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To: BFP Advanced Technologies

Attention of: Dr. Nikolaos Papadopoulos

Subject: Study on the transmmitivity and hydrophobicity of silica hybrid coatings (thin films) developed by the SolarSkin product on glass substrates

At the laboratory of "Nanomaterials for Photo-induced Processes" the study of thin films of silica hybrid oligomers of the product **SolarSkin** (of BFP Advanced Technologies) on tempered glass substrates was conducted.

More specifically, the optical properties as well as the hydrophilicity or/and hydrophobicity of the afore-mentioned films on four 2x2 cm glass substrates of 3 mm thickness were examined. Samples were the following ones:

i) A glass substrate, which served as the reference sample (glass)
ii) A glass substrate with the **SolarSkin** coating (coated SiO_2)
iii) A glass substrate with the **SolarSkin** coating, which had been subjected to abrasion according to EN 1096.2 standard and subsequent aging for one year (coated SiO_2 aged)
iv) A glass substrate with the **SolarSkin** coating on both its sides (coated SiO_2 double side)

Following BFP Advanced Technologies, the mission of this new coating material is to protect solar panels and render them self-cleaning. In this study, the optical transmission properties of the film are examined in order to assess how much the intensity and the bandwidth of the incident irradiation will be affected. Hydrophobicity was also measured in order to test the ability of the new material to effectively remove contaminants (pollution, dirt, lime) from its surface in the presence of water. In the third sample, the process of abrasion and subsequent aging for one year served in studying possible degradation of the coating's transmittivity and hydrophobicity over time. The same coating was applied on both sides of the fourth glass substrate sample in order to evaluate its potential application in thermal solar systems, too.

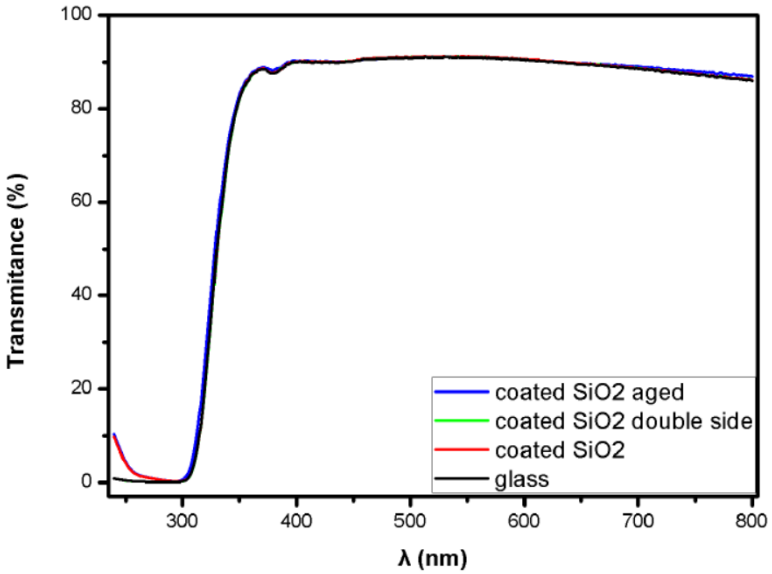
Experimental processes

The thin films were applied on the glass substrates by BFP Advanced Technologies and transferred to NCSR Demokritos for characterization. In order to carry out measurements of the films' diffused reflectance spectra and transmittance a UV-Vis Hitachi 3010 spectrophotometer equipped with one $BaSO_4$ integrating sphere was used. Measurements were taken in the wavelength range of 240-800 nm. Hydrophilicity or/and hydrophobicity of samples was evaluated through contact angle measurements with the aid of a contact angle meter CAM 100 (by KSV Instruments Ltd), equipped with the corresponding software.

Results

Optical transmittance of the coated substrates was compared to the transmittance of the uncoated glass substrate. It should be noted that the transmission reduction observed in all samples in the wavelength below 360 nm is due to the nature of the glass substrate.

It was found that the ratio of penetrating radiation remained in all coated samples constant. An almost negligible shift was observed In the case of the aged sample. These results prove that the protective coating developed by the SolarSkin product does not at all alter the optical properties of the glass substrate and that it assures that these properties are retained for long.



Optical transmission spectra of films.

The determination of the water contact angle with the hybrid silica surface can be used in the evaluation of the hydrophilic or hydrophobic character of the thin film produced by the **SolarSkin** product. A water contact angle higher than 90^0 implies a hydrophobic behavior of the material, whereas a water contact angle lower than 6^0 implies a hydrophilic one.

From the following table it can be seen that the glass substrates initially presented a water contact angle of about 46^0. When coated by the **SolarSkin** film the contact angle was, in all cases, significantly increased. This increased value of water contact angle was retained without any significant alterations even in the case of the aged coated sample.

In order to accurately determine the water contact angle multiple measurements were conducted on different spots of the samples' surfaces. The values obtained were, in fact, a mean value of the recorded measurements.

Table: Mean water contact angle values.

Sample	Contact angle
(glass)	46.07^0
(coated SiO_2)	104.9^0
(coated SiO_2 aged)	100.3^0
(coated SiO_2 double side)	105.8^0

Conclusions – Remarks

It was found that the **SolarSkin** coating did not modify the optical properties of the glass substrate. Compared to the uncoated glass, the incident irradiation penetrated unhindered the thin film without any alterations in its intensity. The study of the films' water contact angle proved that after the application of **SolarSkin** the surface became hydrophobic. Moreover, optical properties were retained over time without any alterations.

According to the results, the coating produced by **SolarSkin** does not alter the optical properties of the glass. Secondly, the hydrophobic character of the coating is verified. Finally, both hydrophobicity and transmittivity of the coating are retained after aging. As a result, the coating would allow self-cleaning of PV modules or panels of thermal solar systems for long periods of time with the aid only of water.

The Scientific Coordinator

Dr. Polycarpos Falaras, Research Director.