Imbibition of water into heat treated polydimethylsiloxane substrates

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Porous media with controlled porosity and permeability are of a great importance in many industrial applications. Wetting of porous substrates plays a significant role in oil recovery, textile technology, reprography and printing, dissolution of powders and many other technical applications [1].
Polydimethylsiloxane (PDMS) is one of the most widely used materials for bioengineering and microfluidic applications. It gained its popularity due to relative easiness of its elasticity modification. A possible way of changing the mechanical properties of the polymer is by changing the cross linking density [2].
Heat treatment has been proposed to modify the surface properties of PDMS [3]. The previous study was focussed on analysing the influence of heat treatment time on the contact angle formed by a water droplet on a treated substrate. The effect of heat treatment on the bulk properties of PDMS precursor has never been studied. The thickness and the elastic modulus of the precursor have not been varied.
In the present study, heat treatment has been used as a method for modification of chemical properties and microstructure of PDMS precursor layers prepared with different crosslinking densities and thicknesses. Thin films of PDMS were prepared by spin coating of 2 ml of the polymer mixed with a crosslinking agent on a glass substrate at 1000 and 3000 rpm for 120 s. After curing the substrates all the films went through annealing at 650^0C for 10 s, 30 s, 70 s and 300 s. In has been found that the surface roughness of the samples increased with increasing of the heat treatment (annealing) time. Simultaneously, the chemical composition of the surfaces was changed by the annealing.
The static contact angles formed by water on treated surfaces increased after the heat treatment during 30 s. After the heat treatment during 70 s complete wetting has been observed. All substrates subjected to a 300 s heat treatment have developed a substantial porosity and shown imbibition behaviour.
The imbibition dynamics has been investigated experimentally. To this purpose, a droplet of 3 µl was placed on a substrate, and imbibition of the liquid into the porous layer was captured using a high speed camera at 1500 frames per second. The results showed that the initial thickness and elasticity of the precursor substrate subjected to heat treatment exerted a strong influence on the area imbibed and on the imbibition rate. We suggest that the thickness and mechanical properties of the polymer precursor films strongly influence the porous structure of the annealed films which governs the imbibition kinetics.

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