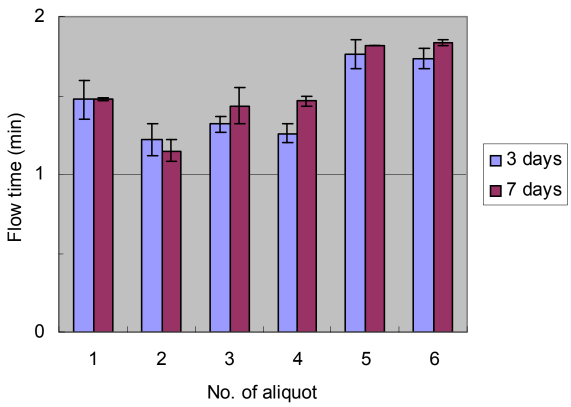

Figure S3. Flow times of 0.5-μL aliquots of DI water injected into the microchips which had been preserved for 3 or 7 days in the bottles. The error bars indicate data ranges (n = 2).

The above speculation is supported by the one-dimensional diffusion model.[1] The total mass index m can be calculated with:

$$m = \frac{\int_0^l (C - C_0)\, dx}{\int_0^l (C_1 - C_0)\, dx} = 1 - 2\sum_{n=0}^{\infty} \frac{1}{\lambda_n^{\,2}} \exp\left(-\lambda_n^{\,2} \frac{D}{l^2} t \right), \quad \lambda_n = \frac{2n+1}{2}\pi,$$

where $D = 3.4 \times 10^{-5}$ cm^2 s^{-1} is the diffusion coefficient of air in PDMS, $l = 2$ mm is the thickness of the PDMS, and t denotes time. Initial increase of m is very fast; we obtain $m = 0.25$ at $t = 1$ min (taking the first 20 terms of the series). This means that exposure of the microchip to the atmosphere without adhesive tape causes 25% deactivation during the first 1 min. If this microchip is degassed again in the bottle, the activity would appear to increase by 33%. This calculation roughly explains the above experimental results. Currently, the flow in the PFSI method is affected by many factors. Improvement of the device design and the operation methods should be explored for construction of a more robust system.

Summary

We confirmed that the ready-to-use microchip can be stably preserved in a portable air-tight package for at least one week. Therefore, degassing of the microchip and the attachment of the adhesive tape are not necessary at the location of use.

Acknowledgement

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Reference

1. K. Hosokawa, K. Sato, N. Ichikawa, and M. Maeda, *Lab Chip* 2004, **4**, 181–185.