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Keeping the Surface Clean: EXOCOAT 151A

AXC.108.02

General Information

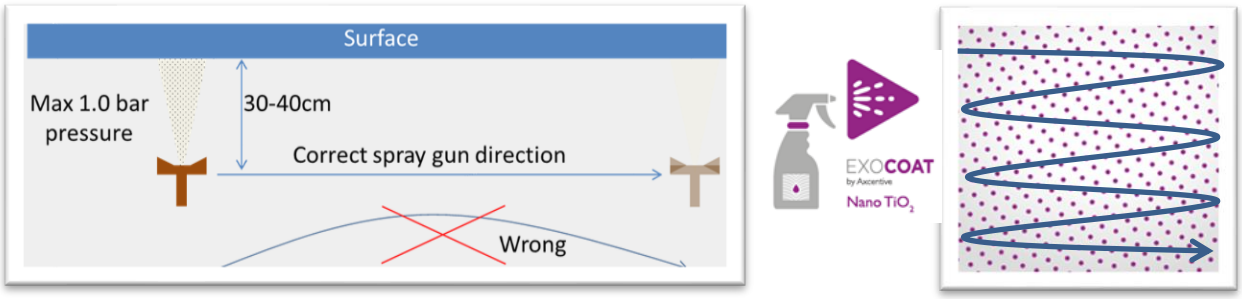
EXOCOAT 151A is a doped nano-titanium oxide sol with a strong photocatalytic performance. The nano titanium oxide sol is activated by visible light and creates a superhydrophilic surface which provides self-cleaning functionality to substrates to which it is applied. The photocatalytic effect results in effective free-radical formation which breaks down organic matter such as dirt and soil. Airborne particles such as volatile organic and nitrous oxide compounds (VOCs, NO_x) are also eradicated by EXOCOAT 151A.
EXOCOAT 151A has a very low activation energy to perform and will show its performance already under visible light. EXOCOAT 151A series should be used as a topcoat.

Application

There are 3 preferred application methods for EXOCOAT 151A sols:

- Application by spray
- Application by brush or roller
- Application by dip coating (10-50cm/min or 4-10 inches/min)

From an efficiency point of view for OEM; brush, roller and spray are the preferred methods for application. Spray should be done at relatively low pressure (0.5 to 1.0 bars or 7 to 14 psi) at a distance of 30 to 40 cm (12 to 16 inches). Preferably apply in a straight line like shown in below picture left. The objective would be to create an invisible and evenly coated surface shown, by systematically zigzagging from one upper corner to the opposite lower as shown in the right picture. This process should be repeated 4 to 8 times preferably in contra direction.



Brush application may be possible yet may result in light interference (birefringence and other) on glossy or metallic surfaces, hence is only advised on porous substrate like concrete walls, high PVC paints and plasters.

The surface area covered with EXOCOAT 151A lies between 30 and 80m^2/l (1200 to 3200sq ft/gallon) largely dependent on the overspray (in case of spray) and/or absorption of the substrate being coated.

Activation

Initiation of the effects of EXOCOAT 151A can be determined by measurement of the coating contact angle. The contact angle (CA) is the angle a water droplet makes with the surface when it is lying on the surface as shown in below picture. A normal contact angle of water on a coated surface (example acrylic

Europe, Americas, Middle East and Africa
Axcentive SARL
Chemin de Champouse
13320 Bouc Bel Air, France
+33 4 42 69 40 90

Asia, India and Australasia
Axcentive Asia Pte Ltd
13 Lorong 8 Toa Payoh,
#07-01 Braddell Tech Park
319261 Singapore
+65 6258 6338

info@axcentive.com • www.axcentive.com

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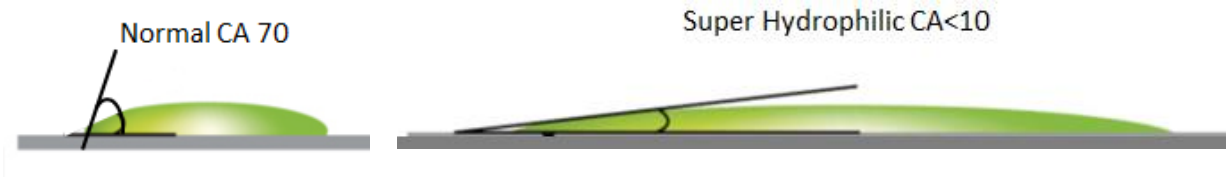
based coating) would be regarded as around 70° whereas a superhydrophilic surface is regarded as having a contact angle below 10°.



The mobilization of the self-cleaning effect of a nano-titanium oxide surface can be measured by the decrease of contact angle before and after activation by light. In the below table, the start of the superhydrophilicity is measured by the CA. Initial reference surface is GI steel with a CA of 70°. This piece was coated with EXOCOAT 151A and the sample was activated with UV light of 2 mW/cm^2 (900 mW/sq ft) for 48hrs. Activation makes the surface superhydrophilic with a CA of 0.

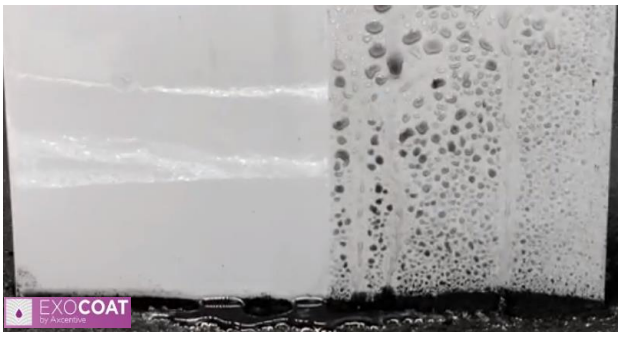
Sample	CA (°)
GI Steel reference	70
GI Steel coated with EXOCOAT 151A	57
GI Steel coated with EXOCOAT 151A activated*)	0

*) UV light of 2 mW/cm^2 (900 mW/sq ft) for 48hrs

For comparison, sunlight (global average) releases about 50 mW/cm^2 (22500 mW/sq ft). So, a coated sample would need about 2 hrs in the sun to fully activate.

A more practical method to follow the effects on the surface, is its response to a powdered substance that would cause fouling and the effect to water spray. An activated surface will be less statically charged and as a result will attract less dirt. This is shown in the left picture in below table, where carbon powder was thrown against the plate, partly coated with EXOCOAT 151A, partly non-coated. Moreover, when this plate was sprayed with water it was noticed the side coated shows full wetting and self-cleaning due to the water sheeting effect (right picture).

Left side EXOCOAT 151A, right side not treated.
Throwing a powder against the plate



Left side EXOCOAT 151A, right side not treated
Spraying the plate with water

Self-Cleaning Effect of Oil

ISO-Norm EN27448 describes the degradation of oleic acid with the use of photocatalytic coatings. This international standard determines the self-cleaning performance of non-porous surfaces by a measurement of the contact angle under activation with UV light.

Europe, Americas, Middle East and Africa
Axcentive SARL
Chemin de Champouse
13320 Bouc Bel Air, France
+33 4 42 69 40 90

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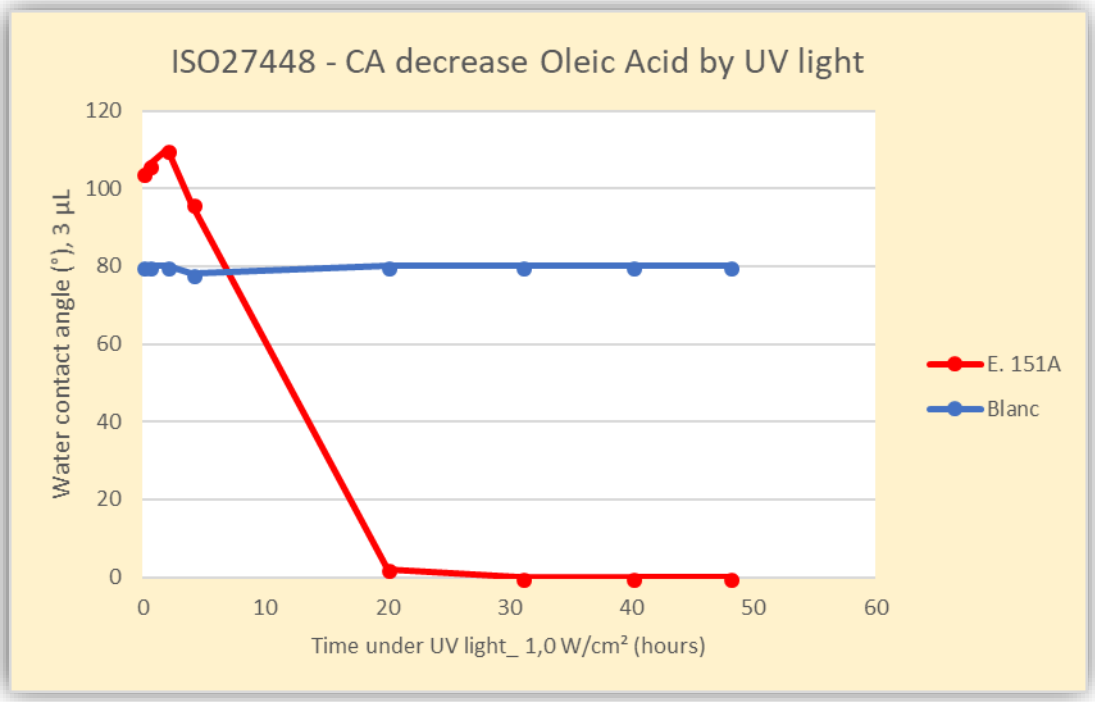
The test consists of a pre-treatment step of a test piece by irradiating it with UV (2 mW/cm² or 900 mW/sq ft) for at least 24h, needed to activate the surface and remove any organic substances, which may be present.
In a next step, a thin layer of oleic acid is applied to the EXOCOAT 151A photocatalyst-coated surface by dip coating in a 0.5% solution of oleic acid in n-heptane. After withdrawal at a speed of 60 cm/min or 25 inches/min, surfaces are dried at 70°C (160°F) for 15 minutes.
Contact angles of samples coated with oleic acid are measured before the start of light-activation and noted as initial contact angles. By exposing the samples to UV light (1 mW/cm² or 450 mW/sq ft), the EXOCOAT 151A layer ought to degrade the organic layer of oleic acid causing contact angles to drop as we would move to a surface only containing nano-titanium oxide.
In below graph the water contact angle was followed at regular intervals which caused a clear drop in the case of the plate coated with EXOCOAT 151A and remained the same with the non-coated reference plate.



The graph clearly shows the effect of EXOCOAT 151A (red line) as coating. Initially the CA was 102° due to the hydrophobicity of oleic acid coated over GI steel, which was amplified by the surface roughness. The CA decreases rapidly, within 20hrs, to 0° from the initial value of the EXOCOAT 151A coated GI steel surface. This decrease in CA can only be explained by the complete degradation of oleic acid to its components H_2O and CO_2 which are consequently released from the substrate. The reaction scheme would be:

$$\text{Oleic acid } (C_{16\text{-}18})COOH \xrightarrow{h\nu,\ TiO_2} H_2O + CO_2$$

Being an organic substance, oleic acid is similar to soil and dirt such as greasy organic matter.
In contrast the blank sample with no EXOCOAT 151A does not show any degradation of oleic acid as seen from a consistent CA.

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13320 Bouc Bel Air, France
+33 4 42 69 40 90

Asia, India and Australasia
Axcentive Asia Pte Ltd
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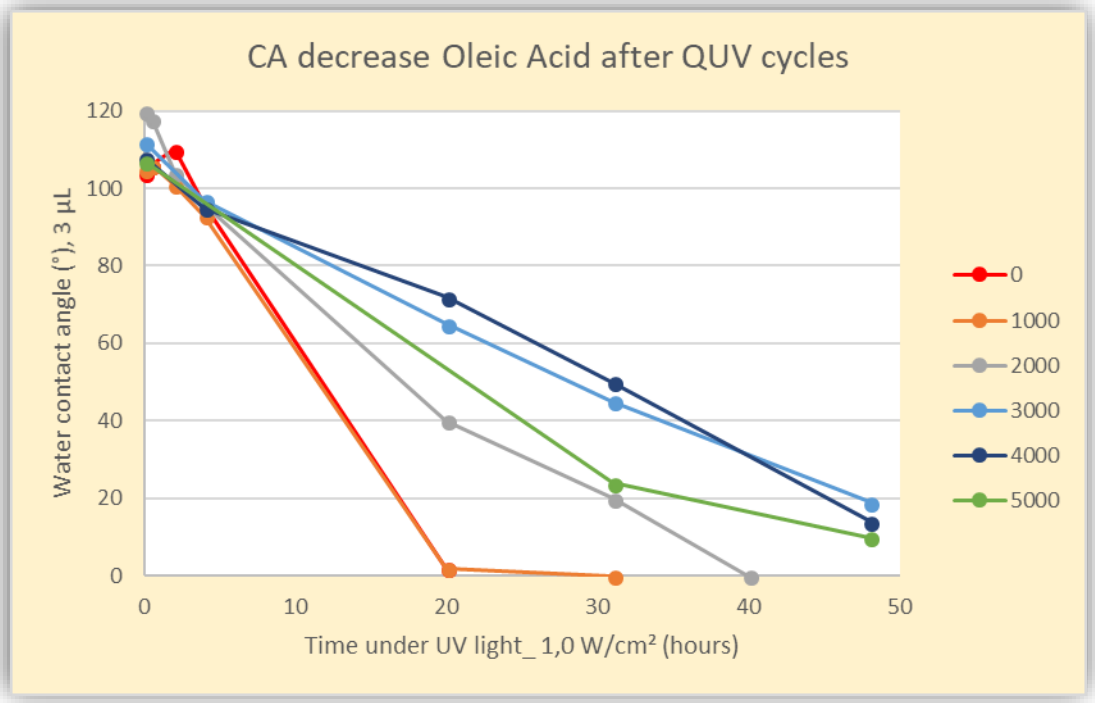
Durability

The QUV accelerated weathering test reproduces the damage caused by sunlight, rain and dew that occurs over months or years outdoors and attest the durability of a product under real conditions. In such test coated plates are subjected to very humid conditions and alternately are radiated with strong UV light. It is generally regarded as a harsh test for a coating and indicates if a coating can sustain outdoor circumstances for longer period. Also, the longer the coating in the UV cabinet the harsher the test.
In our experiment EXOCOAT 151A coated RVS plates were subjected to a maximum of 5000hrs of QUV-A.

In below graph the result of ISO-27448 test is shown after various QUV cycles. The graph shows that after 0 and 1000hrs of QUV-A there is virtually no difference in photocatalytic breakdown of oleic acid, which was completely eliminated after 20hrs. After 2000, 3000, 4000 and 5000hrs the effect is reduced yet still very much present, especially compared to the blank from the former graph, that showed no oleic acid breakdown at all. The sample subjected to 5000hrs of QUV showed complete oleic acid eradication after 40hrs light induction.



A general rule is that a QUV cycle of 5000hrs corresponds to 7-9 years outdoor exposure in moderate European climates, which is between 4-5 GJ/m²/annum global irradiation[1]. Although the time to breakdown oleic acid was longer after the 5000hrs QUV cycle the effect remained clearly visible, so that we can state the EXOCOAT 151A nano-titanium oxide coating is very stable under harsh weather conditions.

[1] Ulrich Schulz, Accelerated Testing, pg 72, Vincentz

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Chemin de Champouse
13320 Bouc Bel Air, France
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+65 6258 6338

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Marker tests

Ink Intelligent[tm,2] has developed markers that indicate photocatalytic activity. They offer 3 pens that have different activity from medium to the highest sensitivity. When they are activated, the ink changes in color. Dependent on the type, the color may change from blue to pink, blue to colorless or colorless to brown as depicted in below table.

Sensitivity	Name	Dye	Color change
Low		Resazurin	Blue to pink
Medium		Basic Blue	Blue to colorless
High		Acid violet 7	Colorless to brown

The inks were applied on the EXOCOAT 151A photocatalyst coating and exposed to UV light (1 mW/cm² or 450 mW/sq ft).

From below table it can be seen the inks respond very fast to the light responsive EXOCOAT 151A. From zero to 6 minutes the inks change in color completely.

- The Explorer ink based on resazurin changes from blue to violet
- The Visualiser based on Basic Blue Diazo has nearly disappeared in 6 minutes
- The Validator based on acid violet has changed from transparent to a brown color.

[2] http://www.inkintelligent.com/

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Axcentive Asia Pte Ltd
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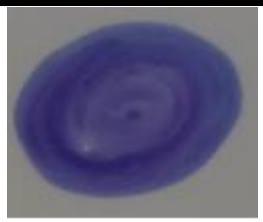
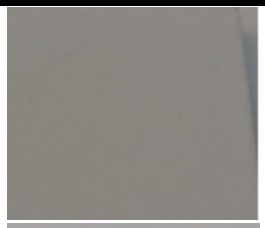
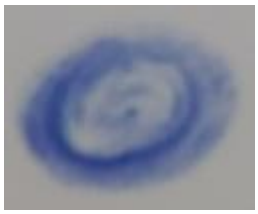
	Resazurin: Blue to pink	Basic Blue: Blue to colorless	Acid violet 7: Colorless to brown
Start 0 minutes			
After 2 minutes 1 mW/cm²			
After 6 minutes 1 mW/cm²			

It demonstrates the rapid reaction and activation of the EXOCOAT 151A to UV light.

Conclusion

EXOCOAT 151A is a nano-titanium dioxide sol capable of cleaning surfaces in 3 distinct ways. First, it renders the surface anti-static so that powders do not adhere well and thus leaves the surface less soiled. Second, its superhydrophilicity promotes water sheeting that cleans the coated surface whenever it is exposed to water. Third, the photocatalytic process triggered by light eliminates and fully degrades organic material as for example oleic acid in 24hrs and basic bleu organic dye complex in a matter of minutes.

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