Corrosion Resistance and Antibacterial Activity Performances of Ni-TiO_2 Composite Coatings

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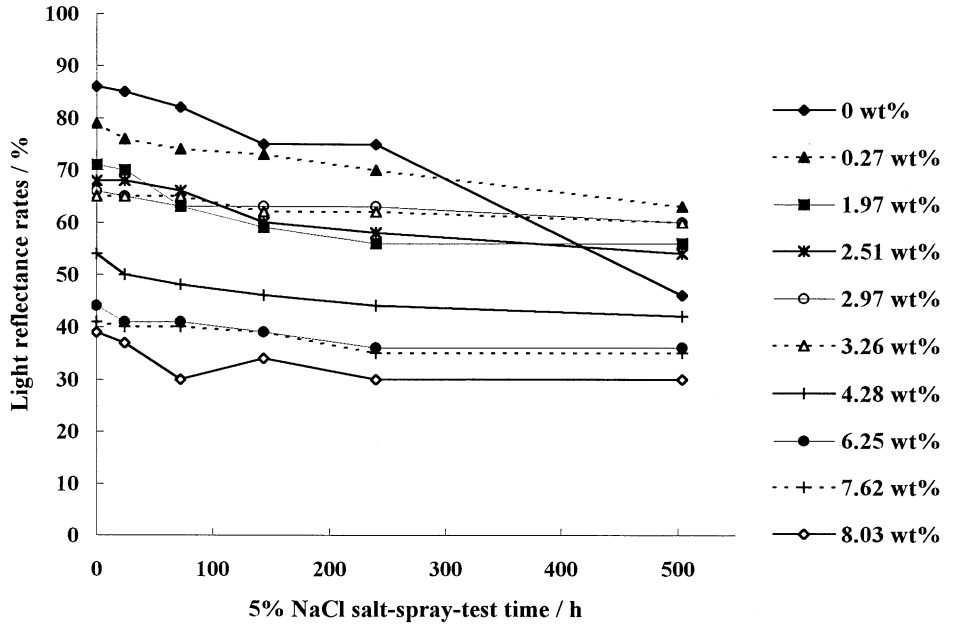
The novel properties for the corrosion resistance in a 5% NaCl salt-spray-test and the inhibitory capability of Ni-TiO_2 composite coating for the growth of pathogenic bacteria (*E. faecalis*, *E. coli*, and *P. aeruginosa*), under fluorescent irradiation and using a "drop-method" antibacterial experiment was set forth in this paper. The antibacterial activity of Ni-TiO_2 composite coating became more significant by increasing the TiO_2 contents in the composite coatings.

Our previous investigations have shown that corrosion resistance coatings always resulted in weak antibacterial activity. Whereas, although the coatings possessed a significant inhibition capability for the growth of bacteria, but they usually corroded very quickly.[1,2] In order to solve the difficult problem that is present in the application of industry, we suggest and attempt to demonstrate that the contained TiO_2 nickel composite coatings play an important role.

There is a range of composites, such as alumna, silicon nitride, etc., which, when dispersed in nickel,[3,4] show a definite improvement in corrosion resistance, compared to the matrix metal alone. The Ni-TiO_2 composite coatings whether possess a better corrosion resistance or not have been studied in our tests. In addition, the TiO_2 photo-catalytic destruction of microbial cells has also been described,[5] even though these studies have primarily used the TiO_2 particle to operate on the microorganisms or organisms.[6,7] Therefore, we hypothesized that as the TiO_2 photo-catalytic property was applied in the electrolytic composition field, under the condition of light irradiation, the Ni-TiO_2 composite coatings may be able to induce antibacterial activity, and that the inhibition could be enhanced by increasing the TiO_2 contents in nickel matrix coating. Our experimental results ascertained this.

Corrosion studies were performed in a 5% NaCl salt-spray-test that is based on JIS Z 2371 at 35°C from 0 to 500 h, respectively. After tested, the light reflectance rates from the surface of Ni coating and Ni-TiO_2 composite coatings were measured by a Gloss Checker. In our antibacterial experiments, the gram-positive bacteria used were *Enterococcus faecalis* IFO 12965, and the gram-negative bacteria were *Escherichia coli* IFO 3806, *Pseudomonas aeruginosa* IFO 13275.

Figure 1 shows the variations in light reflection rates from the surface of different TiO_2 contents in Ni-TiO_2 composite coatings with exposure time in the salt-spray-tests. It was found that before corrosion tests, with increasing TiO_2 contents in the nickel matrix, the light reflection rates gradually decreased. However, a significant depression only occurred in the nickel coating after a long lapse of time in the salt-spray-test. The test results indicate that the light reflection rates of nickel coating decreased more rapidly than that of other Ni-TiO_2 composite coatings when the exposure time was over 240 h, in other words, the violent corrosion reaction was curried out on the surface of nickel coating. After 240 h, the light reflection rates of nickel coating continually fell with rapid velocity, but Ni-TiO_2 composite coatings showed very little variation by prolonged exposure time. It was also evident that Ni-TiO_2 composite coatings provided a better corrosion-resistance than only nickel matrix at longer time exposure to salt spray



Figour 1 Variation in light reflectance rates of different TiO_2 contents in composite coatings with the exposure time in a 5% NaCl salt-spray-test at 35°C.

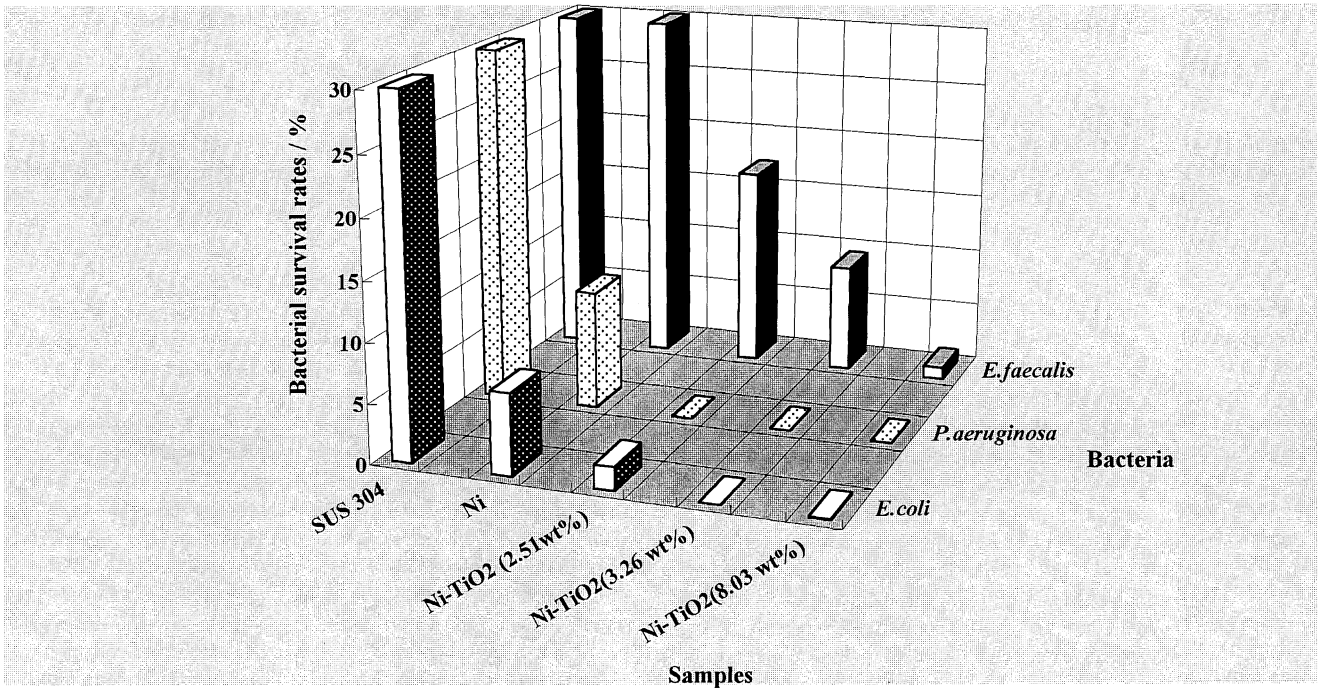


Figure 2 Relationship between antibacterial activity and the TiO_2 contents in composite coatings. Under irradiation incubation at 25°C for 24 h.

environment.

On the other hand, we have evaluated the effect of the TiO_2 contents in composite coatings on the antibacterial liability under 7500 Lux light irradiation (Figure 2). On the basis of the experimental data, we found not only did Ni-TiO_2 composite coatings show more significant antibacterial activity than stainless steel (SUS 304), which was used as a control in our antibacterial experiments. But also antibacterial activity was enhanced with increasing the TiO_2 contents in nickel matrix coating.

The Ni-TiO_2 composite coatings showed survival rates of gram-positive bacteria *E. faecalis* to decrease with increasing TiO_2 weight content in coatings. When TiO_2 in coating was 8.03 wt%, the survival rate of *E. faecalis* was approximately 1%.

As pointed out in Figure 2, the survival rates of gram-negative bacteria *E. coli* on the surface of the composite coating contained 2.51 wt% TiO_2 was obviously less than that of the nickel matrix. Furthermore, as the TiO_2 contents in composite coating were continually increased, the survival rates of *E. coli* were drastically decreased and were close to zero.

Regarding *P. aeruginosa*, proof significant antibacterial activity of the Ni-TiO_2 composite coatings was achieved. The number of survived *P. aeruginosa* bacteria on the surface of pure nickel coating was approximately 10%. The level of survival rates of *P. aeruginosa* was decreased to approximately zero even when the TiO_2 was only 2.51 wt% in coatings.

The Ni-TiO_2 composite coatings possessed greater inhibitory capability than nickel coating alone. It is considered feasible that TiO_2 homogeneous dispersed in composite coatings, as a photocatalyst, causes photochemical reactions to generate antibacterial chemical materials, resulting in being primarily responsible for bacterial degradation and bacterial death.[7]

Based on the comparison of our experimental results, we found out that when the TiO_2 particles were added in nickel matrix, not only the corrosion resistance property of coatings was strengthened, but also the inhibitory capability for the normal proliferation of bacteria was promoted at the same time.

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