Ultraviolet HardeningType Antistatic Hard Coat Paint for Plastic

1. Introduction

Plastic has excellent advantages including easy process ability, light weight property, anticorrosive property and so forth, while it is vulnerable to electro static charge, dust and dirt, and scratch and damage. Especially, in transparent resin such as acrylic resin, damage on its surface will deteriorate its product value conspicuously, therefore, to avoid damages, generally conducted is hard coating on it. Further, in these years, applications for viewing things through transparent resins, there is a great demand for antistatic measures so as to avoid dust attachment.

The present documents introduce paints that hold both hard coating property and antistatic property, and characteristics of their application films.

2. Hard Coating and Antistatic Finish

In hard coating, there are direct application method, hardened film transfer method, laminating method and so forth. Direct application method is further divided into deposition method including vacuum deposition, spattering and so forth, thermal hardening method where coating liquids such as melamine system, urethane system and so forth are applied and gardened, and hardening method where multifunctional acrylate system coating liquids of polyester acrylate, urethane acrylate, epoxy acrylate and so on are applied and hardened by use of ultraviolet ray, electron beam and so forth. At present, ultraviolet hardening method, exceeding in productivity, surface hardness, and durability, is employed most widely.

On the other hand, mechanisms of antistatic property are roughly divided into 2 kinds, that is, ionic conduction type wherein moleculars discomposed as ion by water content in atmospheric air move on the surface or inside of materials thereby electric flows occur, and electron conduction type which is by conductive oxides. Ionic conduction type is vulnerable to influences of environmental conditions such as water content and so forth, and is hard to obtain stable antistatic performances, on the other hand, electron conductive type is free from influences of environmental conditions, and is able to obtain stable antistatic performances.

Conductive oxides are of electron conductive type where electric flows occur by movement of electron or electron hole caused by failure in crystal structure, and electric flows are based on the formation of electric paths by contact among conductive oxides. As conductive oxides, listed are tin oxide, zinc oxide, antimone oxide, ITO, and so forth, and for the purpose of antistatic measure, generally used is antimone dope tin oxide.

3. Product Features and Paint Specifications

Paints for plastic, having both hard coating property and antistatic property, have high transparency and low haze property by our original technology to highly disperse ultra fine particles. These ultra fine particles are already in use for antistatic screens on CRT surface which especially requires high transparency and low haze property.

Table 1 shows kinds of ultraviolet hardening type antistatic paints and their representative characteristics. As for surface resistance, we offer products ranging from 10^7~10^{10} Ω/□. While, Fig.1 shows time passing changes (liquid time passing) of surface resistance values of R-308 and R-310. In both R-308 and R-310, changes in surface resistance values at 60 days at room temperatures are small,thus stable.

Paint properties are as shown below:

Appearance	: Dark blue
Solid content	: 30 ~ 35%
Resin	: UV hardening resin
Specific gravity	: 0.9 ~ 1.0
Viscosity	: 1.6 ~ 3.2 cp
Main solvent	: Ketone system

Filming conditions are as shown below:

Base materials	: PMMA, PC, PVC, PET, etc.
Application method	: Bar coating, reverse coating, flow coating, etc.
Optimized film thickness	: 1 ~ 5μm
Drying method	: Hot wind drying (50 ºC) 30 seconds ~ 5 minutes
Hardening method	: High voltage mercury lamp (110W/cm) 20 ~ 30 seconds

4. Notes in Application

4-1. Phenomenon of Increase of Film Resistance Values

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4-2. Phenomenon of Increase of Surface Resistance Value in Application

4-2-1. Application under Low Humidity

Table 2 shows the influences of humidity at application upon surface resistance values. In comparison of application under humidity 27% and that under humidity 50%, in the case of humidity 27%, the surface resistance value increases by 1 to 2 digits from a specified value. This is considered because evaporation speed of water content in paint at low humidity will increase relatively, and film structure gets porous. On the other hand, in the case under high humidity (67%), there is no significant difference between the surface resistance value and that in the case of humidity 50%, however, water content evaporation is restricted relatively, and water content in film exceeds its allowable value, and whiting phenomenon owing to brushing is recognized.

4-2-2. Concordance Between Device and Paint

Table 3 shows the influences of coater pollution at application upon surface resistance values. In comparison of the surface resistance value of the first sheet applied by bar coater and that of the third sheet, it is known that in the first sheet, the surface resistance value increases by 1 to 4 digits from the specified value. This is considered to be caused by filler or resin cohering when the concordance of paint to bar is not sufficient.

4-3. Phenomenon of Increase of Surface Resistance Value in Application

From the above discussions so far, for the stable generation of the specified surface resistance value of ultraviolet hardening type antistatic paint, attention must be paid to the following 3 points in application.

1 Painting conditions : Set temperature at 20 ~ 25 ºC, and set humidity at 40 ~ 60%.

2 Applying device : Clean it sufficiently so as to avoid any influence from paint in foregoing process. Make paint concordance with rolls and so forth in the device sufficiently. After then, sample a film for evaluation.

3 Resistance measurement : Evaluate the surface resistance value of film after one day.

5. Characteristics of Applied Film (Examples of Applications)

Surface resistance values of films applied by R-307 ~ R-310 are of electron conduction type arising from filler, therefore, they are free from influences of humidity.

Table 4 shows one example of characteristics of an antistatic hard coat acrylic plate wherein paint R-310 is applied to an acrylic base plate. In the table, the Permeability of all rays is 92%, haze value is 0.4%, representing high transparency and low haze property, and its optical performances appear as excellent as those of general acrylic plates. The surface resistance value shows 10^9 ~ 10^{10} Ω/□, and electric charge discharges instantaneously even at impression of 10kV by a static honest meter, thus its antistatic property is extremely excellent. As for its hard coating property, pencil hardness shows 5H, and the results of steelwool scratching test appear preferable.

Table 5 shows the test results of temperature dependency of P-308 surface resistance value (humidity 50%, JIS L1094). As for the base material, employed is PET of 50µm. The table shows that there is scarce change between surface resistance value at 10 ºC and that at 40 ºC .

Table 6 shows the results of heat resistance test of R-308 (processing time : 2 hours). As for the base material, employed is PET of 50µm. There is not so large changes in surface resistance values before and after processing at both processing temperatures -30ºC and 150 ºC, showing that its heat resistance property is preferable.

Table 7 shows the results of chemical resistance test on R-308 and R-310 (dipping time : 10 minutes). As for the base material, employed is PET of 50µm. With boiling water, ethanol, acetone, and toluene, changes of surface resistance values before and after processing appear small (below 1.2 times of the specified value), thus it shows that their chemical resistance property is preferable.

Fig.3 shows the results of weather resistance test on R-308 and R-310. The test was conducted by use of an ultraviolet carbon arc lamp type weather resistance tester (JIS K5400, 63±3 ºC, no rain, PET 50µm, #7 applied). The applied film has an excellent durability against ultraviolet ray, and there is hardly changes in permeability of all rays even over 600 hours of feed meter, surface resistance

value is apt to become a bit low, and it is understood that both the paints have sufficient transparency property and antistatic property.

6. Conclusion

Our antistatic hard coat paints for plastic are characterized by high transparency and low haze. Transparency property and antistatic property are properties that counteract to each other, however, it is considered that there will be an increasing demand for increasing both these properties in the near future. Further, antistatic hard coat plates enable to solve the large 2 problems of transparent resins, that is, scratch vulnerability and dust attachment simultaneously, so it is considered that their applications will be developed in various fields in the future.

Our antistatic paints for plastic has various surface resistance values adjusted from 10^9 to 10^{10} Ω/□, and are for various base materials including PET, polycarbonate and so forth. And further, anti glare processing by optical anti reflection, ultra fine concave and convex processing is available, consequently, we believe we can meet your diversified requirements well.

Table 1 Kinds of Ultraviolet Hardening Type Antistatic Paints and Their Representative Characteristics (including base materials)

(Base material) PET 50μm (Diafoil T600E50 U-07)
(Base material characteristics) Permeability of all rays 90.4%, haze value 0.6%
(Application) Bar coat #7-50 ºC 5 minutes - 110W/cm 20 seconds
(Film thickness) 1μm
(Measurement) Mitsubishi Chemical low raster IP, high raster IP (terminal) ASP, HRS
(Measurement environment) 22 ºC 50%

	R-307	R-308	R-309	R-310
Surface resistance $/\Omega\cdot\square^{-1}$	5x10^{7}	3x10^{8}	4x10^{9}	5x10^{10}
Total light transmittance / %	86.9	87.4	89.0	90.0
Haze / %	0.7	0.7	0.7	0.7
Pencil hardness	F ~ H	H ~ 2H	H ~ 2H	H ~ 3H

Table 2 Influences of Humidity at Application upon Surface Resistance Values

(Base material) PET 50μm (Diafoil T600E50 U-07)
(Application) Bar coat #7-50 ºC 5 minutes - 110W/cm 20 seconds
(Film thickness) 1μm
(Measurement) Mitsubishi Chemical low raster IP, high raster IP (terminal) ASP, HRS
(Measurement environment) 22 ºC

		R-307	R-310
Surface resistance $/\Omega\cdot\square^{-1}$	Humidity 50 % (nomal)	8x10^{6}	2x10^{9}
	Humidity 27 % (low)	4x10^{8}	1x10^{11}
	Humidity 67 % (high)	9x10^{6} (brushing)	7x10^{9} (brushing)

Table 3 Influences of Coater Pollution at Application upon Surface Resistance Values

(Base material) PET 50µm (Diafoil T600E50 U-07)
(Application) Bar coat #7-50 ℃ 5 minutes - 110W/cm 20 seconds
(Film thickness) 1µm
(Measurement) Mitsubishi Chemical low raster IP, high raster IP (terminal) ASP, HRS
(Measurement environment) 22 ℃

		R-308	R-310
Surface resistance /Ω·□$^{-1}$	the first sheet	2×10^8	9×10^{11}
	the third sheet	2×10^7	1×10^8

Table 4 Characteristics of an Antistatic Hard Coat Acrylic Plate

Total Light Transmittance		/ %	92
Haze		/ %	0.4
Adhesion (cross cut)			100 / 100
Tensile strength		/ Mpa	68.6
Elongation		/ %	3.0
Bending strength		/ Mpa	88.3
Modulus of elasticity		/ Mpa	3138
Taber abrasion test	100 cycles ΔHaze	/ %	3.0
	500 cycles ΔHaze	/ %	12.0
Steelwool scrathing test			A
Pencil hardness			5H
Surface resistance		/Ω·□$^{-1}$	$10^9 \sim 10^{10}$

Table 5 Temperature Dependency of P-308 Surface Resistance Value

(Base material) PET 50µm (Diafoil T600E50 U-07)
(Application) Bar coat #7-50 ºC 5 minutes - 110W/cm 20 seconds
(Film thickness) 1µm
(Measurement) JIS L 1094
(Humidity) 50%

Temperature	/ ºC	10	40
Surface resistance	$/\Omega\cdot\square^{-1}$	$4.0\text{x}10^{7}$	$3.8\text{x}10^{7}$

Table 4 Characteristics of an Antistatic Hard Coat Acrylic Plate

(Processing time) 2 hours
(Base material) PET 50µm (Diafoil T600E50 U-07)
(Application) Bar coat #7-50 ºC 5 minutes - 110W/cm 20 seconds
(Film thickness) 1µm
(Measurement) Mitsubishi Chemical low raster IP (terminal) ASP, 4 terminals
(Measurement environment) 22 ºC 50%

Temperature		/ ºC	-30	150
Surface resistance	Before treatment	$/\Omega\cdot\square^{-1}$	$4.0\text{x}10^{7}$	$4.0\text{x}10^{7}$
	After treatment		$4.5\text{x}10^{7}$	$3.7\text{x}10^{7}$

Table 7 Results of Chemical Resistance Test on R-308 and R-310

(Processing time) 10 minutes
(Base material) PET 50μm (Diafoil T600E50 U-07)
(Application) Bar coat #7-50 °C 5 minutes - 110W/cm 20 seconds
(Film thickness) 1μm
(Measurement) Mitsubishi Chemical high raster IP (terminal) HRS
(Measurement environment) 22 °C 50%

		Boiling Water	Ethanol	Acetone	Toluene
R-308	R(before) /x$10^{8}\Omega\cdot\square^{-1}$	1.5	1.7	1.6	2.4
	R(after) /x$10^{8}\Omega\cdot\square^{-1}$	0.91	1.8	1.5	2.4
	R(after)/R(before)	0.61	1.05	0.88	0.98
R-310	R(before) /x$10^{10}\Omega\cdot\square^{-1}$	2.0	2.6	3.1	3.9
	R(after) /x$10^{10}\Omega\cdot\square^{-1}$	2.9	2.8	3.1	3.7
	R(after)/R(before)	1.12	1.06	1.08	1.00

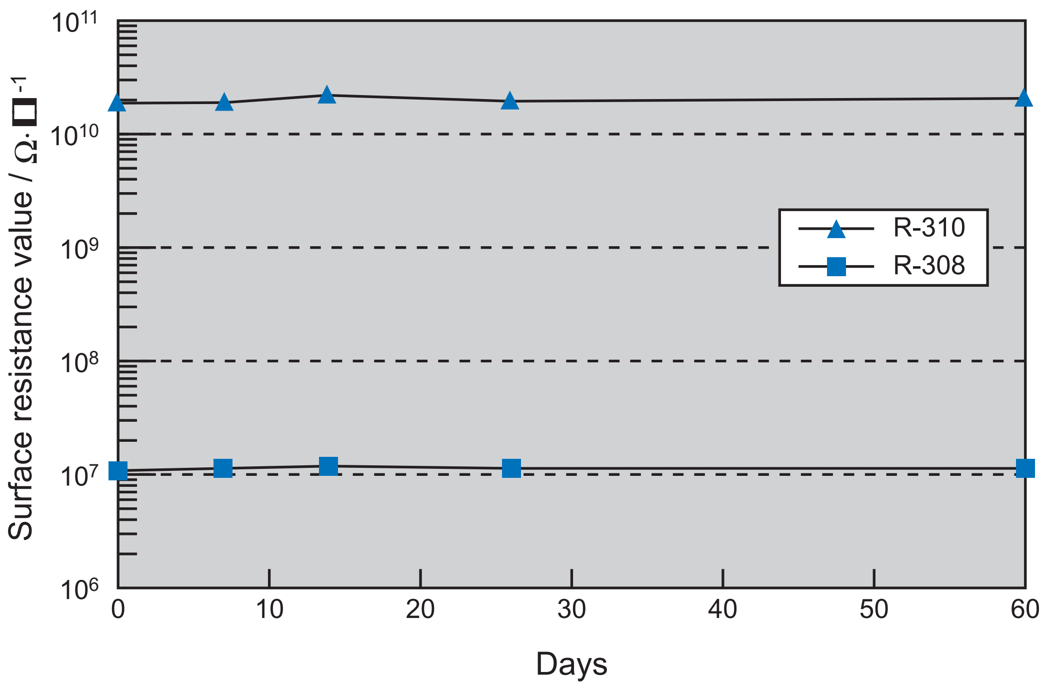

Fig.1 Time Passing Changes (liquid time passing) of Surface Resistance Values of R-308 and R-310 (50μm PET, film thickness 1μm)

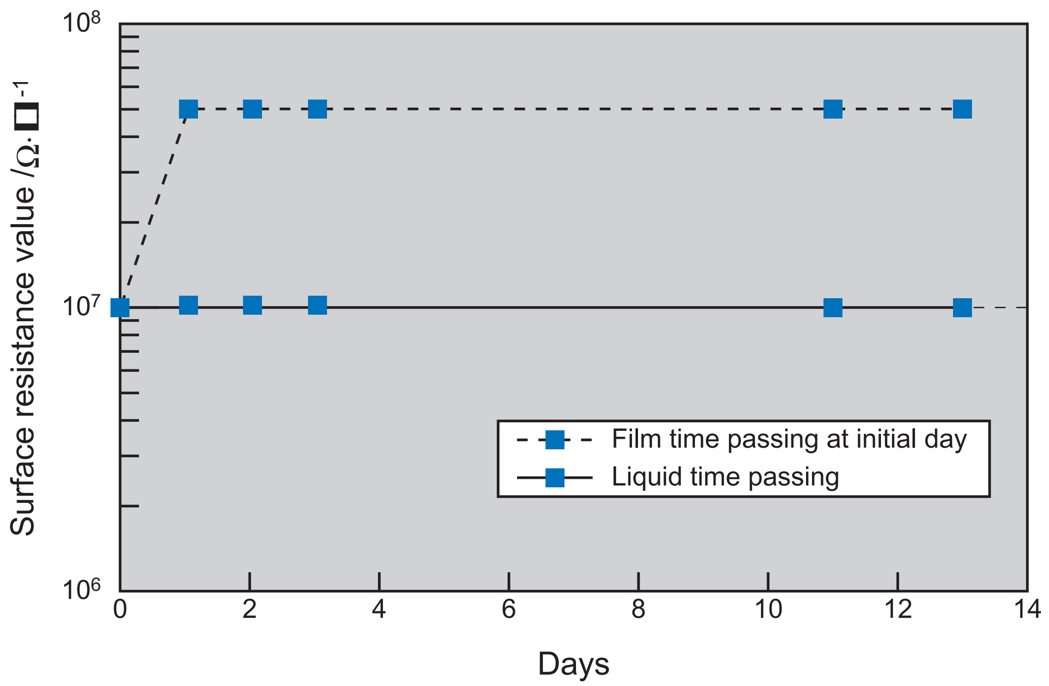

Fig.2 Film Time Passing and Liquid Time Passing of Surface Resistance Values of R-308 (50μm PET, film thickness 1μm)

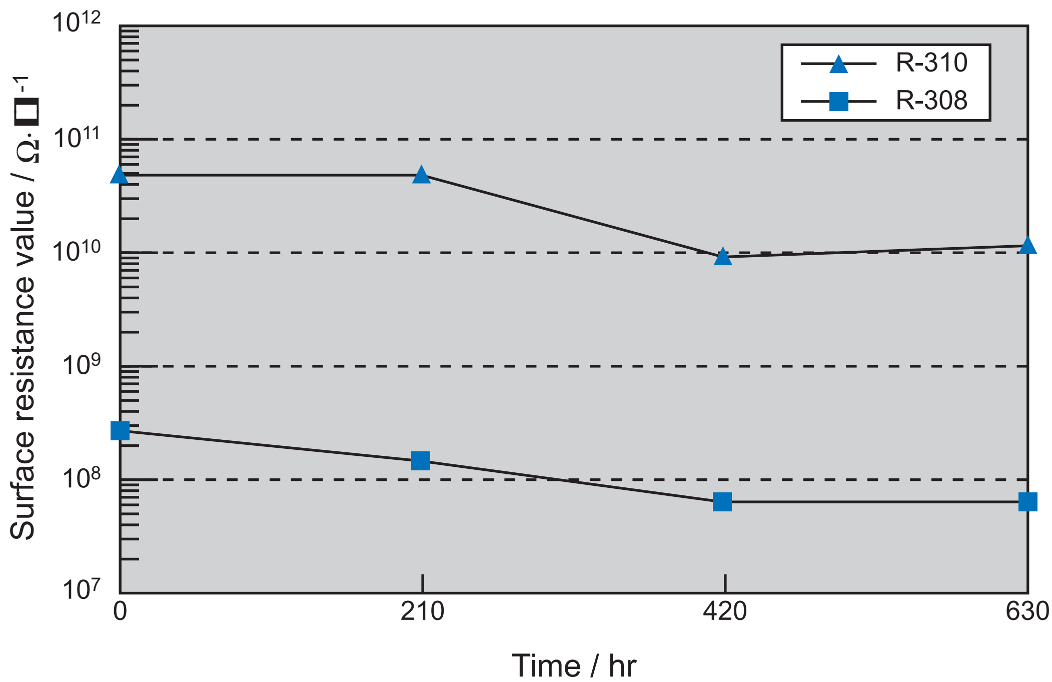

Fig.3 Results of Weather Resistance Test on R-308 and R-310 (JIS K 5400, PET 50μm, bar coat #7 applied, film thickness 1μm)