attension

## APPLICATION NOTE 3

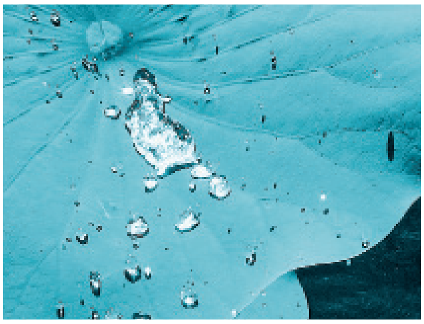
# Self-cleaning coatings

This application note illustrates how the Attension Theta Optical Tensiometer can be used to characterize surfaces such as self-cleaning coatings.

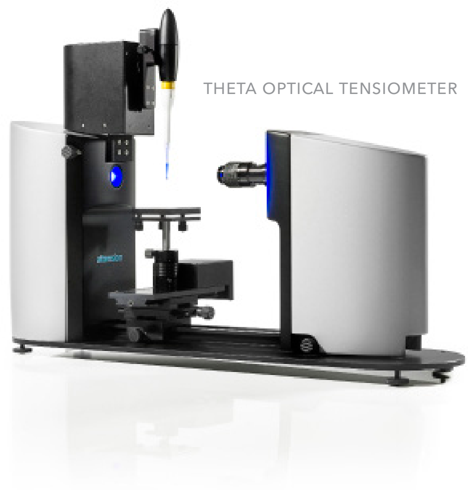
### Introduction

The growing interest towards self-cleaning coating technologies is due to their high potential in commercial products and their ability to reduce cleaning labour costs. These coatings have a wide variety of applications such as window glasses, cements, textiles and paints. For example, a fabric with self-cleaning properties would save cost in fabric cleaning and extend the lifetime of the textile[1]. Self-cleaning coatings can be divided into two categories: hydrophobic and hydrophilic coatings. Both of these types are able to clean themselves when water is present. Wettability, hydrophilicity and hydrophobicity can be characterized by using tensiometers.

A common case in nature is the “lotus effect”, where water droplets can be seen on the surface of a lotus leaf due to its hydrophobicity. Hydrophobic coatings have high water contact angles, above 90 degrees. The self-cleaning coatings are usually superhydrophobic as their water contact angle is greater than 150°. These surfaces are highly water repellent and water tends to form spherical droplets that roll away from the surface, carrying dirt away. It is well-known that contact angle is determined by both, the chemical and topographical properties of a surface. A superhydrophobic surface can be obtained only if the hydrophobic surface is roughened on the micro and nanometer scales. Therefore, the efficiency of a self-cleaning coating is dependent on the roughness and chemical composition of the surface and dirt particle adhesion to water droplet. These surface properties can be assessed using an optical tensiomter.



*THE LOTUS EFFECT is a special case of water repelling, or hydrophobic, behavior*



THETA OPTICAL TENSIOMETER

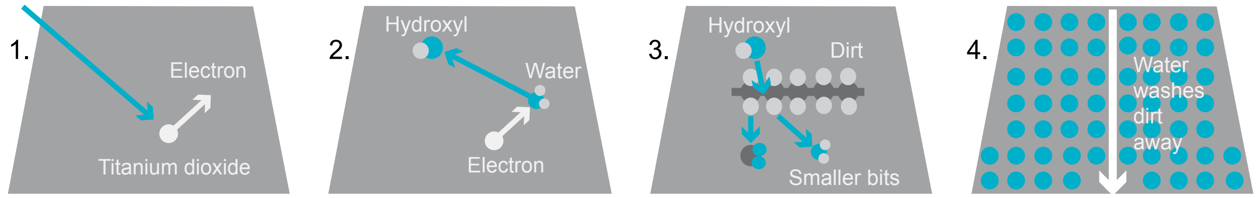



**Figure 1.** The principle of hydrophilic self-cleaning coating. UV illumination makes the electrons of the $TiO_2$-surface to break water molecules into hydroxyl radicals. (2) These radicals react with organic dirt, breaking them into smaller particles (3). The small particles are easily washed away by water (4)[2].

The hydrophilic self-cleaning coatings are based on photocatalysis: when exposed to light, they are able to break down impurities. Self-cleaning windows from this coating material are already commercially available. These kinds of windows act in two ways to clean its surface. The organic dirt absorbed on the window is broken down chemically by photocatalysis and water washes the dirt away by forming sheets due to the low contact angles. Titanium dioxide ($TiO_2$) is a well-known coating for hydrophilic self-cleaning surfaces[2] due to its favorable physical and chemical properties. It is non-toxic, chemically inert when there is no light present, inexpensive, easy to handle and already well-known in household chemicals (pigment in cosmetics and paint). The strong oxidation power and superhydrophilic properties of titanium dioxide make it a good material to be used as a self-cleaning coating especially for outdoor purposes. The self-cleaning effect of titanium dioxide is illustrated in Figure 1.

| SUBSTRATE MATERIAL | CONTACT ANGLE (°) OF SUBSTRATE COATED WITH PU BINDER | CONTACT ANGLE (°) AFTER 24H UV ILLUMINATION* |
|---|---|---|
| **High density polyethane** | 81,3 | Superhydrophilic |
| **Polyvinylchloride** | 62,0 | 58,7 |
| **Glass disk** | 58,7 | Superhydrophilic |

* after previous plasma treatment and palmitic acid deposition

**Table 1.** Water contact angles on different sample surfaces

## Case study: $TiO_2$ coating on polymers

Kasanen *et al.*[3] have studied the effect of $TiO_2$ photocatalytic coating on polymer and glass surfaces by using an optical tensiometer. The surfaces were first coated with a waterborne polyurethane (PU) dispersion, after which a suspension containing $TiO_2$ particles was injected on the surface of the PU. The samples were also plasma treated by using oxygen as a reactive gas, coated with palmitic acid and finally UV-radiated to conduct photocatalytic studies. Static water contact angles of the samples were measured with an optical tensiometer (Attension, former KSV Instruments). Results of the study are shown in Table 1.

The contact angle results show that plasma treatment turned out to be essential in order for the $TiO_2$ to have a photocatalytic effect. Without the plasma treatment, the samples did not behave superhydrophilically. The substrate type was also influencing the activity of $TiO_2$-coating.

## Conclusions

Self-cleaning coatings can be used in many different industrial areas to improve the usability and functionality of varied materials. The self-cleaning coatings are based on either hydrophilic or hydrophobic technologies. Therefore, their wettability properties are correlated to the efficiency of the coatings. The surface properties of self-cleaning coatings can be characterized with optical tensiometry by using contact angle measurements.

### References

*[1] T. Yuranova, R. Mosteo, J. Bandara, D. Laub, J. Kiwi, Self-cleaning Cotton Textiles Surfaces Modified by Photoactive SiO2/TiO2 Coating, Journal of Molecular Catalysis A: Chemical 244 (2006), 160-167.*

*[2] A. Nakajima, S. Koitzumi, T. Watanabe and K. Hashimoto, Photoinduced Amphiphilic Surface on Polycrystalline Anatase TiO2 Thin Films, Langmuir 16 (2000), 7048-7050.*

*[3] J. Kasanen, M. Suvanto, T.T. Pakkanen, Self-Cleaning, Titanium Dioxide Based, Multilayer Coating Fabricated on Polymer and Glass Surfaces, Journal of Applied Polymer Science 111 (2009), 2597-2606.*

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