Technical Report

Cockroach Repellent Steel Sheet, Anti-Virus Steel Sheet

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Abstract

Cockroach repellent steel sheet "PAINTITE™B (ZJM)" and antiviral steel sheet "Anti-Virus Series" using a visible light responsive photo catalyst were developed. "PAINTITE™B (ZJM)" showed repellent resistance to cockroaches, having the same corrosion resistance and lubricity as the conventional lubricity steel sheet. "Anti-Virus Series" is a group of products that have both antiviral and design. "Feluce™ (Anti-Virus)" showed antiviral ability, having the same fingerprint resistance and workability as those of Feluce™, steel sheets with a hairline pattern on the surface to give a metallic impression.

1. Introduction

Health consciousness continues to grow increasingly in our daily life, and as a consequence, the need for functions of hygienic security and safety is expanding also with steel products. To this end, Nippon Steel Corporation has developed the following two products with hygienic functions: insect-proof steel sheet, PAINTITE™B (ZJM), having repellent properties against cockroaches and other insect pests; and antiviral steel sheets, the Anti-Virus series. This paper introduces the properties of these products.

2. Insect Repellent Steel Sheet

The expression "repellent" refers herein to the characteristic to deter insects. The inside of home appliance bodies is dark and warm, and has all the conditions that attract insects. Unsanitary insect pests typically such as cockroaches, in particular, carry salmonella bacilli, dysentery bacilli, and other pathogens, and their feces and carcasses are allergens. In addition, when insects enter the inside of home appliance bodies, they may cause malfunctions. For these reasons, there is a great need for repelling insects, especially cockroaches. Against this background, Nippon Steel has developed insect repellent steel sheet, PAINTITE™B (ZJM), having the ability to repel cockroaches and other insect pests, and launched the product onto the market.

Figure 1 shows a schematic cross-sectional view of the developed product. It is characterized by an insect repellent component contained in the lubricating film on the surfaces of the substrate, a galvanized steel sheet. When a cockroach senses the repellent substance, it feels uncomfortable and leaves the place. This product, which has been developed for the application to the body panels of home appliances, is characterized by insect repellent ability focusing mainly on cockroaches in addition to corrosion resistance to secure good durability, lubricity required for press forming, and chromate-free surface treatment film suitable for healthy work environments.

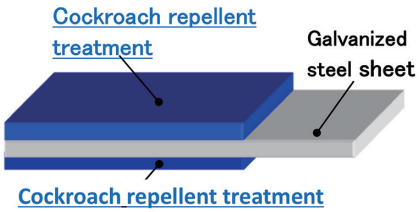

Fig. 1　Cross-sectional image of cockroach repellent steel sheet

2.1 Cockroach repellent ability

The cockroach repellent property of the product was evaluated. Twenty German cockroaches were left in a container in which two shelters, the inside of which was dark, were provided. The floor of one of the shelters was made of an insect-proof steel sheet, PAINTITE™B (ZJM) (hereinafter referred to simply as ZJM), and that of the other was made of a comparative material, a lubricating steel sheet, PAINTITE™B (ZJ) (hereinafter referred to simply as ZJ) without insect repellent ability. Since cockroaches like dark places, they stay in such shelters except when they seek food. The cockroach repellent ability was evaluated by comparing the number of cockroaches in each of the shelters after 24 hours of the test. **Figure 2** illustrates the test method, and **Fig. 3** the test result. There were no cockroaches in the shelter of the insect repellent steel sheet, but all of them were found to live packed in the shelter of the lubricating steel sheet, which verified the cockroach repellent ability of the developed product.

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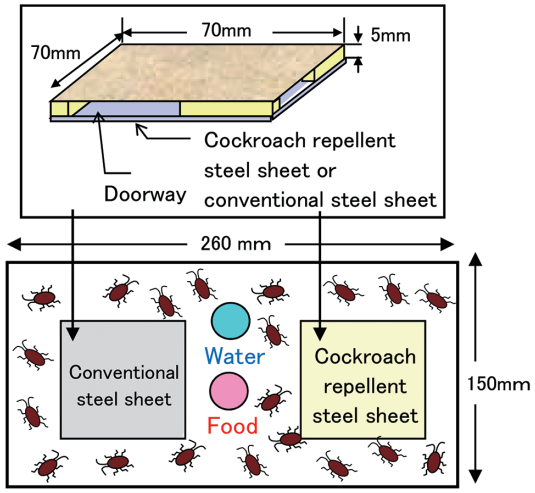


Fig. 2 Cockroach repellent test

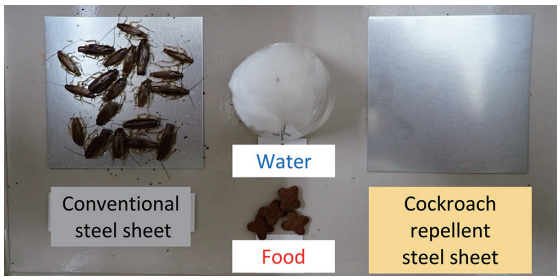


Fig. 3 Photograph after cockroach repellent test

2.2 Corrosion resistance

The corrosion resistance of ZJM was investigated. A salt spray test was conducted according to JIS Z 2371 using flat test pieces, and the occurrence or otherwise of white rust was visually evaluated. The edges were sealed. As in the insect repellent test, ZJ steel sheets were used as comparative test pieces. **Figure 4** shows the test pieces after 240 hours of the salt spray test. The insect repellent steel sheet (ZJM) exhibited the same corrosion resistance as that of the conventional lubricating steel sheets (ZJ).

2.3 Lubricity

The coefficient of dynamic friction was measured as an index of press formability; a HEIDON-14 friction tester (manufactured by Shinto Scientific Co., Ltd.) was used for the measurement. The coefficient of dynamic friction was calculated from the stress of sliding a stainless steel ball 10 mm in diameter on the specimen surface at a speed of 150 mm/min under a load of 1.0 N. Sheets of ZJ were used as comparative specimens. **Table 1** shows the result. The dynamic friction coefficient of ZJM was the same as that of ZJ.

3. Antiviral Steel Sheets

Nippon Steel has developed the Anti-Virus series as a new brand of steel sheets having both good appearance and anti-virus properties. These products are intended for applications in which they are touched by a great number of people such as office furniture and interior finishings of public buildings. For this reason, fingerprint resistance and good workability in press forming are required in addition to good appearance and anti-virus properties.

The top coat of the Anti-Virus series contains a visible light responsive photocatalyst. It exhibits a strong oxidative effect even at the illuminance of an indoor lighting level, and exerts an antiviral effect. It also has a hybrid function to exert the effect even in the dark.

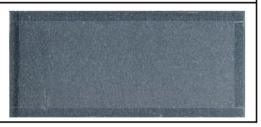
Treatment type	Appearance
Cockroach repellent (ZJM)	
Conventional (ZJ)	

Fig. 4 Photograph after 240-hour salt spray test

Table 1 Coefficient of dynamic friction

Treatment	Coefficient of dynamic friction
Cockroach repellent (ZJM)	0.05
Conventional (ZJ)	0.05

In the lineup of Nippon Steel's steel sheet products for appearance design, the Anti-Virus series is a new variety having an anti-virus ability as an additional function. The properties of antiviral steel sheets are explained herein using FeLuce™ Anti-Virus, as an example. It is a product in which an antiviral function has been provided to FeLuce™, hairline polished electrogalvanized steel sheets. As the basic characteristics of FeLuce™ are presented in a separate article of the current issue, the readers are invited to refer to it. **Figure 5** shows the structure of FeLuce™ Anti-Virus. The antiviral effect is produced by the photocatalyst in the outermost coating layer.

3.1 Antiviral ability

The antiviral ability of FeLuce™ Anti-Virus was investigated using virus A without an envelope (lipid bilayer membrane) and virus B with an envelope. A series of antiviral tests were conducted in compliance with JIS R 1756:2020 or applying it mutatis mutandis. The illuminance at the time of the test was set equivalent to a dark place and 500 lx. The test time was 0, 5, 30, 60, 120, and 240 min. FeLuce™ Silver Anti-Virus was used as the object test pieces, and FeLuce™ Silver (without antiviral ability) as comparative test pieces. The antiviral ability was evaluated assuming that the plaque forming unit (PFU) determined after the test by the plaque method was equal to the number of viruses. The virus detection limit in the present study was 10.

Figure 6 shows the results of the antiviral test on the non-enveloped virus A. The test time was 240 min. In the dark, the number of viruses on FeLuce™ Anti-Virus was less than that of FeLuce™ by 99.9%. When the illuminance was 500 lx, the number of viruses on the test pieces of FeLuce™ Anti-Virus was lowered to below the detection limit (10 at most); it was less than that of FeLuce™ by 99.99% or more. These results indicate that FeLuce™ Anti-Virus exerts an antiviral effect in both dark and light places (has a hybrid function), and that the antiviral effect in light places is higher than that in dark places.

Figure 7 shows the results of the antiviral test on the enveloped virus B. The test time was 240 min. In the dark, viruses on FeLuce™ Anti-Virus test pieces were decreased to below the detection limit; the number of viruses on them was less than that on the comparative

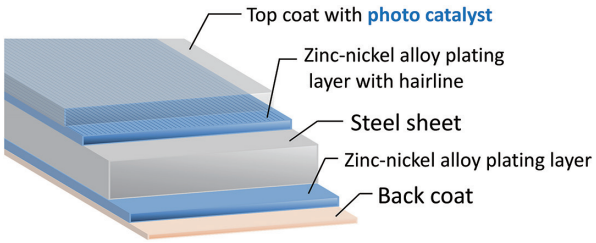


Fig. 5 Cross-sectional image of FeLuce™ (Anti-Virus)

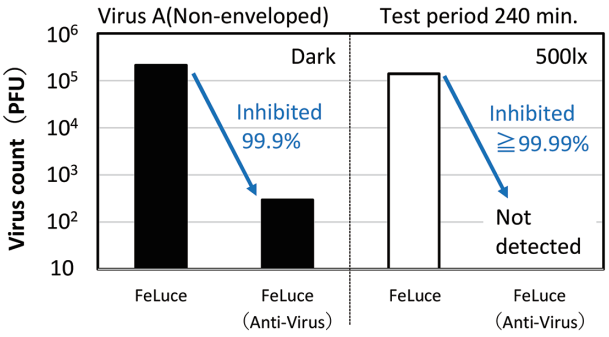


Fig. 6 Result of antiviral test using non-enveloped virus A

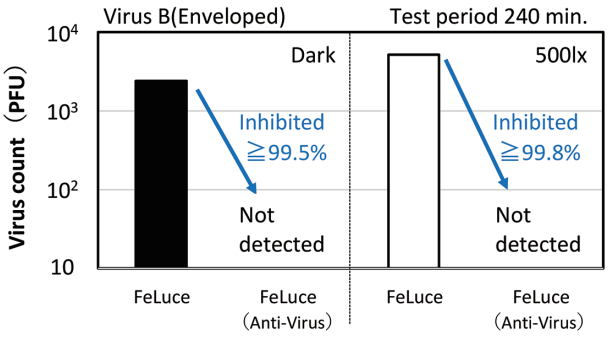


Fig. 7 Result of antiviral test using enveloped virus B

test pieces by 99.5% or more. Under an illuminance of 500 lx, the virus count of FeLuce™ Anti-Virus was below the detection limit; it was less than that of FeLuce™ by 99.8% or more.

Figure 8 shows the relationship between the antiviral test time and the number of viruses. The non-enveloped virus A was used and the illuminance was set at 500 lx. The decrease in the virus count of FeLuce™ Anti-Virus from that of FeLuce™ was 99% after the test for 5 and 30 min, 99.9% after 60 min, and 99.99% after 120 min. These results confirm that the antiviral effect of FeLuce™ Anti-Virus appears within a short time period.

3.2 Fingerprint resistance

FeLuce™ Anti-Virus is intended for applications in which it is touched by human hands, but the good appearance is spoiled if fingerprints are left on the surface. In this relation, the fingerprint resistance of the product was examined. Test pieces were immersed for 5 s in an acetone solution containing 0.5 mass% white petrolatum, and the appearance before and after the immersion was evaluated visually as well as in terms of color difference (ΔE^*), which was calculated based on the measurement of color tone (L^*, a^*, b^*) using a colorimeter (CR-400 made by Konica Minolta, Inc.). FeLuce™ was used as a comparative material. The result is shown in **Table 2**. This

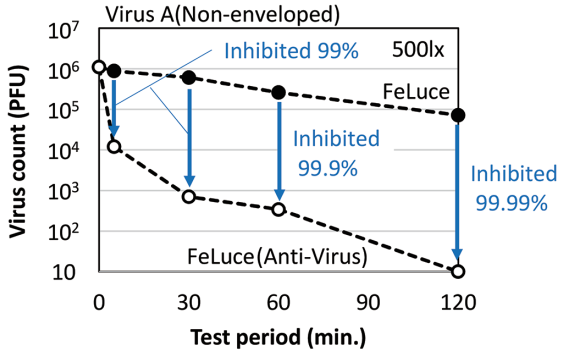


Fig. 8 Relation between test period and virus count for non-enveloped virus A

Table 2 Result of fingerprint resistance test

	Visual judgment	Color difference (ΔE^*)
FeLuce (Anti-Virus)	Invisible	0.8
FeLuce	Invisible	1.0

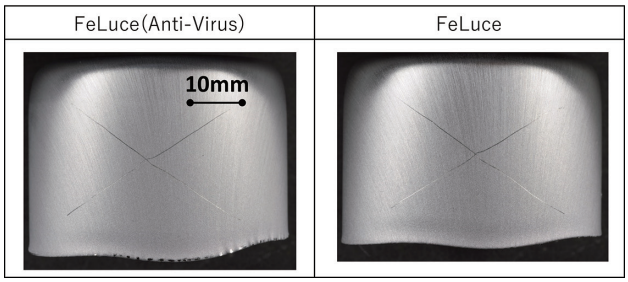


Fig. 9 Workability of FeLuce™ (Anti-Virus)

result shows that FeLuce™ Anti-Virus has the same fingerprint resistance as FeLuce™.

3.3 Workability

Since FeLuce™ Anti-Virus is supposed to be formed into final products by pressing, its formability was tested. Specimen sheets underwent cylindrical drawing using dies having an inner diameter of 50 mm and a shoulder radius of 5 mm. The drawing ratio was set at 2.0. After the forming, a cross was inscribed in the body surface with a cutter, the pieces were immersed in boiling water for 1 h, and then a peeling test of the cross cut portion was conducted using adhesive tapes. FeLuce™ was used as a comparative material. **Figure 9** shows the appearance of the specimens after the peeling test. No swelling or peeling of the coating film was observed at the cross cut, verifying that FeLuce™ Anti-Virus has the same high workability as that of FeLuce™.

4. Conclusion

Insect repellent steel sheet, PAINTITE™B (ZJM), and antivirus steel sheet, FeLuce™ Anti-Virus, have been presented above. These products were developed in response to the growing health awareness in our daily life. The use of these products is expected to make our life safer and more secure.

Supplementary explanation on antiviral test

(1) The data shown herein are the results of tests conducted in

compliance with JIS R 1756 or applying it mutatis mutandis, and their validity in actual environments is not guaranteed. The actual effect will vary depending on the conditions and the method of use. The information published herein is related to photocatalytic functional steel sheets, and not to the effects of final products for which such steel sheets are used.

(2) In consideration of the provisions of the Pharmaceutical Affairs Act (Act on Securing Quality, Efficacy, and Safety of Products Including Pharmaceuticals and Medical Devices), no specific virus names are given herein. Viruses without an envelope (lipid bilayer membrane) are generally considered to be highly resistant to disinfectants.

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