PRESS RELEASE

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Scientists Develop Indoor-active Photocatalyst for Antiviral Coating Against Various Variant Types of Novel Coronavirus SARS-CoV-2

(Japan, April 14) **Photocatalyst made using a combination of titanium dioxide (TiO_2) and copper oxide (Cu_xO) nanoclusters inactivates various variant types of novel coronavirus SARS-CoV-2. Scientists in Nara Medical University, Kanagawa Institute of Industrial Science and Technology, and Tokyo Institute of Technology have developed this antiviral photocatalyst, in a recent breakthrough, which has been proven to be effective under both darkness and indoor light.**

Highlights

- ✓ Cu_xO/TiO_2 inactivates various variant types (Alfa, Beta, Gamma, and Delta) of SARS-CoV-2 below their detection limit for 2 h under visible light irradiation (Figure 1).
- ✓ Cu_xO/TiO_2 also exhibits the antiviral activity even under dark conditions.
- ✓ Antiviral activity on Cu_xO/TiO_2 is caused by denaturation of spike proteins and RNA fragmentation of SARS-CoV-2 viruses.

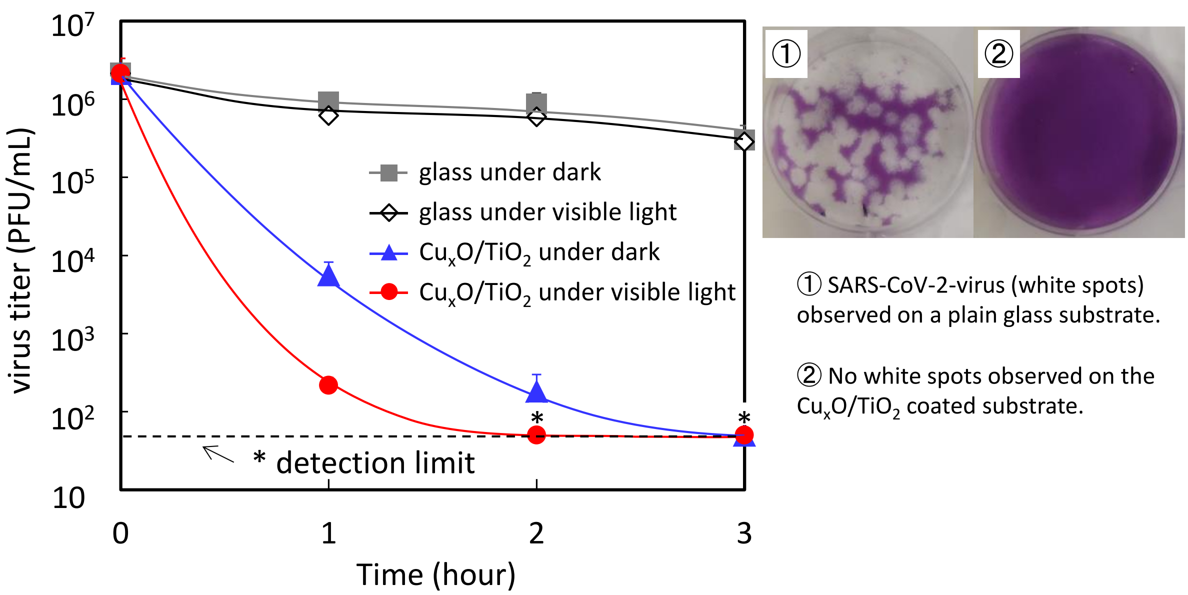

Figure 1: Antiviral effect towards Delta valiant of SARS-CoV-2 by the photocatalyst coating under light and dark conditions

The TiO_2/Cu_xO coating inactivates viruses even under dark condition. Its antiviral activity is further enhanced by visible light irradiation.

Image credit: Ryuichi Nakano from Nara Medical University

The novel coronavirus (SARS-CoV-2), responsible for the ongoing COVID-19 pandemic, has affected millions of people worldwide. The main transmission pathway of the virus is through droplets released by infected people into the air. Additionally, these droplets exist on various surfaces as well. Viral infections mainly occur in indoor environments where many people gather, Antiviral chemicals, such as alcohol and hydrogen peroxide, are often used to decontaminate regularly touched surfaces. These chemicals essentially render the virus inactive by breaking down their proteins. However, these chemicals are volatile in nature and, therefore evaporate away. As a result, the disinfection process has to be carried out regularly.

Now in a study published in *Scientific Reports*, a research team of Nara Medical University, Kanagawa Institute of Industrial Science and Technology, and Tokyo Institute of Technology has developed a solid-state photocatalyst as an alternative defense against the virus. Unlike chemical disinfectants, solid-state coatings remain for a long time, and since the viral outbreak, have been the subject of intensive research around the world. Solid-state antiviral coatings have the advantage of being non-toxic, abundant, and chemically and thermally stable.

Many of these solid-state coatings use TiO_2 photocatalysts that, when exposed to ultraviolet (UV) light, cause oxidation reaction that can destroy organic matter like the spike proteins found on the surfaces of coronaviruses. However, these coatings are activated only when exposed to UV light, which is not present in typical indoor environments. In most of indoor environments, lightings are usually turned off in the night time, thus the antiviral material under dark condition is desired.

To get the coating to work under visible light as well dark conditions, the team has developed a composite consisting of TiO_2 and Cu_xO nanoclusters (Figure 2). Cu_xO nanoclusters are composed of a mixed valence number oxide, in which Cu(I) and Cu(II) species are present. The Cu(II) species in Cu_xO contributes to the visible-light-driven photocatalysis reaction, whereas the Cu(I) species plays a crucial role in denaturing virus proteins, thereby causing their inactivation under dark conditions.

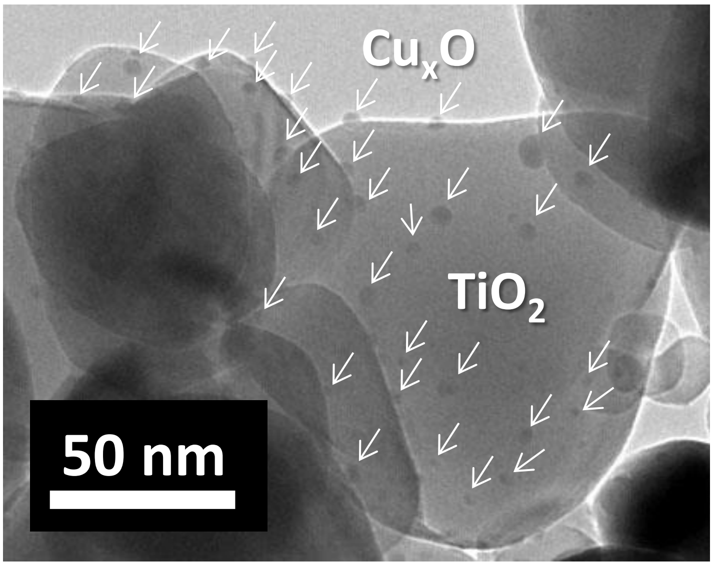

Figure 2. TEM image of copper oxide/titanium oxide composite (Cu_xO/TiO_2)
Small Cu_xO nanoclasters are grafted on TiO_2 particles.
Image credit: Masahiro Miyauchi from Tokyo Institute of Technology

By coating the Cu_xO/TiO_2 powder on a glass, the team showed that it could inactivate even the highly virulent Delta variant of SARS-CoV-2 as shown in Figure 1. The team has also confirmed the inactivation of Alfa, Beta, and Gamma variants by Cu_xO/TiO_2 in addition to the wild type strain.

The team carefully investigated the antiviral mechanism using sodium dodecyl sulfate-polyacrylamide gel electrophoresis (SDS-PAGE), ELISA assay, and RT-qPCR analysis. These analyses strongly suggest that the Cu(I) species in Cu_xO denaturalises spike proteins and also causes RNA fragmentation of SARS-CoV-2, even under dark condition (Figure 3). Furthermore, white light irradiation causes the photocatalytic oxidation of the organic molecules of SARS-CoV-2. Based on this antiviral mechanism, the present antiviral material is not limited to a specific variant of the virus and will be effective to inactivate various types of a potential mutant strain.

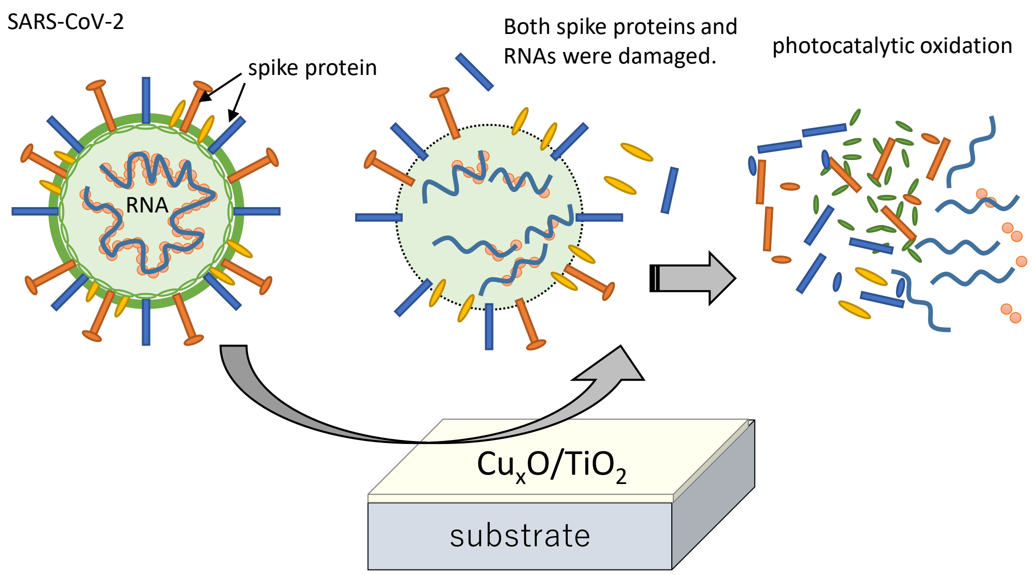

Figure 3. The proposed antiviral mechanism of the photocatalyst coating
The TiO_2/Cu_xO coating inactivates the virus by fragmenting and oxidizing spike proteins and RNAs of SARS-CoV-2.
Image credit: Ryuichi Nakano from Nara Medical University

White light illumination in the present study is usually used as an indoor light apparatus. This can make the Cu_xO/TiO_2 photocatalyst very effective in reducing the risk of COVID-19 infection in indoor environments, which are usually subjected to both light and darkness periodically.

Hopefully, this study will take us one step closer to protecting ourselves better against the coronavirus, and adjusting to the post-COVID era.

Reference

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About Nara Medical University

A prefectural medical vocational school was established in Nara in April 1945 and was transformed into the predecessor of Nara Medical University in 1948. It was then reorganized into the present Nara Medical University in 1952. Nara Medical University College of Nursing was established in 1996, and it was re-organized as the Faculty of Nursing, School of Medicine, Nara Medical University in 2004. Since then, Nara Medical University has been steadily advancing as a medical university with the Faculty of Medicine and the Faculty of Nursing, School of Medicine.
https://www.naramed-u.ac.jp/university/english/

About Kanagawa Institute of Industrial Science and Technology

Kanagawa Institute of Industrial Science and Technology ("KISTEC") is a local incorporated administrative agency established in April 2017. KISTEC has been founded by merger of public test and research institute Kanagawa Industrial Technology Center ("KITC") and public interest incorporated foundation Kanagawa Academy of Science and Technology ("KAST"). We promote regional industry and science and technology, utilizing the mutual advantages of KITC’s technical support capability and KAST’s research and development capability. And we also try to make the residents’ lives more enriched, and to fulfill the needs of our users, with five main activities; “Research and Development”, “Technical Support”, “Commercialization Support”, “Personnel Training”, and “Collaborative Network”.

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