The property of antibiotic antifinger –resin on zinc coated steel sheet

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The antibiotic antifinger-resin for zinc coated steel sheet was developed for the application at electric home appliance. Nano-type silver was employed to enhance the antibiotic property. Although there are lots of silver nano processes and methods, almost all the silver nano processes include unavoidable impurities. We have founded that the impurities affect the plating properties such as corrosion resistance, chemical resistance, adhesion property and so on. The antibiotic property are evaluated by agar dilution method. The other coating layer properties were done by using salt spray test, color different meter and so on. In the present paper, controls for concentration of nano-silver and impurties to obtain the optimum properties of the thin antifinger-resin coated steel sheet are described

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【 Introduction 】

Conventionally, plain or zinc-galvanized steel plates have been treated with chromium or chromate to secure corrosion resistance[1]. However, chromium is known as an environmentally hazardous substance, thus it is not currently used. As a result, resin coating is commonly used to impart corrosion resistance to steel plates. Treatment of the peripheral equipment with the resin results in deterioration of weldability due to non-conductivity of the resin. In order to improve poor weldability, the resin layer is generally formed with a minimum possible thickness. However, if the resin layer is applied in the form of a very thin film, it causes undesirable decrease of corrosion resistance for the steel plate.

As another generally known aspect, myriad of harmful bacteria inhabit peripheral equipments which are commonly used in daily life. In particular, various bacteria live wherever moisture and oxygen are available, and cause a variety of diseases and disorders.

As an attempt to solve the previously discussed problems, some researchers have developed a coated steel plate with a mixture of a resin and a metal. However, the coated steel plate has poor corrosion resistance due to the use of an acidic anti-bacterial agent, thus it requires separate chromium treatment to improve corrosion resistance after a plating process. However, it also harmfully affects the surrounding environments.

In addition, there are numerous products such as pre-coated metal (PCM) steel plates in which antibacterial property was imparted to zinc-galvanized steel plate or a resin treated pipe or the likes. Most of these products possess anti-bacterial property by forming a thick resin-coating layer. Therefore, there is no problem in corrosion resistance, but unfortunately it does not consider conductivity and/or adhesion. The present research has been performed to solve the above problems, and the object is pursued to provide an aqueous silver-containing solution having antibacterial activity. The silver-containing solution is designed to have a concentration of impurities which is specifically controlled. By means of coating the silver-containing solution, it is possible to impart superior antibacterial activity, corrosion resistance, conductivity and adhesion to a steel plate.

【 Experimental 】

- Materials

Polyethylen arcylic resin was selected for antibacterial composition, which was known as anti-fingerprint resin. A curing agent was also added to polymerize the resin. Materials were obtained from Aekeyoung P&C domestic company. Those were used as-received, unless it is otherwise noted.

Generally, silver (Ag), copper (Cu), zinc (Zn) and the likes are metals known to exhibit antibacterial activity. Inter alia, Ag exerts excellent sterilizing activity [2,3]. Meanwhile, as a method for refining silver into nano-sized particles, there may be generally employed a method to prepare polymer-silver nanocomposite using silver salts and other polymers (hereinafter, referred to as "composite method").

According to refinement of silver particles by the composite method, silver metals are reduced into fine particles by formation of a polymer-silver nanocomposite using silver salts and polymer materials. Specifically, in the composite method, silver particles are prepared by mixing a silver salt with the type of alcohol, surfactant, and water.

The silver salt that used in the present study is selected from the silver nitrate ($AgNO_3$). The possible surfactants may be at least two, which are selected from the groups consisting of polyethylene, polyacrylonitrile, polymethylmethacrylate, polyurethane, polyacrylamide, polyethylene glycol and polyoxyethylene stearate. In order to meet both physical properties of dispersibility and stability, it is preferred to use the surfactant having a molecular weight of 35,000 to 120,000

Nano silver composite via the composite method was prepared by the Pohang University of Science and Technology (POSTECH) in Korea.

- Substrate and Resin Coating

Electrogalvanized steel sheet was used as a substrate for resin coating. Zinc coating weight was 20/20 (front/back) g/m^2. Resin was coated with a bar coater, and then the specimen was baked in a dry oven. The antibiotic and anti-finger resin was coated with a thickness about 1.0 μm.

- Measurement of physical properties

The corrosion resistance was evaluated by SST (salt spray test) which follows the ASTM B117 standard. The specimens for corrosion test were conducted by 70 X 150 mm^2 panels. For the uncoated condition, the edges of each panel were masked with a tape and exposed to corrosive environment in the salt spray cabinet during the set time. For the coated condition, panels were exposed in the salt spray cabinet for 96 hours, followed by the evaluating the amount of the surface area of white rust. In order to test antibiosis property, two strains of microorganisms, staphylococcus aureus and escherichia coli, were tested. The test was carried out at the FITI Testing and Research Institute of Korea as the agar incubated method. Chemical resistance was estimated by the difference of whiteness value (△E) after 20 times rubbing with MEK solution.[4] For the adhesion property, the specimen surface was cross-cut to 100 square patterns with 1 mm distance, and then peel tests were performed using a scotch tape.

【 Result and discussion 】

Resin solutions used in this research were waterborne and thermoset resin. The antibacterial resin was prepared by adding the nano-silver composite to the mixed solution of polyethylen arcylic resin and the curing agent.

As previously mentioned, silver composite was composed of a silver salt, the type of alcohol, surfactant, and water. Anionic parts of the silver salts, the alcohol, and surfactants as impurities were remained in the resulting product, i.e., silver-containing solution, after formation of fine silver particles.

However, when the silver-containing solution in admixture with a resin composition is applied to a steel plate, the remaining other components besides silver (Ag) and water may serve as impurities which adversely affect the physical properties of the thin resin coated steel plate such as corrosion resistance, chemical property and adhesion.

- Germ quality

Fig. 1 shows the germ quality with concentration of silver. The used

silver solution was aqueous silver-containing solution comprising nano-sized silver particles wherein silver (Ag) particles with a diameter of 10~20 nm have concentration of 10,000 ppm. Germ quality was sharply getting higher as silver concentration increased. However, with the addition of above 40 ppm, germ reduction was not decreased any more. Therefore, the optimum concentration is decided as 40 ppm for the Germ reduction.

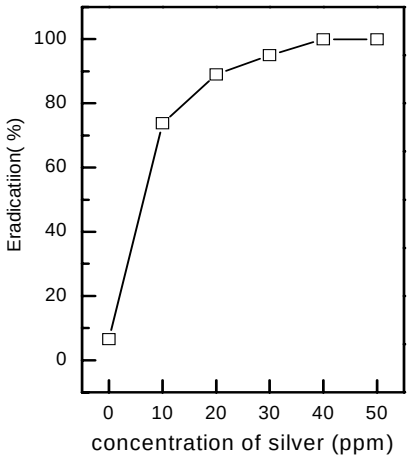

Fig. 1. Reduction of germ according to the concentration of silver.

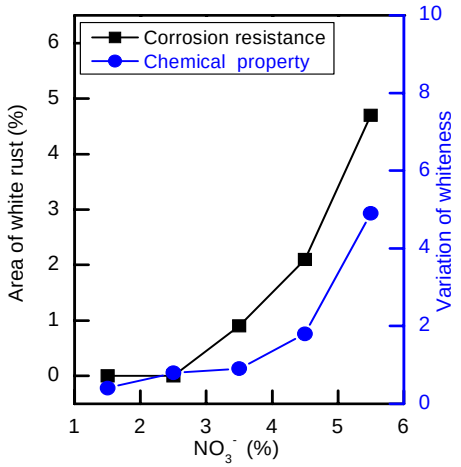

Fig. 2. Corrosion resistance and chemical property according to the concentration of NO_3^-.

- Coating qualities

The referred ingredients content was added to the mixture based on the weight of the silver-containing solution.

Fig 2 presents the white rust area and the variation of surface appearance with the concentration of anionic parts of the silver salts (NO_3^-) after SST 96 Hours; The first sign of white rust was observed at 3.5% NO_3^- concentration. The area of white rust and the variation of surface appearance were increased as the concentration of NO_3^- increased.

Fig. 3 and 4 show the corrosion resistance and the chemical property of coatings obtained by antibacterial-resin solution with alcohol and surfactant. The white rust occurred at 6.5% and 4.0% in the case of alcohol and surfactant, respectively. In both cases, the white rust area and variation of surface

appearance were increased according to the increase of concentration. In this study, ethyl alcohol was added to the solution with the 99.9% concentration.

From the test results, the corrosion resistance and chemical property was deteriorated as the increase of impurity of anti-bacterial material. Therefore, it can be assumed that the corrosion resistance and the chemical property are associated with concentration of impurity of anti-bacterial material. In order to obtain the good quality of antibiotic and antifinger-resin coated product, the impurity of anti-bacterial material needs to be controlled.

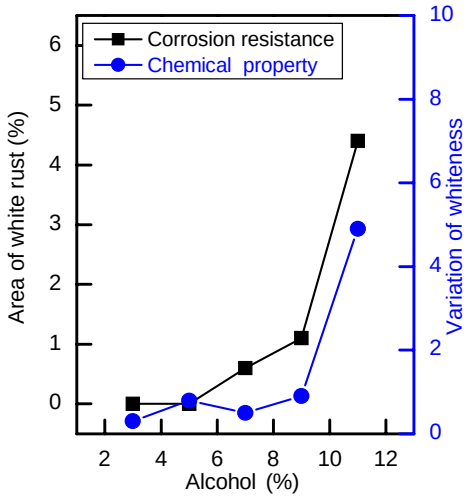

Fig. 3. Corrosion resistance and chemical property according to the concentration of alcohol.

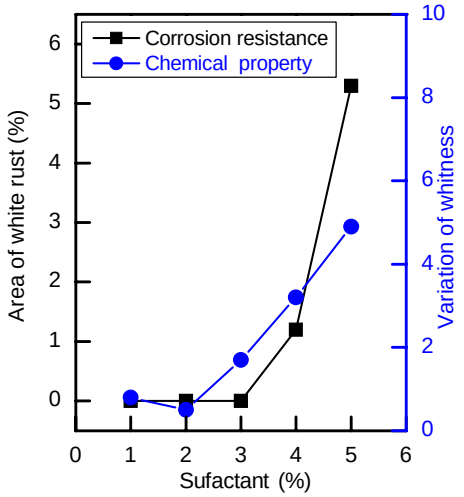

Fig. 4. Corrosion resistance and chemical Property according to the concentration of surfactant.

Observed hours of white rust with the concentration of mixed impurity were shown in fig.5. When the concentration of anionic part of a silver salt is 1.5%, the white rust on the sample surface appeared at 5.0 % total impurity concentration during the corrosion test (SST 96 hours). The effect of anionic parts of the silver salts (NO_3^-) is larger than any other elements. To obtain the good anti corrosion quality, the impurities needed to be controlled by 2.5 wt% (or less) of anionic part of a silver salt as well as 4.5 wt% (or less) of the sum of another impurity plus anionic part of the silver salt, based on the weight of the

silver-containing solution.

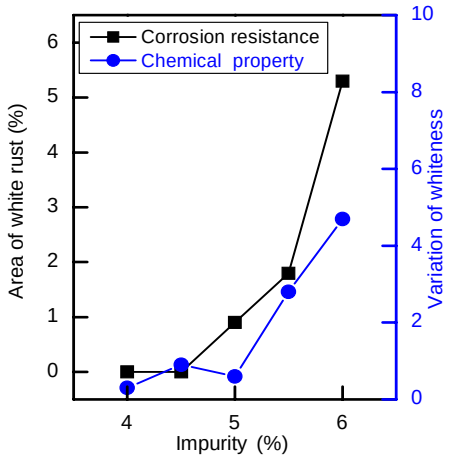

Fig.5. Corrosion resistance and chemical property according to the concentration of Impurity

Photo 1, 2, and 3 shows the antibacterial property, the corrosion resistance, and the adhesion of coating at optimum concentration of antibacterial material with controlled impurities. As shown in photo 1, germ on the sample surface formed by newly developed antibacterial antifinger-resin treatment was almost sterilized. The sign of white rust was not observed on the surface of specimen after 96 hours exposure in salt spray cabinet (photo 2). Photo 3 shows the good adhesion result of coating layer.

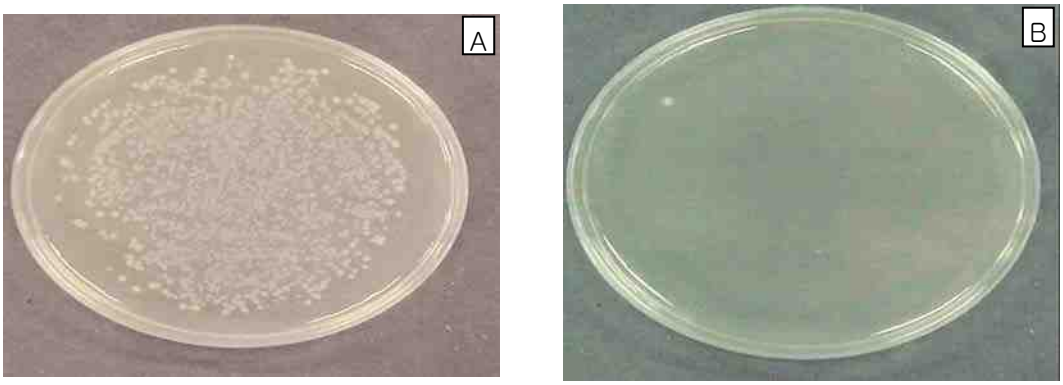

Photo 1. Germ reduction by antifinger-resin coated steel sheet (A:general resin, B:developed resin).

From the above test results, it was estimated that the optimum condition of antibacterial antifinger-resin for good product property was related with the concentration of silver and included impurities.

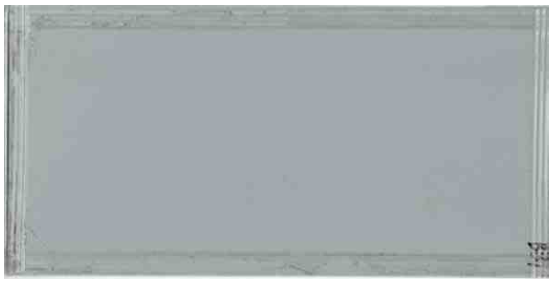

Photo 2. Surface appearance of antibacterial antifinger-resin coated steel sheet after SST 96 hours.

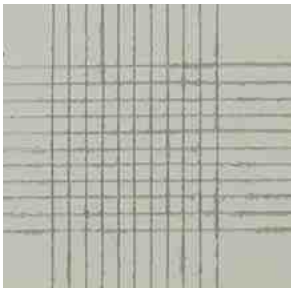

Photo 3. Adhesion test appearance of antibacterial antifinger-resin coated steel sheet

【 Summary 】

1) Steel plates, which are coated by the newly developed antibacterial resin with a silver-containing solution, exhibit superior antibacterial properties.

2) When the silver-containing solution in admixture with a resin composition is applied to a steel plate, the remaining other components besides silver (Ag) and water may serve as impurities which adversely affect the physical properties of the thin resin coated steel plate such as corrosion resistance, chemical property and adhesion

3) It can be assumed that the corrosion resistance and the chemical property are associated with concentration of impurity of anti-bacterial material. In order to obtain the good quality of antibiotic and antifinger-resin coated product, the impurity of anti-bacterial material needs to be controlled.

【 References 】

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