ChemicalTechnology

Strong & durable sterilization by improved photocatalyst

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Background

Photocatalytic reaction has turned out to be too slow and benign for practical sterilization purposes. Main reason is the unexpectedly low density of active oxygen arose from this reaction under the natural environment. Therefore some supplemental measures must be taken to make this reaction actually practical for the public hygiene or healthcare. We adopted metallic fine copper powder as the supplemental ingredient with perfectly sufficient results so far. Thus together with Nafion resin we have successfully invented new photocatalytic coating (Hereafter referred to "NFE2")

Theory & Outline

We have chosen copper ion Cu^{2+} to attain strong sterilization function in place of active oxygen such as hydrogen peroxide H_2O_2 and for this durable supply source adopted fine copper Cu powder.

Fundamental reaction of the photocatalyst TiO_2

Anodic reaction

$H_2O \rightarrow 2H^+ + 1/2O_2 + 2e$

Cathodic reaction

$O_2 + 2H^+ + 2e \rightarrow 2OH\cdot$

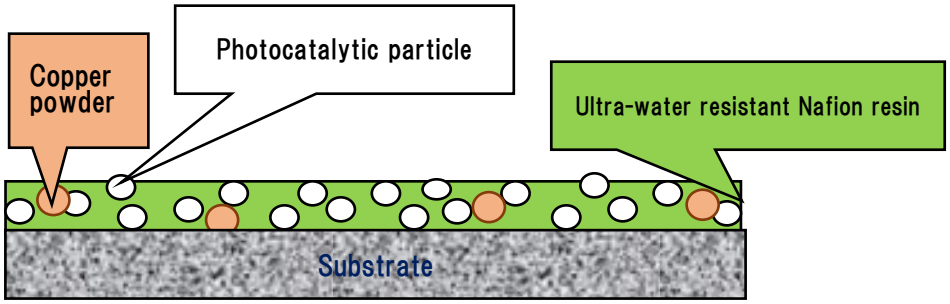
$2OH\cdot \rightarrow H_2O_2$

Our supplemental reaction

$$Cu + H_2O_2 \rightarrow Cu^{2+} + 2OH^-$$

Generated oxygen peroxide then reacts with metallic powder Cu thus arise strong Cu^{2+} slowly into the Nafion made photocatalytic layer. Copper ion concentration in the layer will become high enough in the cause of photocatalytic reaction to eradicate all kind of microorganism while only non-hazardous small amount will be dispersed in the environment thanks to the cation exchange nature of Nafion adopted as the binder of this coating. Only intermittent irradiation is necessary for this function to continue as copper ion Cu^{2+} will accumulate without any major consumption in the ordinary circumstance.

Cross Sectional Structure of this photocatalytic coating layer



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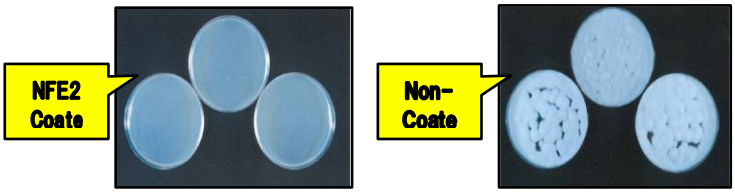
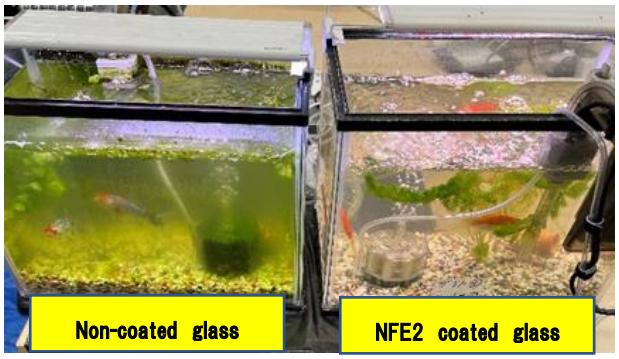
Case Study 1 Mold control



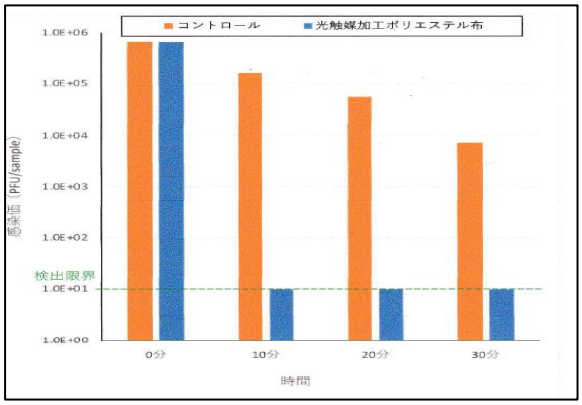
Coated surface shows strong mold control function against Penicillium, Cladosporium and even Trychophyton fungus. As already mentioned it can be detected immediately and with persistence unlike any conventional photocatalytic coating.

Case Study 2 Algae control



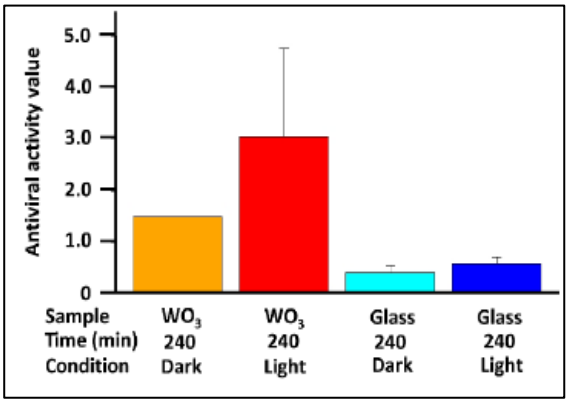
This effect can be expected from the beginning as copper ion Cu^{2+} has long been applied just for this purpose. But superb water resistance is derived from the peculiar nature of Dupont made fluoropolymer Nafion, with has been otherwise widely adopted currently as the solid electrolyte of fuel cells.

Case Study 3 General virus control



We have tested this NFE2 coated surface against various viruses including flu and norovirus. The latter is a notoriously resilient non-envelope type but disappeared within 1hour. We have already confirmed its effectiveness against initial COVID-19 by the cooperation of Nara Medical College, of which result shows the inactivation of this virus within 15min.

Case Study 4 Against Omicron variant



In the improving process of this coating we can fortunately accept the cooperation of University of Tokyo team to clarify the effectiveness against Omicron variant. We adopted this time WO_3 in place of TiO_2 to dramatically improve the activity under weak or dim irradiation, which should be necessary for the application to medical facilities in general. The result was quite satisfactory.