The Effect of Additives for Varying Qualities of Organic Coated Steel Sheet

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Steel is prone to corrosive attack, so it is usually coated with corrosion barrier materials. A corrosion barrier polymer, one of various resins, was coated on steel plates. Thin organic coated steel sheet has high corrosion resistance and an anti-fingerprinting property. Beyond these properties, other customers demand weldability and anti-blackening after forming.
Compositions of resin solution are important to control the quality of the organic coated steel sheet. The effect of the resin type, kinds of conductive materials, additives and film thickness were investigated.

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Introduction

Thin organic coated steel sheet has been developed and widely used for home electric appliances since they have good corrosion resistance and easy to produce economically.[1)]
Required properties of organic coated steel sheet for home electric appliances are anti-fingerprinting and self-lubricant sheet
Anti-fingerprinting sheet has good performance against anti-finger printability and self-lubricant sheet had excellent formability without press oil.
But, thin organic coated steel sheet does not have enough heat resistance and conductibility characteristics.
Composition of resin solution will affect the quality of the above characteristics.
In this research, the effect of resin and additives for thin organic coated steel sheet was investigated.
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Experimental Method

Resin Coating

Chromated electrogalvanizing steel sheet was used as a substrate for resin coating.
Chromate coating weight was 20~25 mg/m^2 and that of zinc 20/20g m^2. Resin was coated using a bar coater and then specimen was baked at moderate temperature using the cabinet type drying oven. The dry film thickness was adjusted by various size of bar coater.

Measurements of Physical Properties

Anti-finger printability was estimated by color difference value (ΔE) between before and after vaseline coating. Corrosion resistance was measured with plate specimens. Then corrosion test was performed with salt spray tester.

The dynamic friction coefficient was measured using a draw bead tester and calculated using the following equation.

$$\mu = \frac{Fd - Rd}{Fc \times \pi}$$

Fc : fixed bead clamping force
Fd : fixed bead drawing force
Rd : roller bead drawing force
The test condition is as follows.
- drawing speed : 1000mm/min.
- bead radius : R4.75

Interlaminar resistance

To compare conductibility of organic coated steel sheet, Interlaminar resistance was measured
We measured current value after making a firm contact of an electrode with specimen at a constant pressure.
Standard pressure : 2N/mm^2 ±5%
Experimental voltage : 0.5V
Electric power : 0 ~ 1.0A
R = A (1/I-1)

Heat resistance

Heat resistance was measured by degree of color change during exposure at 250º atmosphere for certain time.

Results and discussion

Although silica improves corrosion resistance, it hampers formability of organic coated steel sheet.[2)] To evaluate the effect of silica, the amount of additive silica in resin was varied without adding any other additive. The thickness of coating film was chosen as 3μm in other to minimize the effect of steel substrate.
Fig.1 shows the effect of silica on friction coefficient. As the amount of silica increases, friction coefficient increases. This result suggests that addition of silica would degrade formability. S0 ~ S4 means that ratio of solid content of resin to silica and it varies from 0 to 40phr.

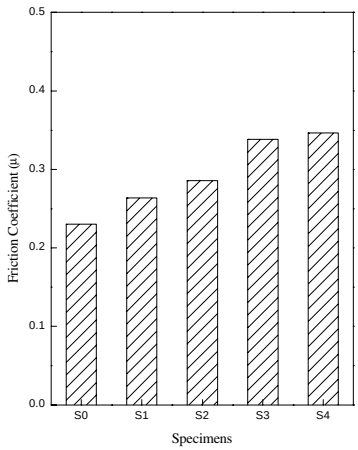

Figure 1 Friction coefficient with silica content

Photo.1 shows the effect of silica on corrosion resistance after 300hrs salt spray test. Without silica, red rust was observed all over the surface. However, in case of S4, white rust was observed only at limited area. This result means that silica in resin improves corrosion resistance of organic coated steel sheet.

Fig.2 shows anti-fingerprinting property of organic coated steel sheet as a function of silica content.

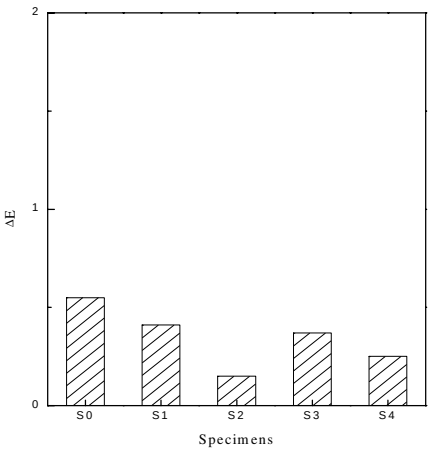

Figure 2 Anti-finger property with silica content

Since hydrophobic silica particles are evenly dispersed in organic coated steel sheet regardless of silica content, anti-fingerprinting property does not seem to be significantly affected by the amount of silica in resin. The even distribution of silica can be confirmed by surface morphology and Si mapping of these samples in Photo.2.

Heat resistance Improvement

To improve heat resistance of organic coated steel sheet, the effect of heat resistant additives on heat resistance was scrutinized. Table 1 shows the variation of chemical composition of solution by changing ratio of the base resin (A) to the heat resistant resin (B).

Fig. 3 shows the weight loss data of each resin with different chemical composition during TGA tests.

Table 1 Composition of resin solution

Item	Base Resin(A)	H.R resin(B)	Hardner	Water
M1	21	16.28	1.628	34.878
M2	16	24.8	1.24	30.707
M3	11	34.1	0.853	26.794

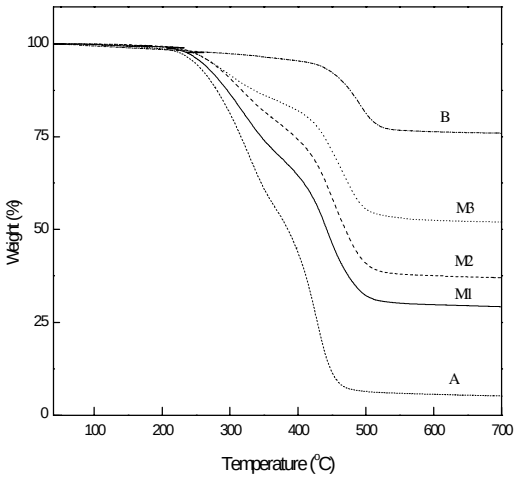

Figure 3 TGA results for various resins

The results show that heat stability is superior as following order; B, H1, H2, H3, A. Heat stability of the heat resistant resin B is so superior to that of resin A that weight loss is only 24.1% up to 700º.

Fig. 4 shows variation of whiteness after exposing each sample with different solution composition at 250º for certain period.

When adding heat resistant resin, no color change was observed. However, base resin shows a sudden decrease in whiteness. Although the heat resistant resin improves heat resistance of organic coated steel sheet, with the heat resistant resin, white spots were observed on the sample surface. Since white spot degrade the surface quality of organic coated steel sheet, there should be a further study to develop a way to remove the white spots.

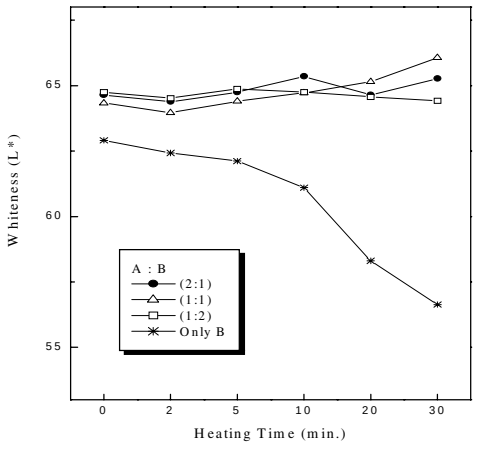

Figure 4 Changes of whiteness for various resins

Variation of friction coefficient, as a function of the heat resistant resin is in Fig.5.

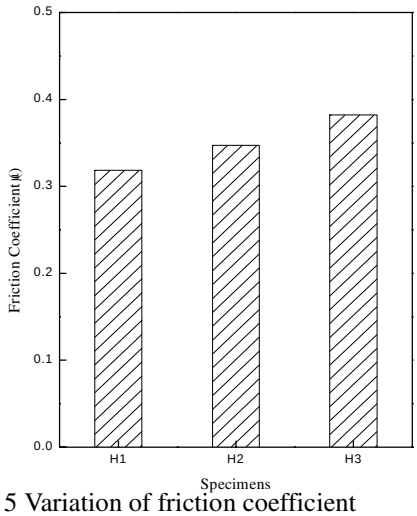

Figure 5 Variation of friction coefficient

Although friction coefficient of the sample with heat resistant resin is bigger than that of base resin, ratio of heat resistant resin to the base resin does not affect significantly. The increase of friction coefficient seems be related to the existence of silica which is in the heat resistant resin.

Metal powder

During welding organic film layer is carbonized and as a result, there are problems of low longevity of welding electrode and poor surface appearance. To solve the above welding problems, we added metal powder to organic coating layer to lower electric resistance of organic film layer. The metal powders used were Fe, Ni, Cu, Zn, Sn, Fe-P and their size was about 1 ~ 5μm. When adding metal powders, friction coefficient increased slightly. (Fig.6)

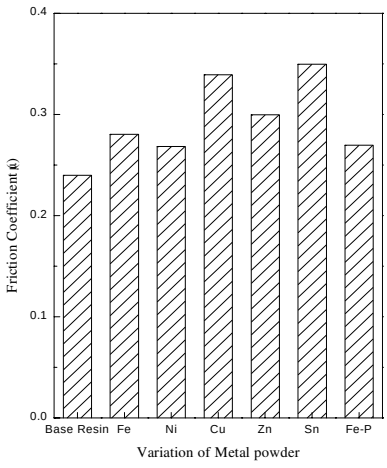

Figure 6 Comparison of friction coefficient

Specimens	Current (A)	Resistance
Fe (10%)	0.990	0.605
Ni (10%)	0.991	0.059
Cu (10%)	0.905	0.677
Zn (10%)	0.631	3.773
Sn (10%)	0.805	1.563
Fe-P (10%)	0.990	0.065
Base Resin	0.088	66.866

This result suggests that metal powders seem to degrade formability of organic coated steel sheet.
Table 2 shows interlaminar resistance of coating layer with 10wt% metal powder. As metal powders were added, its interlaminar resistance decreased significantly. Therefore, addition of metal powder would improve weldability of organic coated steel sheet

Table 2 Electric resistance of metal powders

However, addition of metal powder makes solution unstable that metal powder is settled at the bottom and solution becomes gel.
So, to utilize metal powder added organic coated steel sheet, there should be an appropriate solution which will resolve the above problem.

Results

1) The corrosion resistance was improved by the addition of silica, but silica does not help the lubricating action.
2) Addition of metal powder in resin gives a positive effect on the conductibility whereas it may degrade the resin solution stability.
3) Although addition of heat resistant resin has improves heat resistance of organic coated steel sheet, it deteriorates surface appearance

References

1. T.Shito and H.Fukumoto Testu-to-hagane 81, 4, 405 (1994)
2. C.S.Park and Y.G.Jung, Proc. AESF/FIN '96 (June 1996)

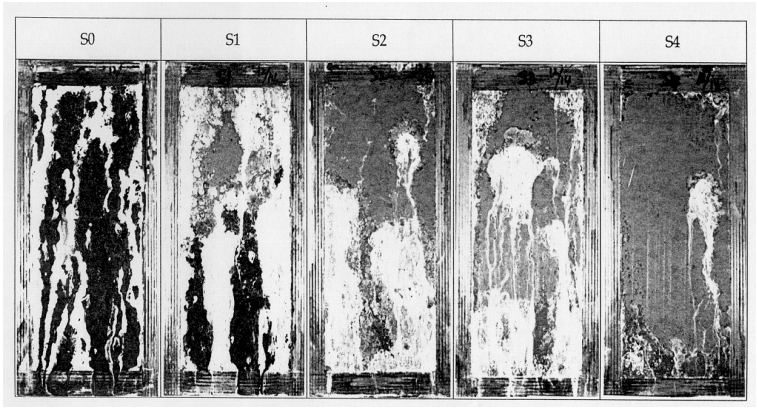

Photo.1 SST results with silica content