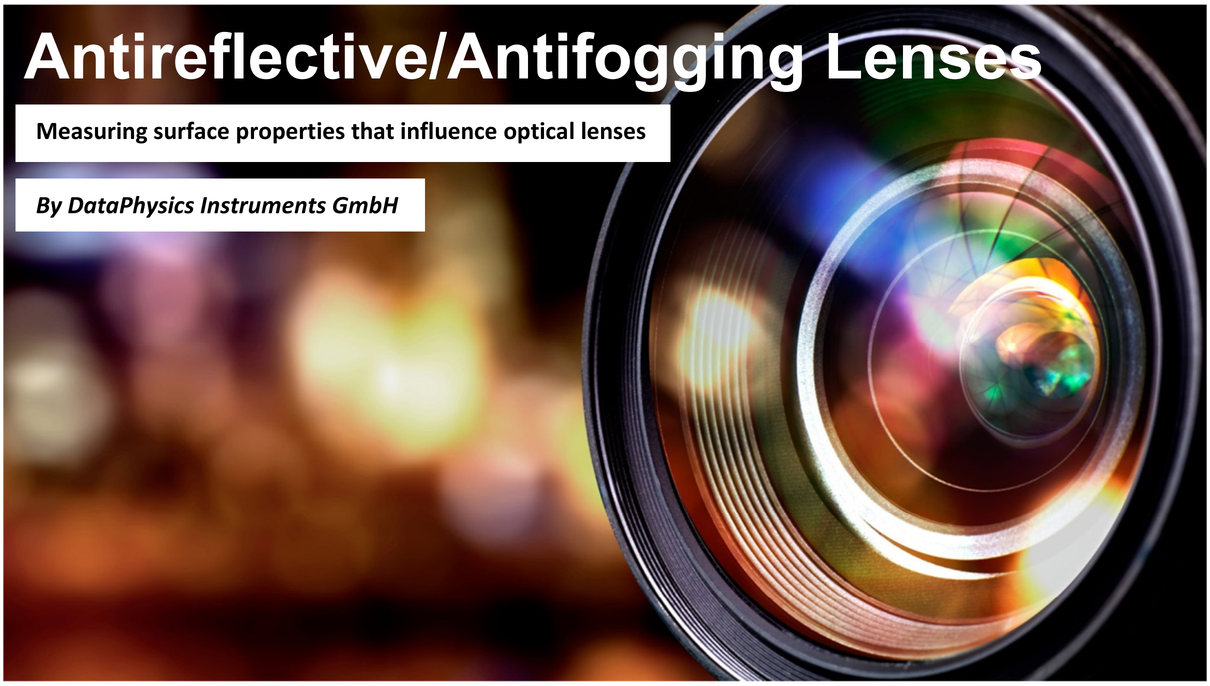
How Contact Angle Measurements Help to Improve Antireflective/Antifogging Coatings



Antireflective coatings are usually applied on optoelectronic devices and lenses in order to reduce light reflection phenomena and mitigate their detrimental effects. They are already widely used in various applications, such as increasing the transmittance of eyeglasses, eliminating the ghost images of flat-panel displays, enhancing the conversion efficiency of solar cells, *etc*. Until now, a variety of methods based on layer-by-layer assembly techniques have been reported to obtain different antireflective coatings. However, most of the methods require a tedious multi-step coating process, and the coatings are normally formed without a calcination step which results in poor mechanical properties. To solve this problem, Junjie et al. recently developed a new superhydrophilic antireflective coating with improved mechanical strength based on a facile and simple method.

In this study, the superhydrophilic broadband antireflective coatings were designed and fabricated based on a dip-coating method followed by calcination (Figure 1).

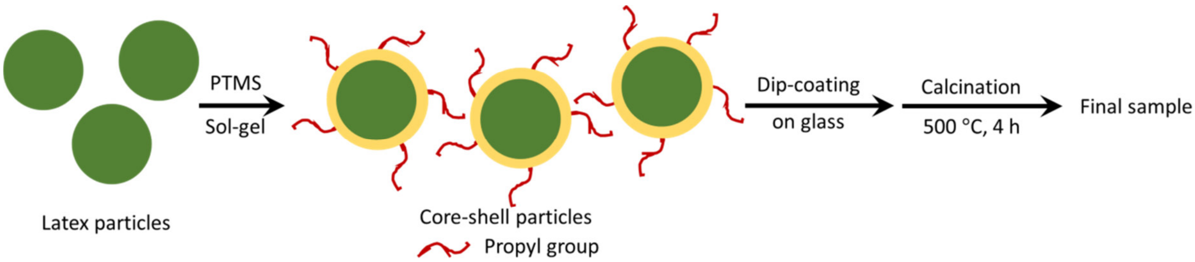


Figure 1: Preparation process of superhydrophilic antireflective coatings

Latex particles with propyltrimethoxy silane (PTMS) shells were used as they allow a water-based, mild production process. As shown in Table 1, three different samples (PTMS-6, PTMS-8, PTMS-10) with different amounts of PTMS were made. First, the core-shell structures of the composite particles were observed by transmission electron microscopy (TEM) and scanning electron microscopy (SEM). Then, dynamic light scattering (DLS) was done showing that the sizes of particles increases when the amount of propyltrimethoxy silane increased.

Table 1: The components, preparation and sizes of different samples

Samples	Latex [g]	H_2O [g]	PTMS [g]	Particle size [nm]	PDI
PTMS-6	10	60	6	72.18	0.067
PTMS-8	10	60	8	90.02	0.056
PTMS-10	10	60	10	114.15	0.049

UV–Vis transmission spectra measurements furnished that the transmittance of the bare glass was 88.7% while the average transmittance of the coatings could reach 98.0% underlining the excellent broadband antireflective properties of these coatings.

Furthermore, contact angle measurements were done in order to clarify the superhydrophilicity and desired antifogging properties of these coatings.

The water contact angles of all three coatings were 0° and the required time for two successive water droplets spreading on the surface was thoroughly recorded (Table 2). When the first water droplet was dropped onto the coatings surfaces, the droplet spreads rapidly and completely within 1.2259 s (PTMS-6), 0.7172 s (PTMS-8) and 0.4554 s (PTMS-10), respectively. For the second droplet, the times were 0.0598 s (PTMS-6), 0.0507 s (PTMS-8) and 0.0299 s (PTMS-10). These experiments underline that the coatings with PTMS-10 has the best superhydrophilicity and antifogging behavior.

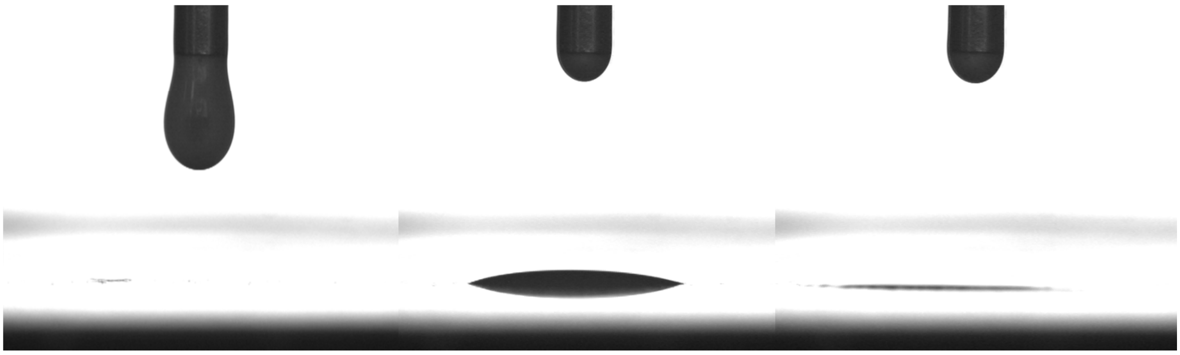
Table 2: Required time for the first droplet (t1) and second droplet (t2) to completely spreading on the surfaces of PTMS-6, PTMS-8 and PTMS-10

	PTMS-6	PTMS-8	PTMS-10
t1 (s)	1.2259	0.7172	0.4554
t2 (s)	0.0598	0.0507	0.0299

Method: Characterization of Superhydrophilic Surfaces

The time until a water drop spreads completely on a surface is a measure for the surface´s hydrophilicity. The faster the spreading, the greater is the hydrophilic character. To quantitatively distinguish different materials a water drop is placed on the surface and through a high-speed video system it is observed how long it takes to spread completely. For these kinds of measurements the optical contour analysis systems OCA 25, OCA 50 or OCA 200 from DataPhysics Instruments are ideal tools.

Picture 1: *Sequence of drop placement and spreading (timescale is in ms range)*



To further explain the mechanism behind it, SEM was used to demonstrate different surface microstructures of the coatings. The bulges on the surface of PTMS-6 coating were small (around 100 nm) and discrete. When the amount of PTMS increased, more bulges with bigger size (PTMS-8; around 200 nm) could be seen on the surface with somewhat overlapping. A worm-like structure formed on the surface of PTMS-10, which can mainly be attributed to the aggregation and deformation of particles with high amount of PTMS in the preparation process. This illustrates the importance of the surface microstructures for tuning the antifogging and antireflective behaviors.

In summary, this research presents a new facile and simple method for the fabrication of broadband superhydrophilic antifogging antireflective coatings based on latex and PTMS. The average transmittance of the coatings was enhanced by 9.3% compared to that of the bare glass substrate in the wavelength range of 400–700 nm. Meanwhile, the authors could show that controlling the roughness and microstructure of the surfaces is of high importance to achieve superhydrophilic antifogging antireflective surfaces for different applications.

An optical contact angel measurement device OCA 200 (DataPhysics Instruments GmbH, Germany) was used in this research.

For more information, please refer to the following article:

Superhydrophilic antifogging broadband antireflective coatings with worm-like nanostructures fabricated by one dip-coating method and calcination; Junjie Yuan, Siyu Yan, Xiong Zhang; Applied Surface Science **2020**, 506, 144795; DOI: 10.1016/j.apsusc.2019.144795