NewsRelease

NIPPON SHOKUBAI

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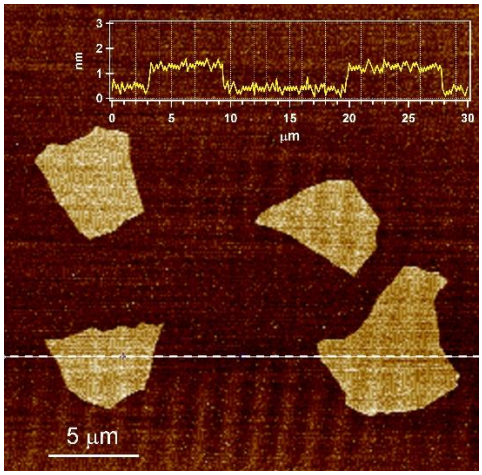
Development of an antibacterial and antiviral graphene oxide composite membrane with high water resistance

– Inactivating various bacteria and viruses including SARS-CoV-2, to improve wet area sanitation –

NIPPON SHOKUBAI CO., LTD. (Headquarters: Osaka, Japan, President: Yujiro Goto, hereinafter "Nippon Shokubai") and a group led by Dr. Hirofumi Miyaji from the Department of Endodontics and Periodontics, Hokkaido University Hospital, have developed a graphene oxide composite membrane with inactivation effects on various bacteria and viruses including SARS-CoV-2, which causes COVID-19. The graphene oxide composite membrane comprising graphene oxide and an antibacterial/antiviral agent can function as an antibacterial/antiviral membrane even in a wet environment.

[Characteristics of the graphene oxide composite membrane]

- Useful in environments requiring both water resistance and antibacterial/antiviral properties
- Selectable for various antibacterial/antiviral agents
- Colorless and transparent, without losing the color tone of the base material



Graphene oxide is a type of nanocarbon material and has a high aspect ratio sheet structure with 1 nm thickness and several micrometers width (Fig. 1). The effectiveness of graphene oxide has been confirmed in various uses, and it is expected to be put into application in a wide range of fields. However, mass production on an industrial scale has been difficult. Using our techniques to safely and stably control chemical reactions in chemical production that we have accumulated to this day, Nippon Shokubai has solved various issues in graphene oxide mass production, and established mass production technology.

Fig.1 Atomic force microscope image of graphene oxide

Graphene oxide has a high adhesiveness to various base materials, and also strongly interacts with various molecules, polymers, etc. by utilizing its shape and rich oxygen-functional groups. Utilizing these properties of Graphene oxide, it can improve the interaction between the base material and substances which have low adhesive properties. Therefore it can lead to water resistance and long-term stability (Fig. 2).

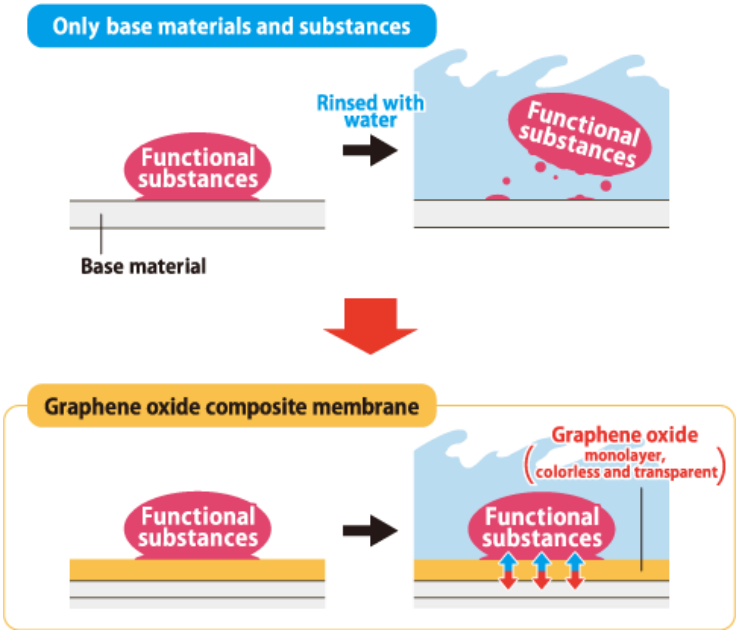


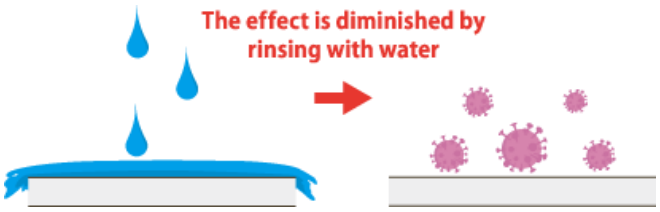
Fig. 2 Schematic diagram of the interaction between base materials and substances with graphene oxide

In the field of antibacterial/antiviral agents and applications, it has been necessary to develop a technology that exhibits antibacterial/antiviral effects with long-term stability and high water resistance by a simple method. However, general disinfection methods and antimicrobial/antiviral methods have a low water resistance, making it difficult to maintain antimicrobial/antiviral effects in a wet environment.

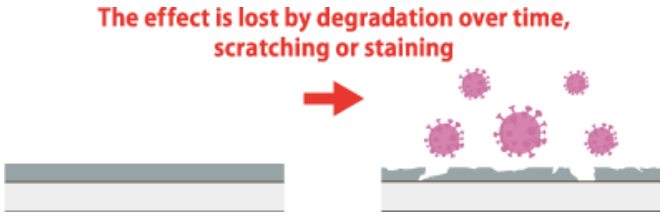
Nippon Shokubai and Dr. Miyaji's group developed the composite membrane combining graphene oxide and antibacterial/antiviral agents such as benzalkonium chloride. We confirmed that the composite membrane has a strong intercalation between the antibacterial/antiviral agents and the base material across the graphene oxide. From this effect, the antibacterial/antiviral agents on graphene oxide were reinforced even in a wet environment therefore, the composite membrane works as an antibacterial/antiviral membrane with resistance to water washing and wetting (Fig.3). Furthermore, the graphene oxide membrane is a colorless and transparent monolayer membrane, and does not reduce the color tones of various base materials (Fig. 4).

General disinfection and antibacterial methods

Disinfection with alcohol, hypochlorous acid, etc.
Problem: Strong disinfection effect, but displays immediately evaporating and decreasing antibacterial/antiviral properties.
This requires disinfection many times every day, damaging the base material.



Cleaning/washing with a disinfecting detergent, etc.
Problem: This is a general method of daily cleaning which has a strong disinfection effect, but the effect decreases easily by rinsing off with water.
It is difficult to maintain the antibacterial/antiviral properties in wet areas.



Antibacterial/antiviral coating (photocatalyst, etc.)
Problem: It requires a coating at the time of laying. It needs light irradiation, and the effect is limited.
It is difficult to regenerate the effect after deterioration by staining and scratching.

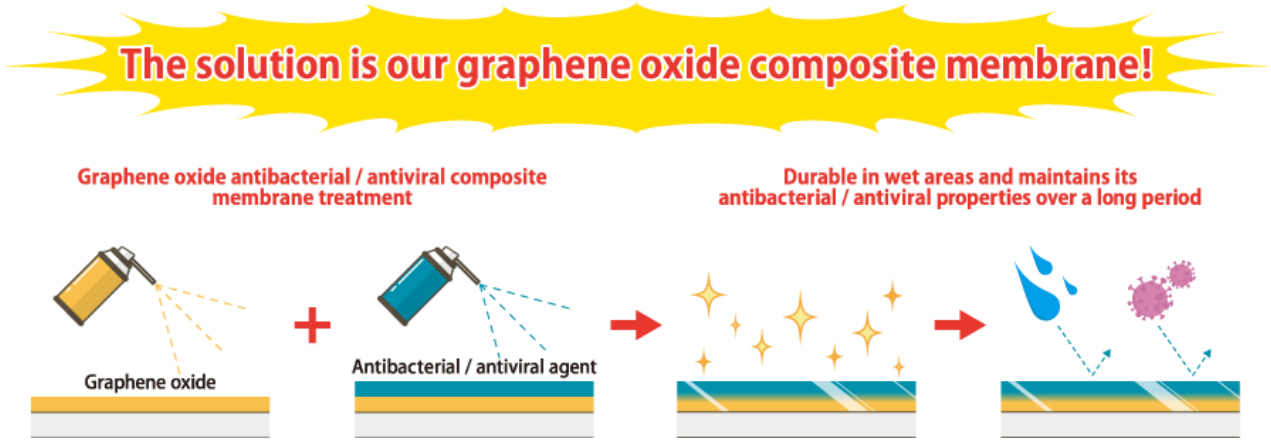


Fig. 3 Effects of the graphene oxide composite membrane developed by Nippon Shokubai and Dr. Miyaji's group

Fig. 4 Graphene oxide composite membrane on glass (transmittance of light with 600 nm wavelength: 99% or higher) Left: Pristine glass substrate. Right: After graphene oxide composite membrane treatment

To further verify its antibacterial/antiviral properties, Nippon Shokubai and Dr. Miyaji's group conducted an antiviral property evaluation using the novel coronavirus (SARS-CoV-2 which causes COVID-19).

[Experimental method]

The antibacterial/antiviral capacity of the following four samples after washing with water was analyzed for antibacterial/antiviral capacity.

- Substrate only (control, with washing)
- Only graphene oxide on substrate (with washing)
- Only benzalkonium chloride on substrate (with washing)
- Graphene oxide-benzalkonium chloride composite membrane on substrate (with washing)

[Results]

Only the graphene oxide-benzalkonium chloride composite membrane shows a strong antiviral effect, and the effect with graphene oxide only or benzalkonium chloride only was weaker (Fig. 5). It shows that the water resistance is improved by compositing graphene oxide and antibacterial/antiviral agents.

We also confirmed that the graphene oxide composite membrane remains even in the sample that was stored in water for 1 month.

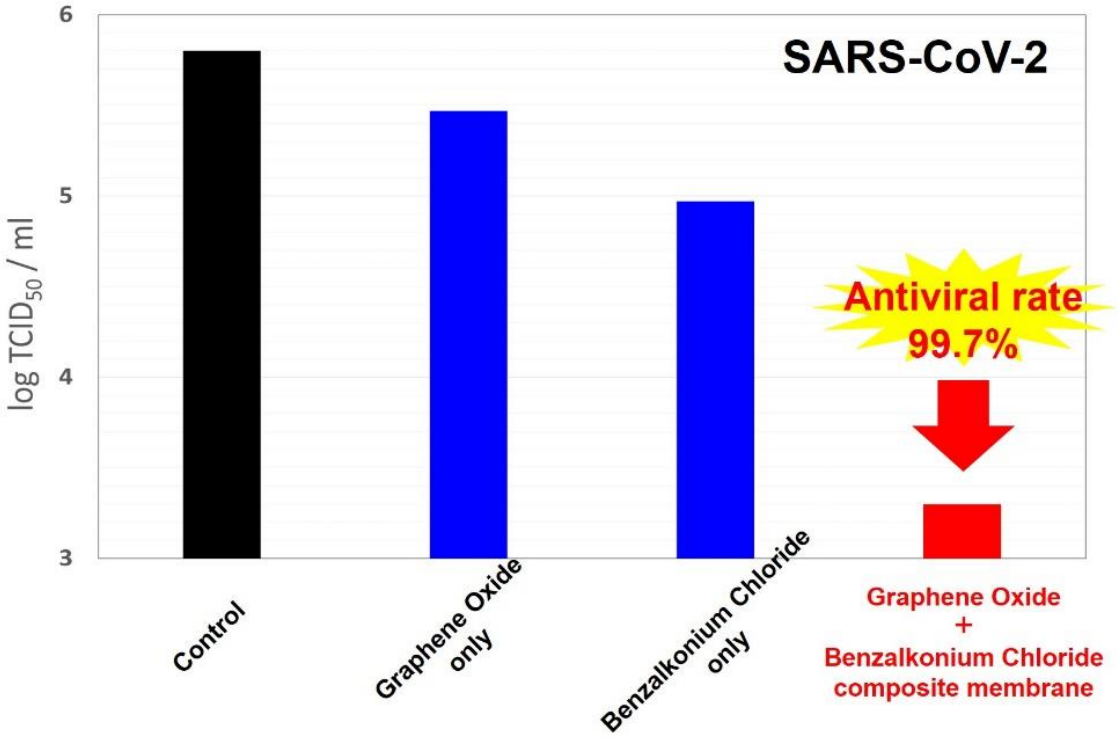


Fig. 5 Anti-coronavirus result of samples after rinsing with water (infectivity titer after culturing for 24 hours)

The graphene oxide composite membrane can be applied to a wide range of bacteria and virus species, because graphene oxide can be combined with various antibacterial/antiviral agents

selected to suit the target bacteria or virus.
Utilizing this colorless and transparent graphene oxide composite membrane, it is expected that the antibacterial/antiviral effects can be maintained for a long period without losing the color tone of base materials, even with environments or materials for which both water resistance and antibacterial/antiviral properties are required. Graphene oxide composite membranes can be applied to wet area environments such as sinks and bathrooms, and window glass and sashes which tend to have condensation. We continue improve the composite membrane.

※The effect was confirmed with the substrate and conditions in which the experiment was conducted this time, and the same effect cannot be obtained with all materials and wet environments.

About NIPPON SHOKUBAI Co., Ltd. (Headquarters: Osaka, Japan, President: Yujiro Goto)
Since 1941, Nippon Shokubai has developed its business with unique catalyst technologies. Nippon Shokubai has supplied, for example, ethylene oxide, acrylic acid, automobile catalysts, and process catalysts. Among these, our global market share of superabsorbent polymer is currently the largest in the world (according to our research in 2020). Nippon Shokubai is a global chemical company operating under its corporate mission of "Providing affluence and comfort to people and society with our unique technology."
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