Technical Note

Antraquinone chemistry

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Control of polymer surface properties after UV-light induced coating with AQ reagent, Immobilizer™

Many different technologies are available to modify the hydrophobicity of polymer surfaces. One of the key features of the anthraquinone (AQ) based technique is the ability to selectively coat parts of a polymer surface by UV-light induced binding of the photo-reactive Immobilizer™ or similar reagents. By masking the light source it is possible to specifically modify defined parts of the surface. After initial binding of the Immobilizer reagent, the surface hydrophobicity can be further adjusted by secondary reactions with different amines. This technology can for example be used to change the surface properties of different parts of complex microfluidics structures (e.g. to create more efficient bubble traps or evaporation barriers).

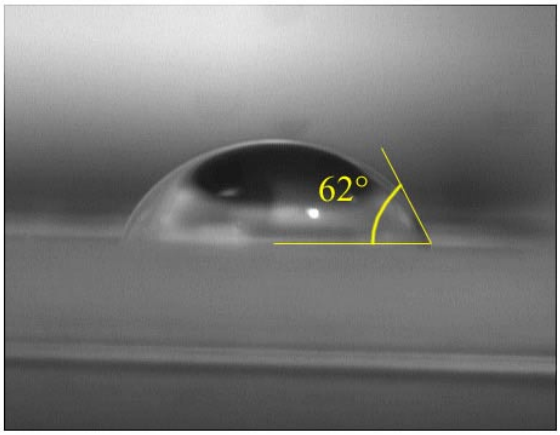

Figure 1: Contact angle measurement on a Immobilizer(tm) coated polymer surface.

Procedure

- Place polymer objects submerged in a Immobilizer™ solution (1600 µg/l)
- Illuminate desired parts with UV-light (UV Stratalinker 2400, from Stratagene, CA. at 254 nm. Illumination at 350 nm is also possible)
- Wash thoroughly with distilled water (dH2O)

Contact angles

The hydrophobicity of a surface can be quantified by depositing a small droplet on the surface and then measuring the angle between the advancing liquid front and the surface plane. This angle is referred to as the contact angle (see Figure 1 below). A low contact angle (<45°) indicates a hydrophilic surface with good wetting properties on which water will readily spread and stick. A high contact angle (>90°) indicates a hydrophobic surface where water forms droplets that do not stick to the surface but are easily displaced. Solvents and detergents in the fluid will further modify the contact angle of the surface. The values shown here are for distilled water, which is often used for reference purposes.

Droplet properties

The modified wetting properties of polymer surfaces after coating with Immobilizer™ reagent is illustrated below. In the experiments, 5 µl droplets of distilled water were placed on different surfaces (Figure 2). The hydrophobicity of the unmodified polymer results in a contact angle above 90º (A), and the contact area between the liquid and the polymer is consequently small. After coating with Immobilizer(tm) the surface becomes more hydrophilic (B) and the contact angle is reduced to 70º. An even more hydrophilic surface can be obtained by binding ethanolamine (EA) to the Immobilizer™ coated surface (C), where the contact angle is reduced to 55º. Reaction with other primary amines can further reduce (or increase) the contact angle depending on the polarity of the reagents. A water droplet on a clean glass slide is included for comparison (D). The contact angle on the glass slide is < 30º and the formed droplet is more irregular.

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Correlation between contact angles and droplet sizes

In many applications where liquid droplets are deposited on a surface is it important to know, how the liquid spread out over the surface. The resulting droplet size is related to the hydrophobicity of the surface as measured by the contact angle. For hydrophobic surfaces with a large contact angle the droplet remain small but loosely attached to the surface. Hydrophilic surfaces with a small contact angle will produce large droplets that are more firmly attached to the surface. Figure 3 shows the relationship between contact angle and droplet size for different surfaces.

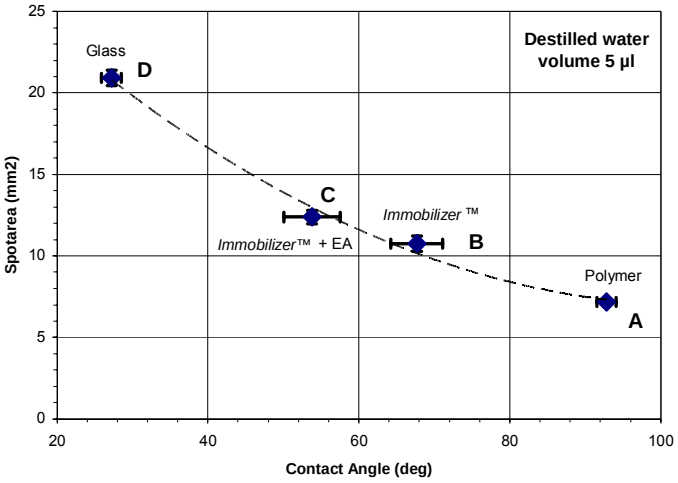
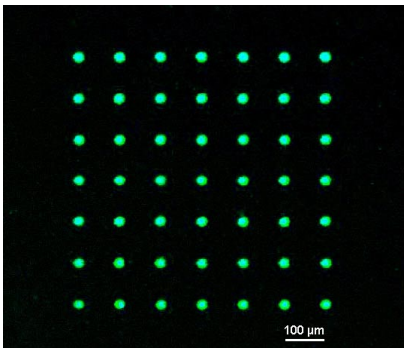


Figure 3: Correlation between contact angle and droplet size on different polymers.

For applications such as production of DNA microarrays a small droplet size is desired. However, a firm attachment to the underlaying surface is also needed so that the droplets remain in position on the surface and dry-out to produce a spot with a reproducible size and uniform intensity. From Figure 3, it is evident that Immobilizer™ coated polymer represents a reasonable compromise between the highly hydrophobic raw polymer and the very hydrophilic glass. Immobilizer™ decreases the hydrophobicity of the surface from 94° to 68°, thus ensuring a reproducible size and density of the generated spots. The overall spot size is only marginally larger (about 50% larger area) so a dense application of droplets is still possible as shown in Figure 4 Figure 4:



Microarray of oligonucleotides generated with a Microgrid II pinspotter (Biorobotics, UK) with a spot to spot distance of only 110 µm.

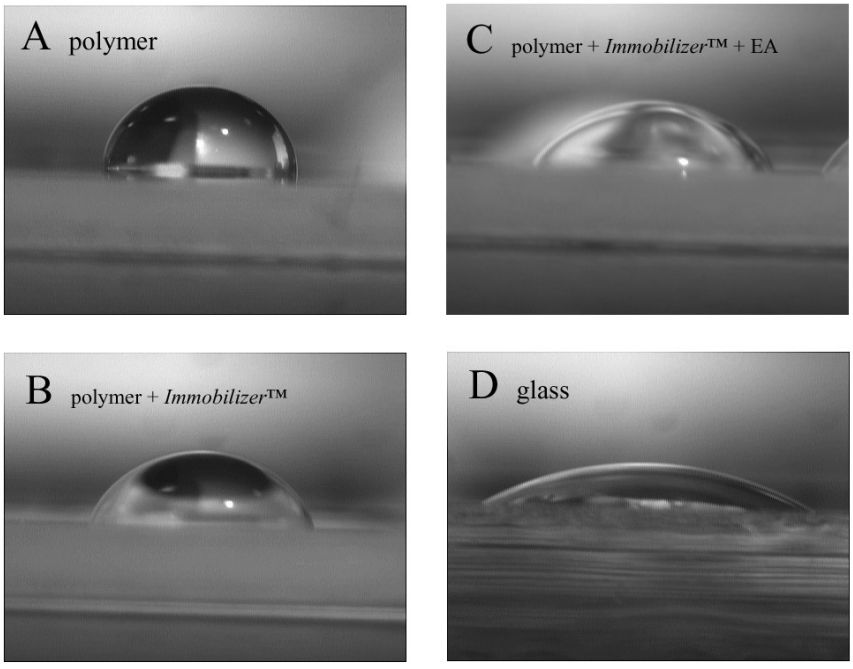


Figure 2: Distilled water droplets (5µl) on different surfaces

Trademarks and Patents

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