What is Photocatalyst ?

Photo-Catalysis is defined as "acceleration by the presence of as catalyst". A catalyst does not change in itself or being consumed in the chemical reaction. This definition includes photosensitization, a process by which a photochemical alteration occurs in one molecular entity as a result of initial absorption of radiation by another molecular entity called the photosensitized.

Chlorophyll of plants is a type of photocatalyst. Photocatalysis compared to photosynthesis, in which chlorophyll captures sunlight to turn water and carbon dioxide into oxygen and glucose, photocatalysis creates strong oxidation agent to breakdown any organic matter to carbon dioxide and water in the presence of photocatalyst, light and water.

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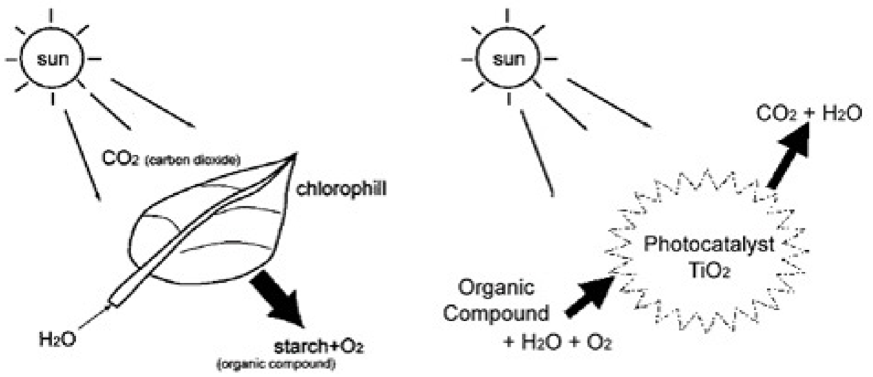
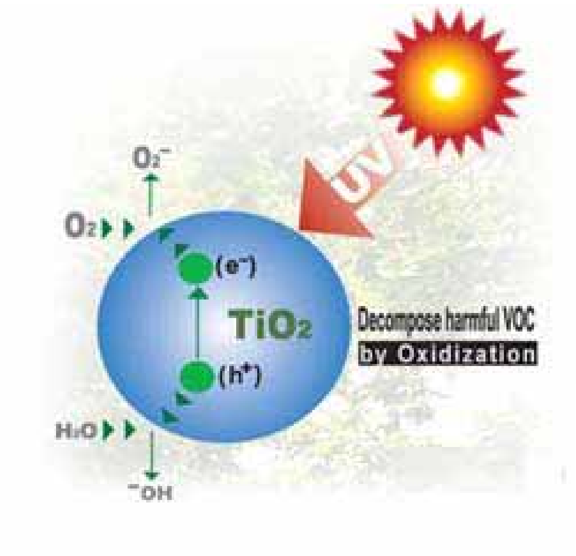


Mechanism

When photocatalyst titanium dioxide (TiO2) absorbs Ultraviolet (UV) radiation from sunlight or illuminated light source (fluorescent lamps), it will produce pairs of electrons and holes.

The electron of the valence band of titanium dioxide becomes excited when illuminated by light. The excess energy of this excited electron promoted the electron to the conduction band of titanium dioxide therefore creating the negative-electron (e-) and positive-hole (h+) pair. This stage is referred as the semiconductor's ' **photo-excitation** ' state. The energy difference between the valence band and the conduction band is known as the ' **Band Gap** '. Wavelength of the light necessary for photo-excitation is:

1240 (Planck's constant, *h)* / 3.2 ev (band gap energy) = 388 nm



O_2- : Superoxide anion

*OH : Hydroxyl radical

The positive-hole of titanium dioxide breaks apart the water molecule to form hydrogen gas and hydroxyl radical. The negative-electron reacts with oxygen molecule to form super oxide anion. This cycle continues when light is available. The overall mechanism of photocatalytic reaction of titanium dioxide

Photocatalytic Oxidation

The most powerful advanced oxidation systems are based on the generation of hydroxyl radicals. The hydroxyl radical is an extremely powerful oxidation agent, second only to Fluorine in power (2.23 in Relative Oxidizing Power). Following is a listing of common chemical oxidants, placed in the order of their oxidizing strength:

Exhibit XIII-11
Relative Power of Chemical Oxidants[4]

Compound	Oxidation Potential (volts)	Relative Oxidizing Power (Cl_2 = 1.0)
Hydroxyl Radical	2.8	2.1
Sulfate Radical	2.6	1.9
Ozone	2.1	1.5
Hydrogen Peroxide	1.8	1.3
Permanganate	1.7	1.2
Chlorine Dioxide	1.5	1.1
Chlorine	1.4	1.0
Oxygen	1.2	0.90
Bromine	1.1	0.80
Iodine	0.76	0.54

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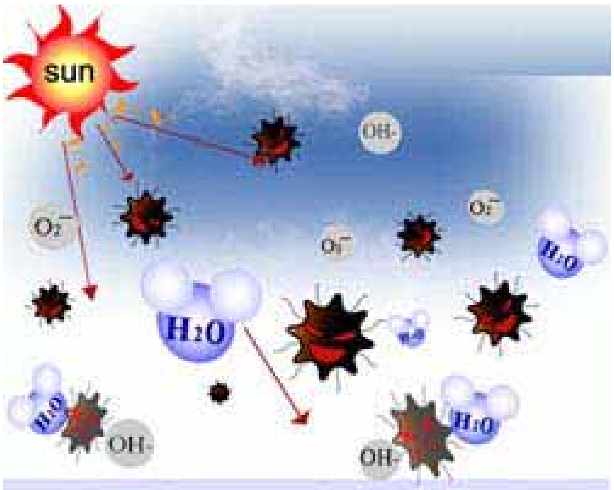
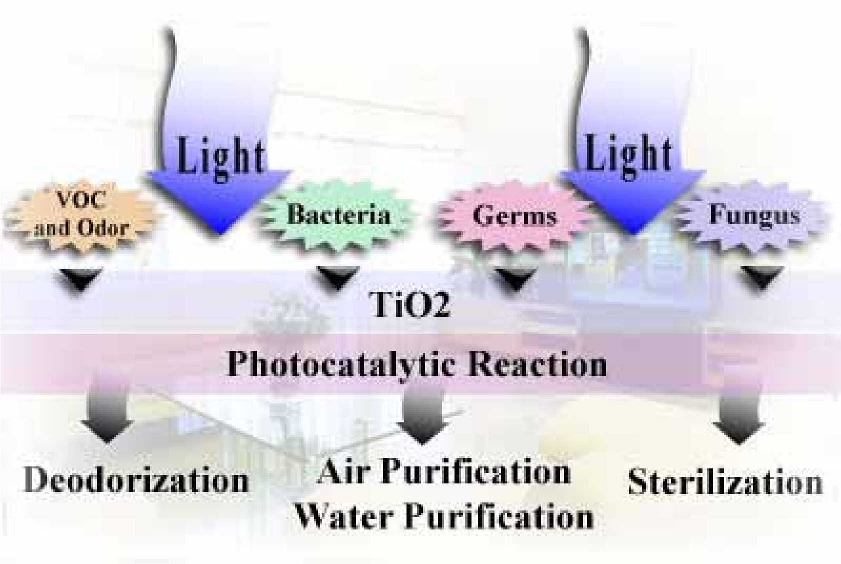
Utilizing the strong oxidation strength of hydroxyl radical, photocatalytic oxidation can effectively disinfect, deodorize, and purify air, water, and different surface area.



Photocatalyst TiO2

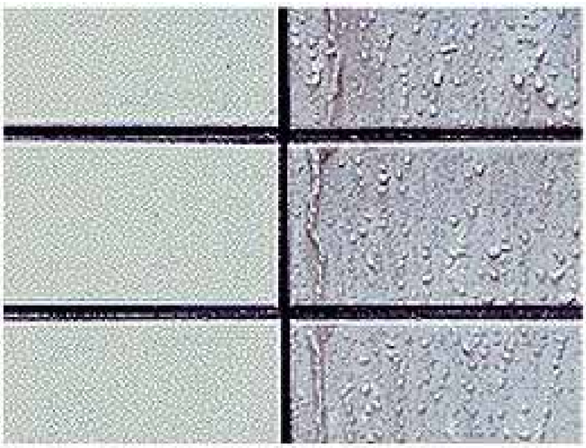
Photocatalyst accelerates the oxidation process in the atmosphere and decomposes any air borne toxic organic matter.



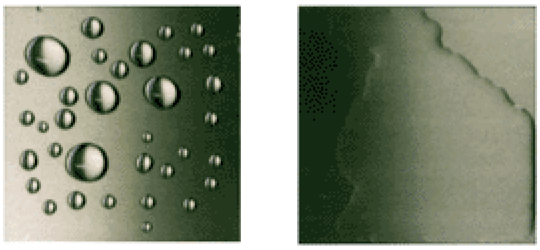
Super-Hydrophilic

When the surface of photocatalytic film is exposed to light, the contact angle of the phtocatalyst surface with water is reduced gradually. After enough exposure to light, the surface reaches super-hydrophilic. 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. And the water took the form of a highly uniform thin film, which behaves optically like a clear sheet of glass.

Fig. 1 Shape of waterdrops on the surfaces of glass, resin and hydrophobic resin

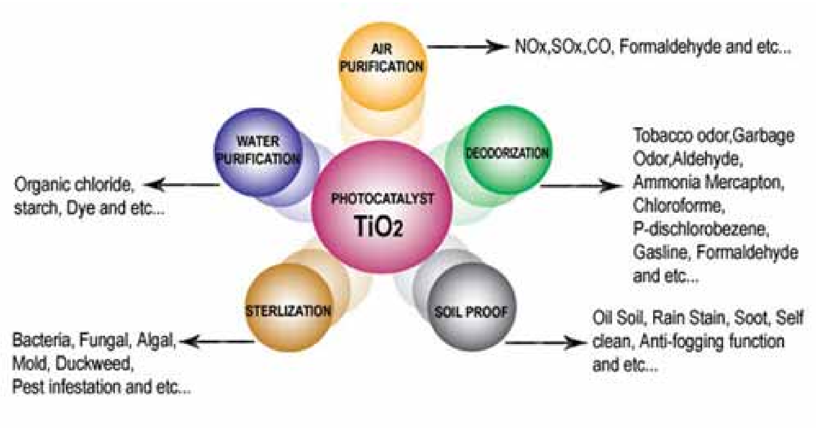


With Photocatalyst Coating Without Photocatalyst Coating



Before UV irradiation (waterdrops) — After UV irradiation (flatly spreading)

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.



1. Anti-Bacterial Effect

Photocatalyst does not only kill bacteria cells, but also decompose the cell itself. The titanium dioxide photocatalyst has been found to be more effective than any other antibacterial agent, because the photocatalytic reaction works even when there are cells covering the surface and while the bacteria are actively propagating. The end toxin produced at the death of cell is also expected to be decomposed by photocatalytic action. Titanium dioxide does not deteriorate and it shows a long-term anti-bacterial effect. Generally speaking, disinfections by titanium oxide is three times stronger than chlorine, and 1.5 times stronger than ozone.

2. Deodorizing Effect

On the deodorizing application, the hydroxyl radicals accelerate the breakdown of any Volatile Organic Compounds or VOCs 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. Some of the examples of odor molecules are: Tobacco odor, formaldehyde, nitrogen dioxide, urine and fecal odor, gasoline, and many other hydro carbon molecules in the atmosphere.

Air purifier with Ti02 can prevent smoke and soil, pollen, bacteria, virus and harmful gas as well as seize the free bacteria in the air by filtering percentage of 99.9% with the help of the highly oxidizing effect of photocatalyst (Ti02).

3. Air Purifying Effect

The photocatalytic reactivity of titanium oxides can be applied for the reduction or elimination of polluted compounds in air such as NOx, cigarette smoke, as well as volatile compounds arising from various construction materials. Also, high photocatalytic reactivity can be applied to protect lamp-houses and walls in tunneling, as well as to prevent white tents from becoming sooty and dark. Atmospheric constituents such as chlorofluorocarbons (CFCs) and CFC substitutes, greenhouse gases, and nitrogenous and sulfurous compounds undergo photochemical reactions either directly or indirectly in the presence of sunlight. In a polluted area, these pollutants can eventually be removed.

4. Anti fogging, Self-Cleaning

Most of the exterior walls of buildings become soiled from automotive exhaust fumes, which contain oily components. When the original building materials are coated with a photocatalyst, a protective film of titanium provides the self-cleaning building by becoming antistatic, super oxidative, and hydrophilic. The hydrocarbon from automotive exhaust is oxidized and the dirt on the walls washes away with rainfall, keeping the building exterior clean at all times.

5. Water Purification

Photocatalyst coupled with UV lights can oxidize organic pollutants into nontoxic materials, such as CO 2 and water and can disinfect certain bacteria. This technology is very effective at removing further hazardous organic compounds (TOCs) and at killing a variety of bacteria and some viruses in the secondary wastewater treatment. Pilot projects demonstrated that photocatalytic detoxification systems could effectively kill fecal coli form bacteria in secondary wastewater treatment.