Anti-bacterial

Photocatalytical active titanium dioxide is internationally recognized as one of the new sterilization materials, which can kill almost all kinds of bacteria and viruses including avian flu and SARS.

It has been widely used in places like hospitals, institutions, schools etc. were sterilization is most demanded. The **Anti-Virus-System** Photocatalyst has got a strong effect on killing almost all kinds of bacteria under the irradiation of light, which can be maintained for a very long time. It throughly decompose bacteria, its body and the endotoxin. Meanwhile, the photocatalyst can wipe out the indoor allergen to reduce the incidence of respiratory diseases.

Sterilization Mechanism of AntiVirus-System products.

Titanium dioxide itself has no toxicity to microbe and cell. It processes sterilization function only after the irradiation with UV- and visible light.

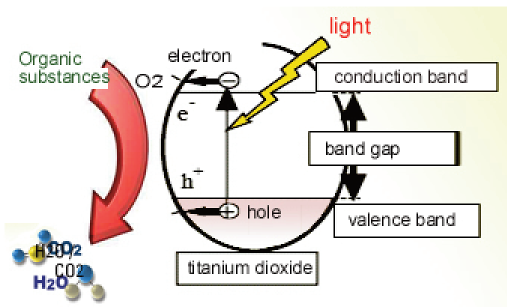
At the present of light, the very strong oxidizing power of titanium dioxide can destroy bacteria's cell wall and membrane, and react with cell component, which inhibits bacteria's activity and ultimately results in the death and decomposition of bacteria. The sterilization of TiO_2 photocatalyst presents the following 2 different biochemical mechanisms.

1. TiO_2 irradiated by light directly reacts with the cells

The electron-hole can directly react with cell wall, cell membrane and cell component. In the sterilizing process of microzyme and bacilli, CoA inside cell oxidized to CoA dimer loses its activity, which causes the respiration of the cell to stop and finally results in the death. During this process, the electron shift between the killed cell and TiO_2 is passed by CoA. Therefore the content of CoA decreases and CoA dimer increases.

2. Indirect sterilization reaction

That electron hole reacting with water will generate active oxygen such as hydroxyl radical. The electronic structure of titanium dioxide is characterized by filled valence band (VB) and empty conduction band (CB). The band gap energy is excited and an electron is promoted from the valence band (VB) to the conduction band (CB). Then an electron-hole pair is generated (electron e- and hole h+).



Typical Redox Potential of Microbe and cell (vs. SCE, PH=7)

Microbe cell	Concentration Cell/L	Redox Potential /V
Microzyme	1×10^{11}	0.74
Escherichia coli	1×10^{11}	0.72
Lactobacillus	5×10^{11}	0.68
Bacillus subtilis	2×10^{11}	0.68
Salmonella typhimurium	6×10^{11}	0.70

Cell component	Concentration Cell/L	Redox Potential /V
Microzyme extravasate	-	0.65
CoA	3.7×10^{3}	0.65
Reductive coenzyme	5.0×10^{3}	0.40
Cysteine	2.5×10^{3}	0.45
Protoplasm	-	0.67

Redox potential of nano TiO^2:
+ 2.6 (vs. SCE, PH=7)

The positive-hole of titanium dioxide breaks the water molecule apart to form hydrogen gas and hydroxyl radical. The negative-electron reacts with oxygen molecule to form a super oxide anion ($O_2^-\cdot$).
Super oxide anion can react with water molecule further, which generates hydroxyl radical peroxide (· OOH) and hydrogenperoxide (H_2O_2). Moreover, active hydroxyl radical can combine to form hydrogen peroxide. This cycle continues when light is available.

The active hydroxyl radical, super oxide anion, peroxide hydroxyl radical and hydrogen peroxide can react with biomacromolecules such as protein enzyme and lipid, which will destroy the cell structure. They react with cell-wall, membrane and its component.

OH for example.

It can provide unsaturated bond or take out its atom H from organic matters.

$$R3CH + \cdot OH \longrightarrow R_3C + H_2O$$

The new free radical will cause at the chain reaction, which will lead to the qualitative change of bacterial protein and the total decomposition of lipid. The bacteria is decomposed and killed at once.

Therefore, the electron hole and $\cdot$ OH,$O_2^-\cdot$, $HO_2\cdot$, H_2O_2 formed on the surface of titanium dioxide can react with cell wall, membrane and its component to kill the cell.

In the sol, the titanium dioxide particles absorb on the surface of animalcule cells or are swallowed by the cells. As to particles swallowed by cells, electron hole and active oxygen ($\cdot$ OH, O −2 $\cdot$, $HO_2\cdot$, H_2O_2) will react directly with cytologic histological elements, which improves sterilization effect.

The positive-hole of titanium dioxide irradiated by light is an extremely strong oxidation agent, the oxygen reacted is also very active.

As a result, titanium dioxide can effectively kill escherichia coli, lactobacillus, bacillus subtilis, etc. Furthermore, it can inhibit or prevent the growth of malignant cells and even kill greenalgae.

Due to function of strong sterilization and malignant cells preventing, titanium dioxide is supposed to be used in indoor antisepsis and sterilization, watertreatment, water pollution and comprehensive management.

Actually, photocatalytic sterilization is supposed to constantly work between bacteria and titanium dioxide instead of simple surface reaction as photocatalytic degradation. As the active hydroxyl radical cannot longtime exist and cannot enter cell membrane to destroy cell structure, the sterilization effect is the result of hydroxyl radical and other active oxygen

($O_2\cdot$, $\cdot$ OOH, H_2O_2).

Since H_2O_2 can enter cell wall, it not only kills the bacteria but also decomposes lipoid like endotoxin released by its death. In addition, it can exist stably for a long time, so H_2O_2 can be the most important reaction medium in photocatalytic sterilization. Of course, the reaction also includes other active oxygen, and H_2O_2 is not the only reactant. The active hydroxyl radical performs strong oxidation inside the cell, which improves its sterilization effect greatly.

Antiseptics Comparison

The traditional antiseptics are divided into the followingthree ones, including organic antiseptic, inorganic antiseptic and natural antiseptic.There are two kinds of inorganicantiseptics, one is to use its strong oxidant ability to kill bacteria and fungus; the other is by means of metal ion. It can effectively kill germ, however the antiseptics themselves like chlorine, chlorineoxide are bad for people's health. The metal ionantiseptics can't continue to decompose the germ body after killing them. Thus the germ body coats the metal ion,which will greatly affect its antibacterial efficiency.

The organic antiseptics compounded by scientific chemical methods usually kill germ quickly, but the germ can adapt itself to organic antiseptics easily. Meanwhile the sterilization brings toxic substances.

	Advantages	**Disadvantages**	**Typical products**
Inorganic Antiseptic	Heat-resistant, wide range of sterilization and no need of light	The silver- antiseptics s are easy to change color, and surface coated with germ body will affect the result.	Silver-zeolite, phosphate, silver silica gel
Organic Antiseptic	Fast and wide range of sterilization, low price	Not heat-resistant, fast-drug, produce toxic substances, have pollution	Phenol
Natural Antiseptic	High effect of sterilization, safety to human, no pollution	Not heat-resistant, difficult in processing the raw material	Chitosan, Sorbic Acid
Photocatalyst	Wide range of sterilization, high and everlasting effect, decomposition of germ body and endotoxin, safety, no pollution, harmless to human beings	Visible light required	**Titanium dioxide based photocatalyst**