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Regioselective Immobilization of a PVC Membrane Composed of an Ionic Liquid-based Dye on Convex-shaped PDMS Surface for Multiplexed Microanalytical Devices

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A novel method for the intact immobilization of a very-thin and soft PVC membrane on a convex-shaped poly(dimethylsiloxane) (PDMS) surface is described. The present method using poly(vinyl alcohol) (PVA) film as a sacrificial layer allowed successful immobilization of an intact PVC membrane using an ionic liquid-based dye on only the convex-shaped PDMS surface without any deformation or increase of the inhomogeneity. In addition, two different kinds of PVC membranes were successfully immobilized simultaneously toward multiplexed detection.

Keywords Ionic liquid, optical sensor, plasticized poly(vinyl chloride) membrane, microanalytical devices

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spin-coated on a PVA film can be easily handled or cut, while controlling the immobilization position is also possible. In order to investigate whether a PVC membrane could be transferred to a PDMS substrate from a PVA film homogeneously, the color distribution in the immobilized PVC membrane was evaluated. Figure 2 shows a digital image of a PVC membrane on the PDMS substrate obtained with a flat-bed scanner and a normal distribution of the blue intensity of an immobilized PVC membrane on the PDMS substrate (Count, 316; Ave, 193.93; RSD, 1.60%).

In this case, the PDMS substrate side was faced downward to the scanner so that the PVC membrane side would remain intact. The relative standard deviation of the blue intensity obtained had a very small value (1.60%), which was slightly larger than that of a PVC membrane on a PVA substrate under the same spin-coating condition (1.29%) (Fig. S5, Supporting Information). The obtained error was supposed to include errors by manual handling when the PVC membrane was transferred to the PDMS substrate or those by spin-coating. Although step-by-step procedures were required when the PVC membrane was transferred, the prepared PVC membrane was accurately immobilized without any deformation or increase of the inhomogeneity, because the relative standard deviation was not increased substantially. In addition, PVA dissolution-based immobilization of liquid membranes in this work has a strong advantage from the view point of membrane thickness control, which can be easily determined by the spin-coating condition, and can be transferred directly. Previously, the immobilization of a very thin and soft membrane having a constant thickness at a specific position has been difficult. Thus, the present immobilization method can be considered to be an effective process to solve the above-mentioned difficulties. On the other hand, we also tried to immobilize the same PVC membrane by stamping a convex-shaped PDMS substrate onto a PVC membrane spin-coated on the glass substrate, like in the microcontact printing method. In this method, the immobilization of a PVC membrane was partially possible. However, due to the deformation of soft PDMS and PVC membranes during the stamping procedure, the reproducibility of the immobilization in terms of the membrane thickness or homogeneous color distribution was very bad. In addition, because the glass substrate is hard to be cut freely, regioselective immobilization is also difficult.

With the present immobilization method, the immobilization of different kinds of membranes on the same substrate can be easily carried out. In order to immobilize two different kinds of PVC membranes, PVC membranes prepared by two different kinds of "dyed plasticizer", [P66614][BTB] and [P66614][PR] (for synthesis and membrane composition, see text and Table S1 in Supporting Information), were prepared independently, and attached at a different position on the same (PET-masked) convex-shaped PDMS surface. Another procedure was the same as described above. Figure 3 shows a PDMS substrate immobilizing PVC membrane using [P66614][BTB] (right side) and [P66614][PR] (left side) respectively. This PDMS substrate was fabricated only by the simultaneous lamination of two different PVC membranes. Thus, various polymer liquid membranes can be freely immobilized on any convex-shaped parts of interest, and it is suggested that multiplexed analysis
using various polymer liquid membranes on the same
microfluidic devices can be possible.

In conclusion, we successfully developed a method that can
immobilize a soft and thin liquid membrane onto a convex-
shaped PDMS surface. Based on this method, a polymer liquid
membrane can be transferred without any deformation or
increase in the inhomogeneity of membranes. In addition,
different kinds of polymer liquid membranes can be easily
immobilized on the same substrate simultaneously. Thus, by
combining with a concave-shaped PDMS plate, immobilizing
various analytical reagents to fabricate a novel CPC sensor
immobilized on the same substrate simultaneously. Thus, by
different kinds of polymer liquid membranes can be easily
microfluidic devices can be possible.

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Supporting Information

This material is available free of charge on the Web at http://
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