PHASE SEPARATION METHOD FOR AQUEOUS SAMPLES CONTAINING UNKNOWN RATIO OF ORGANIC PHASES

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ABSTRACT

We have proposed a two-phase operation method, which can separate an aqueous phases from a liquid sample containing arbitrary ratio of organic phase. Following the phase separation, chemical analysis of only the aqueous phase has been demonstrated while both aqueous and organic phases can be analyzed independently in principle.

KEYWORDS: Two-phase, Phase separation, Surface modification

INTRODUCTION

Microfluidic devices are suitable for the integration of environmental water/soil/air analysis because of their favorable characteristics, such as small sample requirement, and flow automation. In the soil analysis, insoluble organic compounds are often targeted [1]. When we assume the sample introduction to microfluidic systems, several situations are anticipated. When the organic phase is dispersed in the aqueous phase as sufficiently small drops, the sample solution flows with a homogeneous emulsion manner. On the other hand, when the organic phase exists as millimeter-sized liquid phase or larger, the sample flow might be an intermitted flow of 100% aqueous and 100% organic phases in the microfluidic device.

In this paper, we have proposed a two-phase operation method, which can separate an aqueous phases from a liquid sample containing arbitrary ratio of organic phase. Following the phase separation, chemical analysis of only the aqueous phase has been demonstrated while both aqueous and organic phases can be analyzed independently in principle.
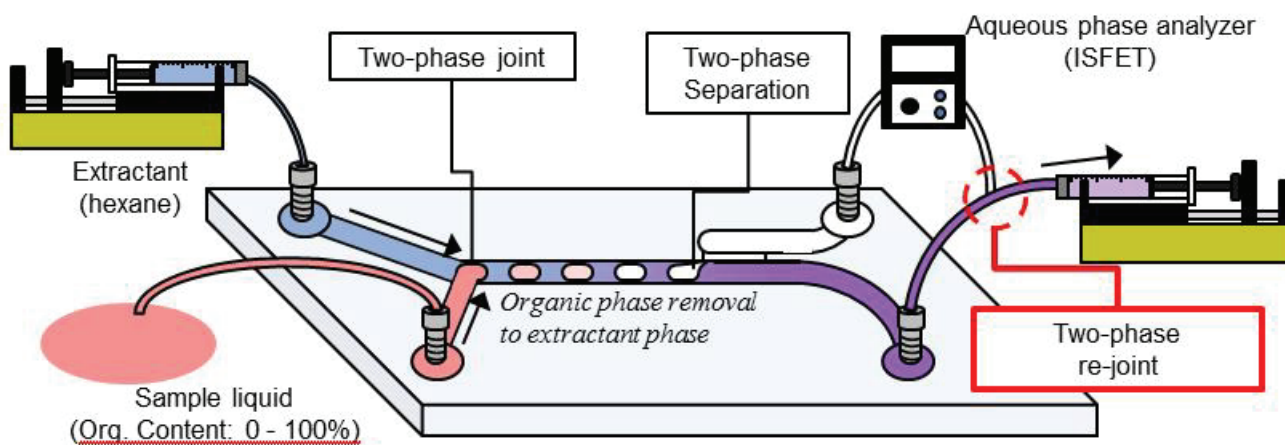

Figure 1: Conception of the aqueous phase analysis in organic-contained liquid sample. When organic-contained sample liquid is introduced to microfluidic devices, the sample flow at each moment contains no organic phase, or only organic phase, or mixed two-phases, depending on sampling situation. In the present method, analysis of the sample with arbitrary organic content is realized by the combination of 1) introduction of extractant, and 2) two-phase re-joint after the two-phase separation and analysis.

THEORY

Figure 1 shows the conception of the aqueous phase analysis in organic-contained liquid sample. As mentioned above, the sample flow at each moment is anticipated to contain no organic phase, or only organic phase, or mixed two-phases, depending on sampling situation. In the present method, analysis of the sample with arbitrary organic content is realized by the combination of 1) introduction of extractant, and 2) two-phase re-joint after the two-phase separation and analysis.

The extractant is pumped with a constant flow rate and the drain-port liquid is sucked with larger constant flow rate. Then, the sample is introduced with the balanced flow rate. Even when the sample flow rate is constant, the aqueous flow rate decreases and the organic phase viscosity deviates, with the organic content increase. Here, we designed the separation structure to purge the aqueous phase through the shallow hydrophilic channel [2,3]. In order to purge the aqueous phase without the organic phase intrusion, the pressure losses of the aqueous and organic flows after the separation, P_{Aq} and P_{Org} should be

$$0 < P_{Org} - P_{Aq} < P_{Laplace,}$$

where $P_{Laplace}$ is Laplace pressure at the shallow channel. The 2nd junction is an equivalent-pressure point for the separated phases and simplifies the pressure balance design.

EXPERIMENTAL

Figure 2 illustrates the chip design. The separated aqueous phase is fed into PDMS chip equipped with an ISFET pH sensor.
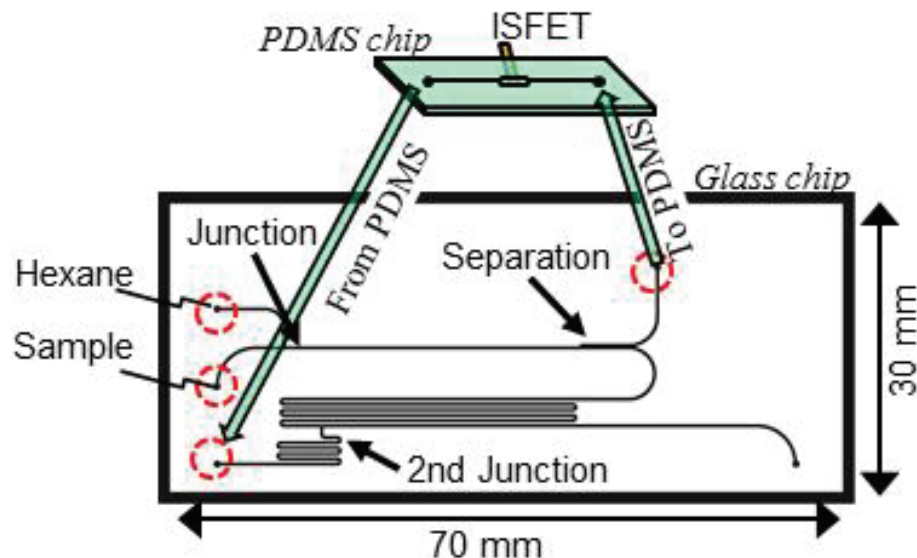

Figure 2: Chip design and connection scheme.

RESULTS AND DISCUSSION

Figure 3 shows micrographs at the 1st junction (left) and the separation part (right) for (a) 100% water and (b) 100% machine oil (~5 mPa·s) samples, respectively. The aqueous phase is successfully purged to the side channel and no organic intrusion is observed even when the aqueous flow is stopped.
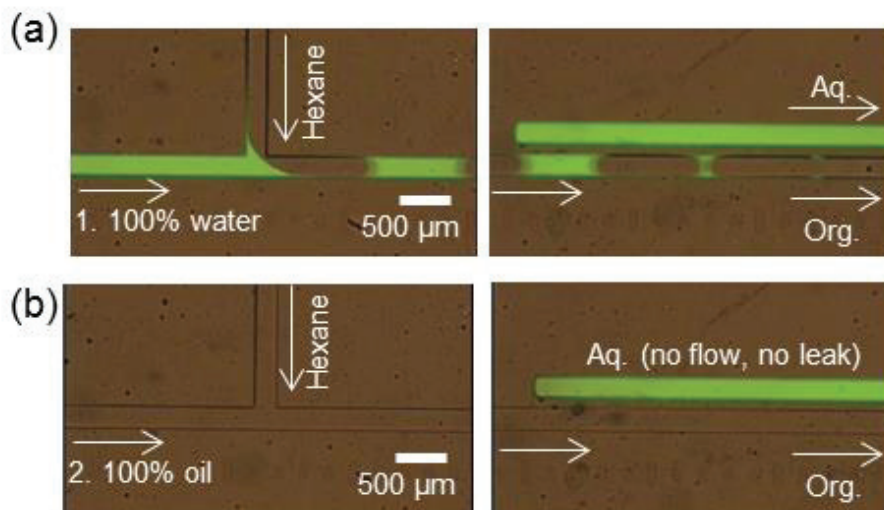

Figure 3: Micrographs of the junction point (left) and separation point (right). Sample: (a) 100% water, (b) 100% oil.

CONCLUSION

In the presentation, we will discuss the applicable range for the organic-phase viscosity, and the range's dependence on the fluidic parameters extractant flow ratio, and channel dimensions.

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