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Design of Effective Photosterilization Field with Titanium Dioxide under Common Light Sources: Enhancement of Deactivation Activity Based on Synergy Effect of NaCl

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Summary

For maintaining our surroundings biologically clean, in recent years, TiO_2 photosterilization has attracted increasing attention because of its stable and strong oxidative power yielding biocidal activity. In a practical aspect of TiO_2 photosterilization system, it should be a problem to be solved that UV rays effective for photo-exciting TiO_2 are very weak in living-based light sources such as a white light fluorescent lamp, which is an obstacle to realize sufficient biocidal activity of TiO_2 for inactivating biohazardous microorganisms and viruses. It has been reported that the enhancement of photocatalytic activity of TiO_2 took place through converting photo-generated H_2O_2 into more reactive •OH via copper-mediated Fenton-type reactions. In the present study, the deactivation of phage was examined using photocatalytic TiO_2 thin films with copper under an ambient lighting condition with a white light fluorescent lamp and the synergy effect of inorganic salts on the deactivation activity.

The copper-aided photo-deactivation of *Escherichia* coli phage was tested on TiO_2 thin films under a illuminating condition of poor UV rays with a white light fluorescent lamp. It was found that the deactivation activity of TiO_2 thin film with $CuCl_2$ was remarkably enhanced with the coexistence of NaCl. However, the coexistence of $CuCl_2$ and NaCl did not affect the deactivation activity on a glass plate without TiO_2, indicating that four factors, i.e., $CuCl_2$, NaCl, TiO_2 and light, were requisite for the enhancement of photo-deactivation activity under an ambient lighting condition. Next, the effect of coexistence of KCl or $NaNO_3$ on the deactivation activity was examined to clarify contribution of Na^+ and Cl^-. An equivalent increase in activity was observed in the case of KCl addition, whereas $NaNO_3$ addition was not effective for the increase in activity, indicating that existence of Cl^- is essential to encourage the activity. Assuming that Cu^{2+} is reduced to Cu^+ by receiving electron from photo-excited TiO_2 and then Cu^+ reacts with photocatalysis-derived H_2O_2 to produce •OH via a Fenton-like reaction, we proposed a possible mechanism that Cl^- stabilizes Cu^+ through complex ion formation and thereby enhances the Fenton-like reaction.