Static and dynamic wetting of porous Teflon® surfaces
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The subject of this work was to produce a self-cleaning surface using industry standard materials and using a less work-intensive and less expensive method than the usual lithographic techniques. A self-cleaning surface is extremely water-repellent and has a low particle adhesion. With these characteristics, a drop of water on such a surface rolls off the surface taking away all the dirt-particles, without the use of a surfactant. These characteristics result from the chemical composition of the surface and the surface texture. The quality of a self-cleaning surface is related to the contact angle of a drop of water on that surface, and to the contact angle hysteresis. In this work, Teflon® materials were used because of the low surface energy.

The first approach made use of Teflon® AF, which is an amorphous Teflon® co-polymer that can be dissolved in a range of perfluorinated solvents. Teflon® AF solutions were spin-coated in a vapour saturated environment. Evaporative cooling causes the vapour to condense onto the Teflon® AF solution, forming an array of drops. After all the solvent and vapour have evaporated, the obtained film surface features holes that are a signature of the intermediate condensate drops. Experiments were performed with a number of different vapours. The best results were
achieved using water vapour and a high spin-coating speed. Contact angles up to 136° were reached. This is an increase of 30° compared to a smooth Teflon® AF film, but not enough for a self-cleaning surface.

The second approach made use of Teflon® colloids. The Teflon® colloids were mixed with sacrificial colloids, and the colloidal mixture was applied to a substrate using spread-coating. The film was subsequently heated to 290 °C on a hotplate in order to remove the sacrificial colloids. This led to the formation of a film containing holes left by the sacrificial colloids. The size of the Teflon® colloids was 200 nm. The size of the sacrificial colloids was varied, as was the mixing ratio of the Teflon® colloids and the sacrificial colloids. The best results were achieved by using a mixture of Teflon® colloids with 8 µm-sized sacrificial colloids with a value of $\varphi$ between 0.5 and 0.7. The sacrificial colloids had formed an organised close packing during the film formation. The resulting film consisted of an organised pattern of holes separated by homogeneous areas made from Teflon® colloids. This surface texture has a mechanically more robust design than other self-cleaning surfaces, which make use of protrusions instead of depressions. Contact angles of more than 170° were reached, in combination with an negligible contact angle hysteresis.

The adhesion of the self-cleaning coating was dramatically improved by using a primer coating. The mechanical robustness of the self-cleaning surface was tested by applying a shear force. For very high pressures, the surface textured is compressed. The advancing contact angle remained above 140° for pressures up to 1 MPa.

The interface of a drop of water on an ultra-hydrophobic surface can be in two different states: a non-composite state in which the water follows the contour of the surface texture, and a composite state in which the drop is suspended over the depressions of the texture, and air is trapped in the depressions. A drop in the composite state usually has a very low contact angle hysteresis. Chapter 6 describes a method to visualise the drop - substrate interface using an inverted microscope. This study shows that there is a transition from the composite to the
non-composite state of the interface, depending on the drop size and therefore weight. In the case of a film with a 3 µm hole texture with defects, the bigger defects fill first, followed by the smaller ones as the drop volume increases.

The behaviour of drops of water upon impact on glass, smooth and self-cleaning Teflon® surfaces has been studied using a high-speed camera, as described in Chapter 7. Since viscous energy dissipation only plays a minor role for a drop impacting a self-cleaning surface, the drop stores its kinetic energy in the increase in surface area and thereby in an increase in the surface energy. This energy is recovered during drop retraction causing the rebound of the drop off the surface, rather than a deposition of the drop onto the surface. At higher impact rates, the drops show break-up and splashing behaviour. In Chapter 8, the effect of addition of poly(ethylene oxide) to water on the impact behaviour has been investigated. The elongational viscosity of PEO solutions can prevent drops from rebounding, breaking-up and splashing.

It would be interesting to combine the inverted microscope technique described in Chapter 6 with high-speed imaging. This way, it will be possible to determine whether the drop interface is in the composite or non-composite state upon impact. If a drop fills the surface depressions upon impact before establishing a composite state, it may take away the dirt-particles from the depressions upon rebound. Otherwise, dirt-particles can remain trapped in the surface depressions thereby reducing the overall self-cleaning effect of the surface.