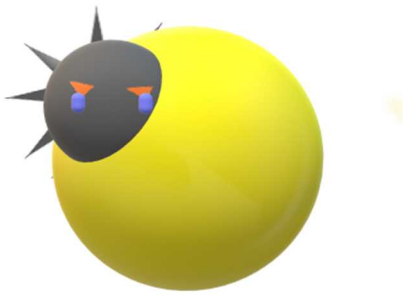
Let’s update to a world where viruses are automatically removed by light-driven antivirus hardware.



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Covid-19 spread to households shortly after its onset was confirmed in December 2019, and as of May 2021, the world remains a pandemic. Vaccines have been developed, but their effectiveness is not sufficient, and it is possible that another virus will not appear next. As a chemistry-related researcher, I thought about how to deal with this problem from a chemistry perspective.

Have you ever heard of the word photocatalyst? A photocatalyst is a substance that promotes a chemical reaction by exposing it to light, and the discovery of the Honda-Fujishima effect on titanium oxide announced in 1972[1)] has received a great deal of attention in the scientific world. In this paper, it was shown that hydrogen and oxygen are generated from water by irradiating titanium oxide with light, and interest as one of the solutions to the energy problem has increased. However, contrary to the initial response that was announced, the results have not been widely accepted in the general society.

There is a problem that only ultraviolet rays can be used for the photocatalytic action of titanium oxide. Most of the ultraviolet rays contained in the sun are absorbed by ozone and oxygen, and the amount of ultraviolet rays that reach the surface of the earth is about 0.1%. It was not possible to generate a practically enough energy for the general public from such a small amount of ultraviolet rays.

So far, I have described failures in the use of titanium oxide as a photocatalyst for the generation of energy sources, but the main subject is from here. Titanium oxide has another aspect of having the effect of decomposing organic matter.

When water and organic matter are present on the surface of the photocatalyst, the organic matter is decomposed in preference to water. As some readers may have noticed that the term decomposes organic matter, viruses are also organic matter and are also decomposed by titanium oxide.

Here is another paper[2)]. The content of this paper is that by modifying titanium oxide with titanium nanoparticles and copper nanoparticles or iron nanoparticles, a photocatalytic reaction can be caused with high reaction efficiency by visible light(It is reported that 99.2% of the visible light emitted to titanium oxide was used for

photodecomposition). There is also a paper showing that the virus can be decomposed with visible light by using titanium oxide modified with nanoparticles in this way.

What if titanium oxide with these metal nanoparticles could be applied to the walls of the room? The virus on the wall will be automatically decomposed just by exposing it to indoor light. You could paint it on the railings of train stations, hospital walls, window glass, keyboards, and smartphones. Titanium oxide is colorless and transparent if it is a thin film, so you can make everything around you into 'light-driven antivirus hardware' by applying it to without damaging the landscape.

Since the photocatalytic reaction that does not choose the reaction partner does not depend on the type of virus, it is an effective method not only for Covid-19 but also for various viruses.

Now that you know the potential of photocatalysts, some readers may be wondering why titanium oxide exhibits photocatalytic activity. I will explain it briefly below.

When light is applied to titanium oxide, the highest energy electron in titanium oxide receives the energy and becomes an electron with higher energy. This high-energy electron stays in that state for a certain period, and when oxygen comes here, it hands over the electron. Here, in other words, titanium oxide lost one electron, but since this state is unstable, it steals electrons from nearby organic matter and water. The process by which titanium oxide gives electrons to oxygen is called reduction, and the reaction of taking electrons from organic matter and water is called oxidation. When organic matter is oxidized, it undergoes another unstable state and finally becomes carbon dioxide, and when water is oxidized, it is decomposed into hydrogen and oxygen. Titanium oxide is a type of semiconductor, and some semiconductors absorb light like titanium oxide.

In semiconductors other than titanium oxide, electrons in a high-energy state generated by light absorption return to their original state on a very short time scale of nanoseconds, but in titanium oxide, the time to return to the original state is microseconds.

That is, titanium oxide has a greater ability to retain electrons in high energy states than other similar substances, which is why titanium oxide exhibits a special photocatalytic effect. Further, when transition metal nanoparticles such as copper are attached to titanium oxide, the electrons generated by irradiating titanium oxide with light are retained in place of titanium oxide. At this time, transition metals such as copper retain electrons in a state of lower energy than titanium oxide, so that light can be absorbed even with visible light. Those who are curious about the details of the principle should investigate titanium oxide. You will surely find interesting properties other than photocatalyst.

That concludes essay. In the future, it will become common for everything around us

to have a photocatalytic function, and even if we go to a restaurant, we may not need to disinfect the table with alcohol.

references

1) A Fujishima, K Honda, Electrochemical photolysis of water at a semiconductor electrode, nature, 238 (5358), 37-38
2) Min Liu, et. al. Enhanced Photoactivity with Nanocluster-Grafted Titanium Dioxide Photocatalysts, ACS nano, 2014, 8, 7, 7229–7238