

# LUMACTIV

## Technical Manual

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# About Photocatalyst

## 1. What is photocatalyst?

A promising approach for remediating volatile organic compounds or VOCs is to employ photocatalyst that oxidize these compounds. It is a substance that facilitates chemical reactions by photo-irradiation without becoming transformed:



Photocatalyst has the following advantages over any current air purification technologies:

- Real destruction of pollutant rather than a simple transfer on a substrate
- Degradation of pollutant at ambient temperature and pressure
- Build with easily available materials and by mean of well-known techniques
- Economical, cheap and low energy consumption
- Adapted for a large range of pollutant (VOC, bacteria, mold)

## 2. What is titanium dioxide?

Titanium dioxide, also known as titania, is the naturally occurring oxide of titanium, chemical formula  $\text{TiO}_2$ . Approved by the food testing laboratory of the United States Food and Drug Administration (FDA), Titanium Dioxide is considered a safe substance and harmless to human. It is commonly used in paint, printing ink, plastics, paper, synthetic fibers, rubber, condensers, painting colors and crayons, ceramics, electronic components along with food and cosmetics. Many studies have been published on the use of titanium dioxide as a photocatalyst for the decomposition of organic compounds.

Titanium Dioxide molecules contain electrons that are confined to relatively narrow energy bands. The band of highest energy that contains electrons is the valence band, while the band lying above the valence band, i.e. the conduction band, has very few electrons. The difference in energies between the highest energy of the valence band and the lowest energy of the conduction band is termed the band gap energy. When a semiconductor absorbs a photon of energy equal to or greater than its band gap, an electron may be promoted from the valence band to the conduction band leaving behind an electron vacancy or "hole" in the valence band. If charge separation is maintained, the electron and the hole may migrate to the catalyst surface where they participate in redox reaction with sorbed species. (Fig.1)

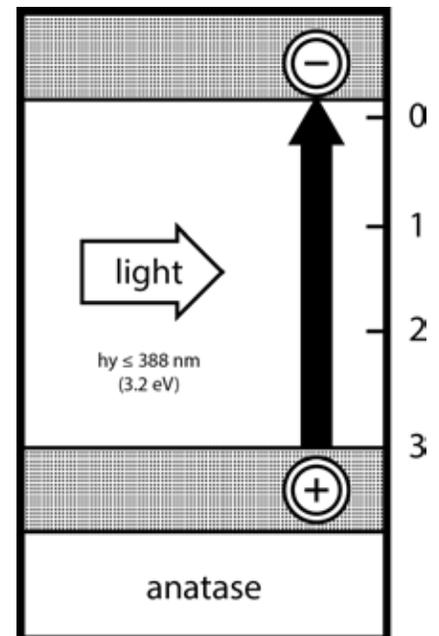


Fig. 1 Energy Diagram for TiO<sub>2</sub>

When Titanium Dioxide is exposed to light in the presence of water vapor, two highly reactive substances are formed: hydroxyl radicals [OH] and a superoxide ion [O<sub>2</sub><sup>-</sup>]. It allows the oxidation of airborne VOCs into carbon dioxide and water at room temperature with UV or near-UV light source. It does not need a special energy and uses clean energy found in ordinary life. Specific titanium dioxide has strong photocatalytic reaction. It has strong oxidation and decomposition strength. (Fig.2)

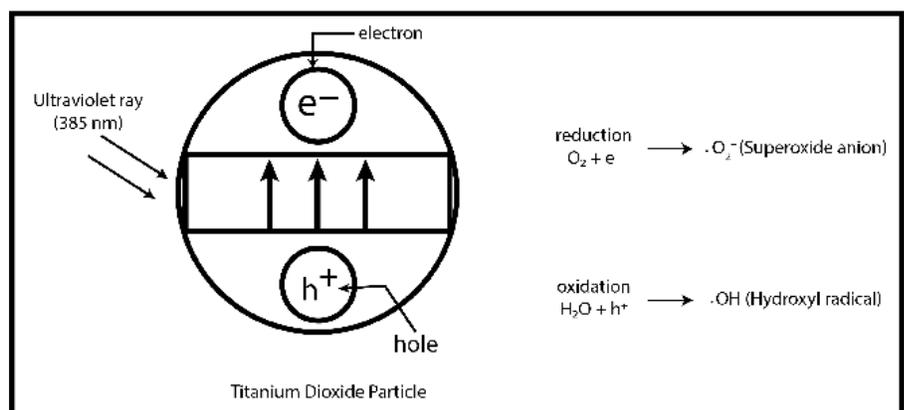


Fig. 2

### 3. Effects of Titanium Dioxide

#### Strong Oxidation Power (Anti-Bacterial, Anti-fungal, Deodorizing, and Sterilizing)

Hydroxyl radicals are among the strongest oxidizing species, even much stronger than chlorine, ozone, and peroxide. They act as very powerful disinfecting agents by oxidizing the cells of microorganisms, causing rupture and leakage of vital composition.

#### A.1 Antibacterial, Anti-Fungal, and Sterilizing

Titanium dioxide has strong oxidation affects to single-celled organism that includes all bacteria and fungus. The very strong oxidizing power of Titanium Dioxide can destroy bacteria's cell membrane, causing leakage of the cytoplasm, which inhibits bacteria's activity and ultimately results in the death and decomposition of bacteria. It is most effective in controlling bacteria and virus growth which they are still relatively small in number, before they start multiplying out of control. Generally speaking, disinfections by titanium oxide is three times stronger than chlorination, and 1.5 times stronger than ozonation.

#### A.2 Deodorizing

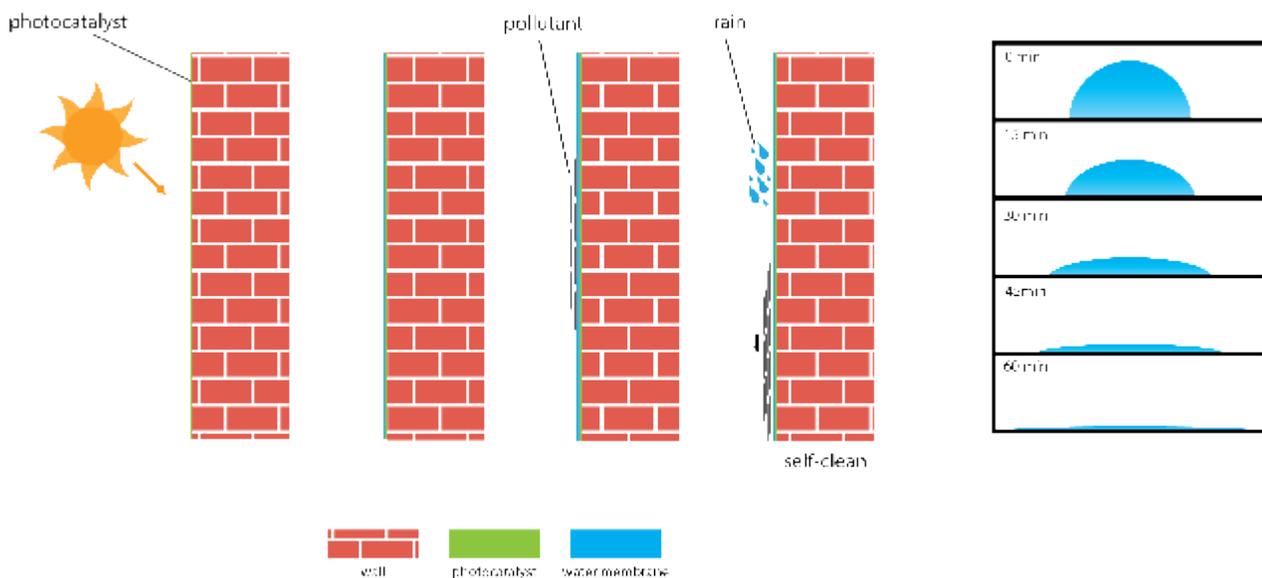
On the deodorizing application, the hydroxyl radicals accelerate the breakdown of any Volatile Organic Compounds(or VOCs) and odor molecules by destroying the molecular bonds. This will help combine the organic gases to form a single molecule that is not harmful to humans thus enhance the air cleaning efficiency.

Titanium Dioxide can successfully treat the following VOCs commonly found in our living spaces:

- CO – boiler, vehicle
- Nox – Stove
- Chloroforme – water treatment
- P-dichlorobezene – air cleaners
- Gasoline – vehicle, mower
- Tobacco – cigarette
- Formaldehyde – furniture, carpet
- Pesticide - sofa, paneling carpet
- Tetrachloroethylene – cooling systems

#### B Hydrophilic Property (Anti-Fogging, anti soiling and Self-Clean)

The hydrophilic nature of titanium dioxide, coupled with the gravity, will enable the dust particles to be swept away following the water stream, thus making the product self-cleaning.



When the surface of photocatalytic film is exposed to light, the contact angle of the photocatalyst surface with water is reduced gradually. After enough exposure to light, the surface reaches super-hydrophilicity. In other words, it does not repel water at all, so water cannot exist in the shape of a drop, but spreads flatly on the surface of the substrate.

## 4. Equipment & Materials

It is necessary to check the environment condition of the area where you are handling titanium dioxide. You may not be able to use a spray gun. In some cases use only brushes or sponge rollers.

### A. Common Items

#### A.1 Equipment

- Dust cloth (4 or 5 sheets)
- Cure sheet with tape by painting
- Cure tape (Paper tape, etc.)
- Dustproof glasses
- Dust mask

### B. Application by Sponge roller or brush

- This is a simple way to apply titanium dioxide to a surface. However there may occur “the iris” (rainbow color) problem.
- You can minimize excess waste of product but it is difficult to determine the thickness of the coating.
- Before applying additional coats, the previous coat needs to be completely dry.

#### B.1 Equipment

- Roller and brush for water paint.
- Paint can or roller pan
- Dustproof glasses

### C. Application by Spray

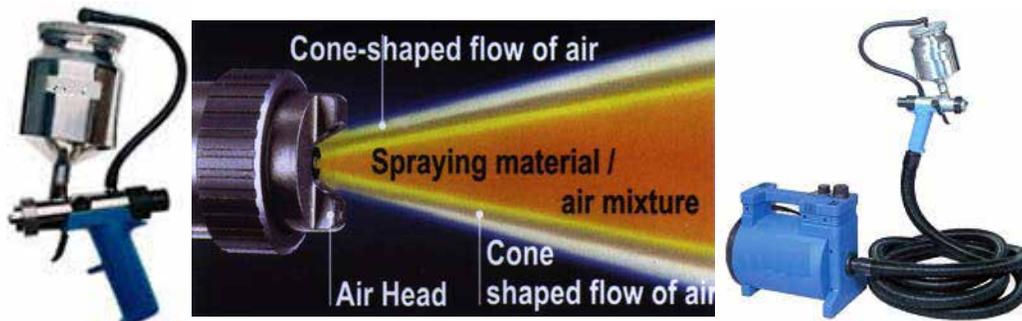
The spray mist condition is controlled by the diameter of the nozzle and air pressure. A coating job can be done within a short time by using a spray gun. Spray coating is the recommended choice for application. It can precisely measure the amount of titanium dioxide used and the thickness of the film can be calculated.

#### C.1 Equipment

##### Turbine-based HVLP System

- Air compressor: ABAC SG90
- Specification: (Recommended)
- Working pressure range: 0.88 MPa (9.8 kg / SCM)
- Discharge rate: 90 LTR / minute
- Spray Gun: ABAC PN2A
- Nozzle size: 0.3, 0.5, 0.8mm

Note: Spray gun is the best for suitable air compressor.



## Compressed Air HVLP System

- Air compressor: Minimum of producing 2 SCFM
- Working pressure: 35-60 PSI
- Spray gun: DeVilbiss Sri HVLP Spray Gun with 0.8mm nozzle tip

## D. Sensors

### D.1 VOC Sensor

- Specific gas measured: Methanol, Toluene, Formaldehyde, Ethanol, Acetaldehyde, Acetone, Methyl acetate, Xylene
- Filter should be replaced every month to ensure proper reading
- Manufacture recalibration is necessary depending on proper maintenance of the device.
- Consult with manufacturer instruction for proper operation



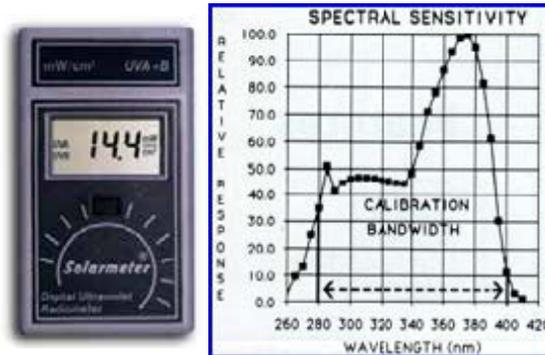
### D.2 Odor Sensor

- Measures variety smells between 0 to 2000 index points.
- Filter should be replaced every month to ensure proper reading
- Manufacture recalibration is necessary depending on proper maintenance of the device.
- Consult with manufacturer instruction for proper operation



### D.1 UV Sensor

- Sensitivity: 0 – 1999  $\mu\text{W}/\text{cm}^2$
- Resolution: 1  $\mu\text{W}/\text{cm}^2$
- Response: 280 – 400 nm (UVB thru UVA)



### E. Additional Equipments

- Portable black lights (20 ~ 40 watts)
- Portable fan unit

## 5. Procedures of coating

DryWired's nano-TiO<sub>2</sub> Photocatalyst solution is neutral aqueous solution. Consequently any material with water-repellent surface or smeared with oil cannot be coated.

### A. Pre-operation survey

- Determine the light source (i.e. location of windows and door and the direction they are facing)
- Identify possible source of odor (i.e. dirty air conditioning filter, old carpet, pet stain, etc)
- Identify surface material (i.e. organic paint, synthetic wall paper, etc)
- Understanding of the life-cycle of surface material (i.e. wall paper, paint history, etc)
- Identify air circulation source and pattern
- Surface suspected to be hydrophobic should be test coated first
- Consult attachment "Pre-Site Survey" form for detailed information

### B. Environment condition measurements

- Ground area measurement.
- As a rule of thumb, the actual coating surface area is approximately three times the ground area.
- VOC reading in PPM, odor reading in PPM
- UV intensity reading in uW/cm<sup>2</sup>
- Consult attachment "Pre-Site Survey" form for detailed information

### C. Specification and Recommendations

#### C.1 UV Intensity

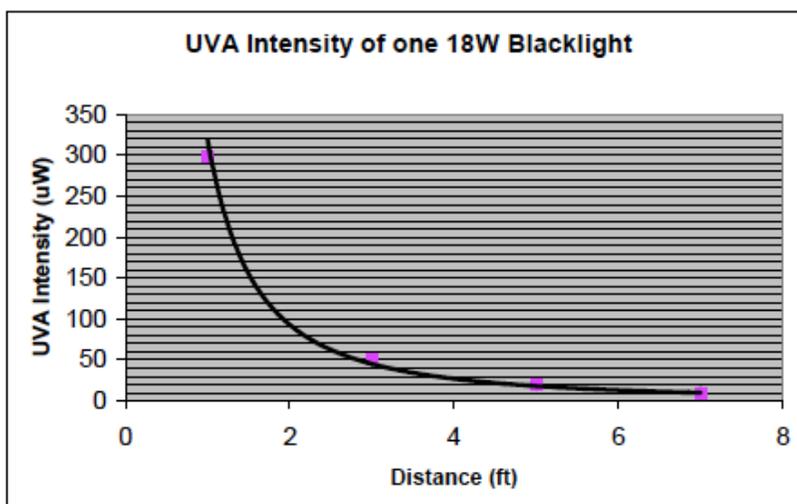
- Minimum UVA intensity required: 10 uW/cm<sup>2</sup> or 1000Lux Brightness
- Additional black light fixtures are recommended when insufficient lighting is available.

#### Black light blue lamps:

- Manufacturer: GE
- Product code: 16360
- Bulb code: F18T8 BLB
- Description: 18-watt black light emits UV spectrum between 300 nm to 400 nm

#### UV Intensity Matrix:

Distance (ft)	1	3	5	7
Measurement A (uW)	300	50	20	10
Measurement B (uW)	298	52	19	9



## Light Fixture Installation Recommendation

- Light fixtures should be placed so the light pattern could overlap.
- The distance between each fixture may vary based on the UV intensity output of the bulb.

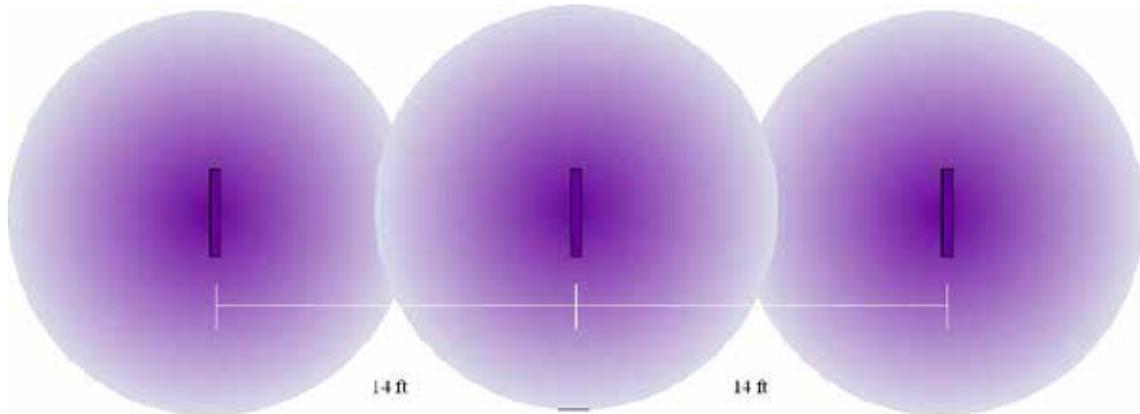


Fig. 1 Light irradiation pattern

## C.2 Humidity Recommendation

- DryWired's photocatalyst coating solution should be applied between 20% to 60% relative humidity for optimal drying time and appearance.
- Low humidity level may cause titanium dioxide particle difficult to adhere to the substrate.
- High humidity level may cause uneven coating which might diminish photocatalytic effect.

## D. Recommended Usage

### D.1 Deodorization and Air Purification Purpose (Interior Space)

- 0.05 to 0.3 micron TiO<sub>2</sub> film thickness is recommended for decomposing low-concentration, gaseous contamination.(Consult Film thickness calculation article for detailed information)
- Porosity and absorbency of substrate material will greatly influence the final product yield.
- In situation where the source of odor/contaminant could not be removed, additional coating is strongly recommended to improve the performance.
- In situation where sufficient lighting could not be achieved, additional coating is strongly recommended to improve the performance.

### D.2 Antibacterial Purpose (Interior Space)

- 0.3 to 1.0 micron of TiO<sub>2</sub> film thickness, in conjunction to optimal lighting condition, is recommended for anti-microbial purpose.
- In situation where sufficient lighting could not be achieved, additional coating is strongly recommended to improve the performance.

### D.3 Self-Cleaning Purpose (Building Exterior Surfaces)

- 0.1 to 0.3 micron of TiO<sub>2</sub> film thickness is recommended for self-cleaning purpose.
- Application condition, porosity and absorbency of substrate material will greatly influence the final product yield.

### D.4 Base Coating

- In situation where PTA is necessary to protect the organic substrate as well as to increase binding strength of TPX coating, the yield of PTA-85 is between 500 to 750 ft<sup>2</sup>/L over smooth, non-porous surfaces (2 ml to 1.3 ml per ft<sup>2</sup>) and 350 to 600 ft<sup>2</sup>/L over porous, textured or absorbent surfaces (2.85 ml to 1.66ml per ft<sup>2</sup>).

#### **D.5 Choose the suitable titanium dioxide solution**

- Depending on the material of surface substrate, dual coating of photocatalyst maybe required.
- Although TPX solution can be used directly on organic substrate surface, a pre-coat of PTA solution is recommended when treating surface with organic substrate.

# Application

DryWired LumActiv™ is a titanium dioxide photocatalytic coating designed to create a self-cleaning coating through a light-activated hydrophilic property with the ability to decompose organic compounds (VOCs), odors, and most airborne noxious substances.

## Surface Preparation

Ensure a clean, dry surface before application. For glass and other hard surfaces a surface degreaser, such as DryWired Glass Cleaner, can be used. If the surface is organic in nature, LumActiv Primer should be applied prior to the final LumActiv product.

## Application

When it is necessary to use LumActiv Primer, the Primer should be applied similarly to the other LumActiv products. Primer must be completely dry before LumActiv Multipurpose or LumActiv Indoor is applied. Dry time of LumActiv Primer is 1 to 3 hours.

## Equipment

Once the surface has been removed of all contaminants and is completely dry, it is important to identify all appropriate equipment has been obtained. It is recommended to calibrate the equipment using water to test the spray pattern, ensuring the desired spray volume and coverage is achieved. Recommended spray nozzle size is 0.3mm, 0.5mm, or 0.8mm.

## Primer

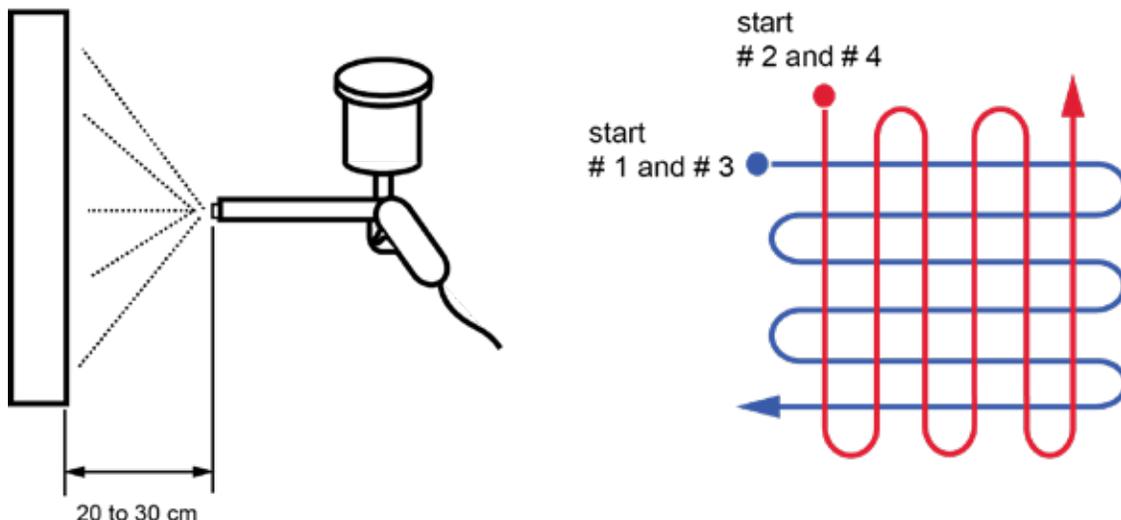
When it is necessary to use LumActiv Primer, the Primer should be applied similarly to the other LumActiv products. Primer must be completely dry before LumActiv Multipurpose or LumActiv Indoor is applied. Dry time of LumActiv Primer is 1 to 3 hours. One pass horizontally and one pass vertically is equal to one coat. Only one coat of LumActiv Primer is necessary.

## Coating Application

Spray gun should be about 20cm to 30cm away from the substrate so that a fine mist can be formed before reaching the surface.

Spray pattern should be followed as shown below. 10 minutes should be allowed between coats in order to achieve optimal adhesion.

If there is an area of the coating that needs to be reworked, the coating should be removed immediately.



**Dry Time**

Dries in seconds under normal conditions. Once the coating has fully dried, the coating will not dissolve in water.

**Cure Time**

The coating will fully cure in about 2 months. At this point, the coating will have achieved maximum hardness (2H-5H depending on the coating/substrate).

**Storage**

Assuming storage procedures have been followed as recommended according to the safety data sheets, shelf life is as follows:

- LumActiv Primer: 5 years.
- LumActiv Multipurpose: 5 years.
- LumActiv Indoor: 5 years.
- LumActiv Glass: 2 years.

**Clean-up**

All tools can be rinsed with water to remove any remaining coating solution. Anywhere the coating needs to be removed because of overspray can be removed by wiping with water and a cloth.