Preparation and Surface Modification of a Microfluidic Chip with Hydrophilic Polymers

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Abstract

Various surface modification methods of a microfluidic chip with plasma treatment and hydrophilic polymers were presented. A normal microfluidic chip prepared using polydimethylsiloxane (PDMS) or plastic materials including polycarbonate have hydrophobic surface of a microchannel of a microfluidic chip. In this study, surface of a microchip was modified by treating plasma for 3 min. Then the hydrophilic surface of the microchip was obtained. To prepare more durable hydrophilic surface of a microchip, various hydrophilic polymers including polyvinyl alcohol (PVA), polyvinylpyrrolidone (PVP), polyethylene oxide (PEO), and poly(ethylene glycol) methyl ether acrylate (PEGMEA) were coated on the surface of the microchip. Then hydrophilic surface of the microchip was characterized by the contact angle measurement. Therefore the PVP or PEO coated microchip showed the most hydrophilic surface.

Keywords: Microfluidic chip, Surface modification, Hydrophilic polymer

Introduction

A microfluidic chip is applicable to a disease diagnosis including diagnostic chips or strips, a miniaturized device, an analytical mini-devices etc [1-4]. There are various kind of microfluidic chips for many applications [5-10]. The polydimethylsiloxane (PDMS) microfluidic chip is famous as a microfluidic chip [11]. PDMS material have many advantages to fabricate a microfluidic chip that are easy fabrication, hydrophobic surface, optical transparency, non-biotoxiciy etc [11]. And there are other types of microfluidic chips such as a glass microfluidic chip [11].

Although PDMS and plastic microfluidic chips have many advantages as a microdevice, the hydrophobic surface of the PDMS and plastic chips is sometimes problematic. Surface modification of a microchip is needed to solve a problematic surface property of a microchip [12-13]. A hydrophobic biomaterial or chemical species in a sample solution can be adsorbed on the hydrophobic surface of the microchip. Thus, surface modification of a microchip is important to prepare hydrophilic surface of the microchip. In this study, hydrophilic surface modification of a microchip was performed to prepare durable hydrophilic surface of a microfluidic chip.

Materials and Methods

Polydimethylsiloxane (PDMS, SYLGARD 184) was purchased from Dow Corning. And mixing ration of PDMS is 10:1 of base elastomer and curing agent to prepare a PDMS chip. Polyvinyl alcohol (PVA), polyvinylpyrrolidone (PVP), polyethylene oxide (PEO), and poly(ethylene glycol) methyl ether acrylate (PEGMEA) were obtained from Sigmaaldrich. 1 wt.% solutions of the above polymers were respectively used as a hydrophilic polymer solution to coat surface of a microfluidic chip.

Surface modification procedures of a microchannel of a polycarbonate (PC) chip with hydrophilic polymers were shown in Fig. 1. An untreated microfluidic chip have hydrophobic surface of a microchannel (Fig. 1a). And the surface of the microchannel can be changed to hydrophilic by applying plasma treatment (Fig. 1b). However the prepared hydrophilic surface of the microchannel may change again to hydrophobic because of polymer chain's reorientation. Thus, hydrophilic polymers needed to coat on the hydrophilic surface of the microchannel to preserve the hydrophilic surface (Fig. 1c and Fig. 1d).

A plasma treatment device from Harrick Plasma was used to treat plasma on a microchip surface. And a contact angle measurement device from LMS Technologies was used to measure contact angle of a water drop on the treated PC surfaces.

Results and Discussion

A microfluidic chip was designed and fabricated as shown in Fig. 2. To prepare a microfluidic chip, a laser beam using a femto-second laser was irradiated on the surface of a PC chip. Then the microfluidic chip was prepared and characterized (Fig. 2a). The microscopic images of the prepared microchannel and the micro-reservoir of the microfluidic chip shows well prepared microfluidic chip device (Fig. 2b and Fig. 2c).

PDMS have hydrophobic surface. However the hydrophobic surface can be changed to hydrophilic surface by applying plasma treatment as shown in Fig. 3. A PDMS chip was treated plasma using a plasma device for 3 min (Fig. 3a) and measured contact angle of a water drop on the surface of the PDMS chip using a contact angle device (Fig. 3b). As shown in Fig. 3c, untreated PDMS surface showed hydrophobic surface. However the treated PDMS surface showed hydrophilic surface as shown in Fig. 3d.

Then various hydrophilic polymers including PVA, PEO, PVP, PEGMEA were coated on the surface of PC chips as shown in Fig. 4. The hydrophilic polymer coated PC chips had hydrophilic surface as shown in Fig. 4b-4e. Then the prepared PC chips were investigated by contact angle measurement with a water drop as shown in Fig. 5. The untreated PC chip had 84.5° as a contact angle (Fig. 5a). The PVA coated PC chip had 63.0° (Fig. 5b). The PEO coated PC chip had 20.5° (Fig. 5c). The PVP coated PC chip had 20.0° (Fig. 5d). And the PEGMEA coated PC chip had 60.0° (Fig. 5e). As shown the images of contact angle and values in Fig. 5, the PVP treated PC surface showed the most hydrophilic

surface of the PC chip. Also the PEO treated PC chip showed very hydrophilic surface. Therefore PVP or PEO is recommended hydrophilic polymer to coat on a microfluidic chip.

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