Antibacterial and Anticorrosion Effects of Titanium Dioxide Photoactive coatings.

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Titanium dioxide has become a popular photocatalyst material for both air and water purification. It has been also shown to be very active for bacterial destruction even under limited UV light available in regular fluorescent lights. Several commercial products have been developed based on this technology for antibacterial applications in hospital and other bacteria prone environments. We have been working on the development of transparent coating for self-cleaning, self-sterilizing and antifogging applications. Recently, we have focused on developing metal-modified TiO_2 coatings for the purpose of enhancing their antibacterial activity and to make these coatings work even in dark. Also, we have developed WO_3-coupled TiO_2 coatings for anticorrosion photoprotective coatings on metal. Again the purpose is to retain their anticorrosion activity even when the light is turned off. We present these two aspects of TiO_2 photoactive coatings.

We have developed nanoporous TiO_2 films modified with antibacterial metal particles such as Cu and Ag. Interestingly, the Ag and Cu particles were deposited photocatalytically on TiO_2 surface. Apart from improving the photocatalytic activity, these metals, which act as antibacterial agents, made the fabrication of highly efficient antibacterial coatings possible. For example, the anti bacterial tiles based this technology work effectively both under dark and illumination conditions, the effect being much higher under light. We have extended this technique to fabricate photocatalytically modified Ag-TiO_2 coatings on silicone catheters and medical tubes, which effectively sterilize the microorganisms under dark conditions. Such coatings are useful for in-dwelling catheters, which are used inside the body, where guiding of light is a problem.

If TiO_2 is in contact with a metal, irradiated TiO_2 injects electrons to the metal through the conduction band, as a result, the potential of the metal can be changed to the flatband potential of TiO_2. If the potential is more negative than the oxidation potential of the metal, the metal can be protected against corrosion. This principle is schematically illustrated in Figure 1. We have made TiO_2-WO_3 coatings on stainless steel to examine the anticorrosion effect under light and dark conditions.

The photopotential of the TiO_2-coated sample was -0.4 V vs. Ag/AgCl, which was found to be much less positive than the corrosion potential for the bare 304 stainless steel (+0.2 V vs. Ag/AgCl). This suggests that TiO_2 can protect the 304 stainless steel from corrosion. The photopotential of this TiO_2–coated stainless steel was very stable and did not change at least for 15 hours. The photoanodic reaction proceeding at TiO_2 should be the oxidation of H_2O by the photogenerated holes in the valence band.

Figure 2 (curve a) shows that the potential of the stainless steel plate fully coated with TiO_2 was about –400 mV. After the UV light was turned off, the potential was shifted in a few minutes to the corrosion potential of the stainless steel (-0.1 to 0.0 V). In contrast, the potential of the stainless steel plate coated with TiO_2 and WO_3 was more negative than the corrosion potential for a few hours even after the light was turned off (Figure 2, curve b). These results indicate the anti-corrosion effect of the TiO_2-WO_3 system after dark.

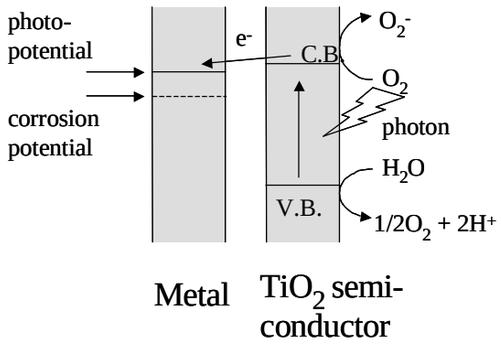

Figure 1 Mechanism of the photoelectrochemical anti-corrosion effect of TiO_2 for metals

Figure 2. Changes of the potential of a type 304 stainless steel coated with (a) TiO_2 and (b)TiO_2-WO_3 (single coating in a 3wt% NaCl solution, pH 5.