Additives for water-borne metallic coatings

1. Introduction

Plastic materials are widely used for various products such as cell phones and laptops since plastics show good properties like moldability and lightness. For plastic surfaces, thermoplastic acrylates, isocyanate cure coatings and UV cure coatings are generally used.
Solvent-borne coatings are still major in the coating industry, however the amount of water-borne coatings is gradually increasing because of environmental issues.
A good example for a water-borne coating is the basecoat and metallic luster is the preferred appearance of plasic basecoats. So luster pigments like aluminum pigments or pearl pigments are added to a basecoat to get this effect.

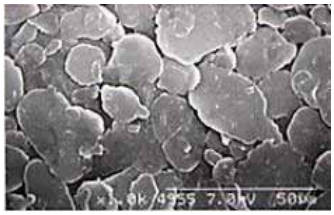


Photo1. Aluminum pigment (Toyo Aluminium)

To focus on an aluminum pigment, its shape is like a flake, the regular particle size is about 15 μm, and the regular thickness is about 0.5 μm. We can get a good metallic luster surface if the aluminum pigments are oriented parallel to the surface. If not, the surface looks dull and darker.
In practice, an aluminum pigment is like a fine flake, so it moves around and swings in the wet film. Therefore it is difficult to keep the pigments parallel to the surface.
For the above reason, several additives are generally used to set aluminum pigments parallel and uniform. These kind of additives increase the paint viscosity right after spraying and prevent the pigments movement. To fix the pigment is important for a good metallic pigment orientation. Later the drying shrinkage of the film brings the pigments parallel to the film surface. (Figure1)

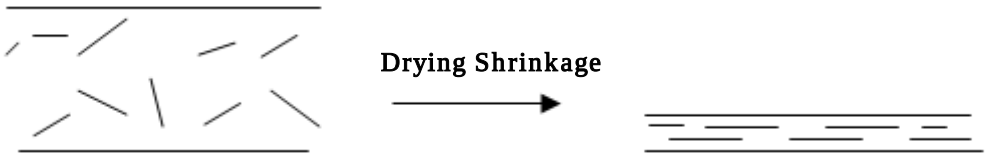


Figure1. Aluminum pigment orientation

In addition to the above mentioned additives, we have various other additives for water-borne metallic coatings. Following you can find these additives in this document.

2. Dispersant for aluminum pigments

1) Mechanism

Solid particles may flocculate with attractive forces such as Van der Waals force. If there are some repulsive forces stronger than the attractive forces, particles are stabily dispersed without any flocculation. The examples of repulsive forces are electrostatic repulsion by electric double layer and steric hindrance by polymer adsorption layer. (Figure2)

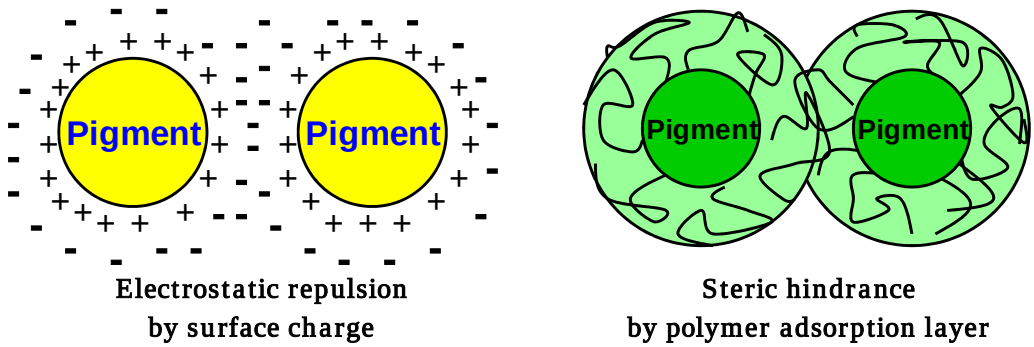


Figure2. Mechanism of dispersing effect

DISPARLON AQ-320 and AQ-330 are dispersants which can work in water or polar solvents. AQ-320 and AQ-330 are compositions of a phosphate part and a polyether part, and both of them are water-soluble. The phosphate part works as an adsorption group in a polar solvent and shows electrostatic repulsion by anionic charge in water. On the other hand the polyether part works as an adsorption group or polymer adsorption layer and also contributes to the solubility to the polar solvents. We combined these two parts appropriately so that AQ-320 and AQ-330 can act as dispersants in water and various polar solvent systems.

2) Dispersing effect of aluminum pigment

Following, we show an application example of AQ-320 and AQ-330 dispersing an aluminum pigment in butyl glycol.
Pigment flocculation increases the viscosity, dispersing of pigments decreases the viscosity.
As shown in figure 3, AQ-320 and AQ-330 brings a lower viscosity of the aluminum slurry compared to Additive A or B. Thus the pigment dispersing abilities of AQ-320 and AQ-330 were much better.
Like this, the improvement of aluminum pigment dispersibility by AQ-320 or AQ-330 decreases the viscosity (Photo 2). As a result, the amount of solvents can be reduced. Moreover, the aluminum slurry which was well dispersed keeps its dispersibility even after the addition to a water-borne coating. In this way, a stable metallic paint can be created.

Table1. Aluminum slurry formulation

Ingredients	Blank	With additive(5%)
Aluminum paste (phosphated)	53. 6	53. 6
Butylglycol	46. 4	46. 4
Dispersant	—	2. 7
Total	100. 0	102. 7

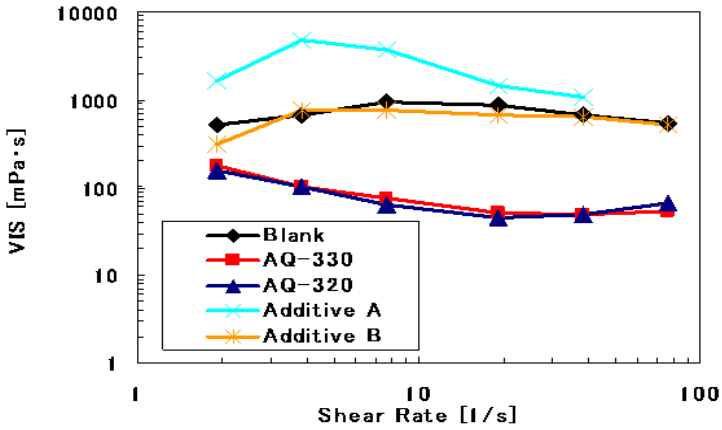
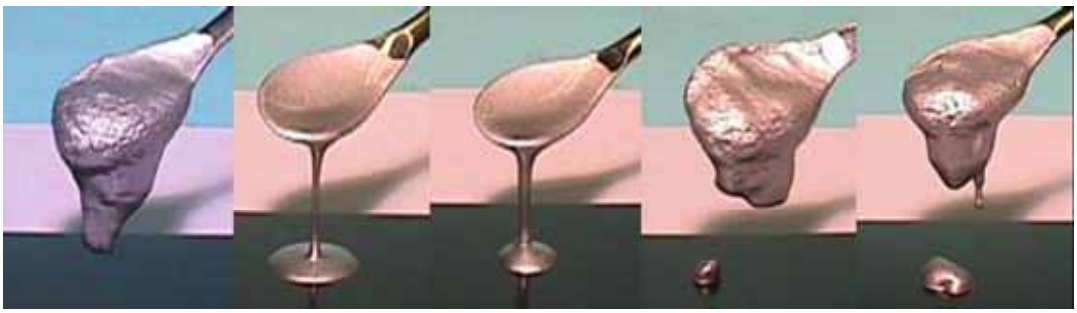


Figure3. Viscosity change by dispersant



Blank AQ-330 AQ-320 Additive A Additive B

Photo2. Flow of an aluminium slurry

3. Rheology control agents for water-borne coatings

1) Mechanism

DISPARLON AQ-600 series are paste form anti-settling agents which are mainly based on an amine salt of polyamide.
AQ-polyamides disperse uniformly in coating and form a network structure in the interaction with the resins and pigments as shown in the model (Figure 4). This network structure imparts high viscosity to the paint on standing condition. However the structure is not fixed strongly and can be broken by stirring. Thus, viscosity decreases by increasing the shear rate. This type of flow is called "Thixotropy". If a coating shows a thixotropic flow, storage problems like settling and hard-caking can be prevented without increasing the application viscosity.

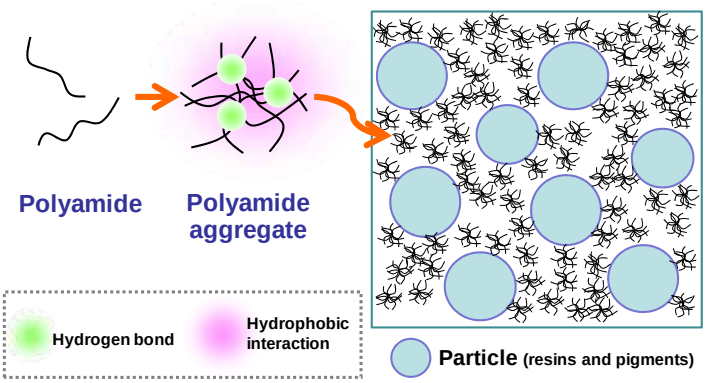


Figure4. Model structure and mechanism

2) Anti-settling and orientation improvement of aluminum pigment in W/B metallic coating

In addition to the anti-settling properties, the unique structural viscosity of AQ-600 series can prevent aluminum pigment from moving in films after spraying and improve the pigment orientation. To evaluate the performances of AQ-600, we used a W/B metallic coating (Table 2).
As shown in Figure 5, compared with acrylic type ASE or urethane thickener, AQ-600 showed excellent thixotropic flow (very high viscosity at low shear and low viscosity at high shear). With this behaviour, AQ-600 gives much better anti-settling effects than ASE and urethane thickener (Photo 3).
In the same system AQ-330 was added to the aluminum slurry as a dispersant. The coating with this pigment preparation showed a good dispersion

Table2. W/B metallic coating formulation

Part A	
NeoCryl A-662	60.4
Butylglycol	7.8
Butyldiglycol	3.6
Methoxypropoxypropanol	3.6
Let down	
Water	11.0
Aluminum slurry	13.6
Thixotrope (solid 0.6%)	X
DMEA (pH=8.0)	Y
Total	100.0

state without any flocculation.

FC#4 20 sec

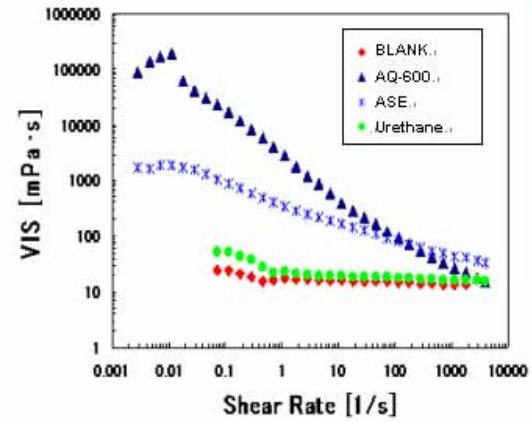


Figure5. Viscosity change by thixotrope

After 30 days / R.T. / FC#4 20sec

Photo3. Anti-settling of aluminum pigment

A Multi-Angle Spectrophotometer is used for measuring the Flop Index (FI) to evaluate the improvement of aluminum pigment orientation. FI is measured by the amount of reflected light from the lamp (near specular : 15°, vertical : 45°, and near light source : 110°).

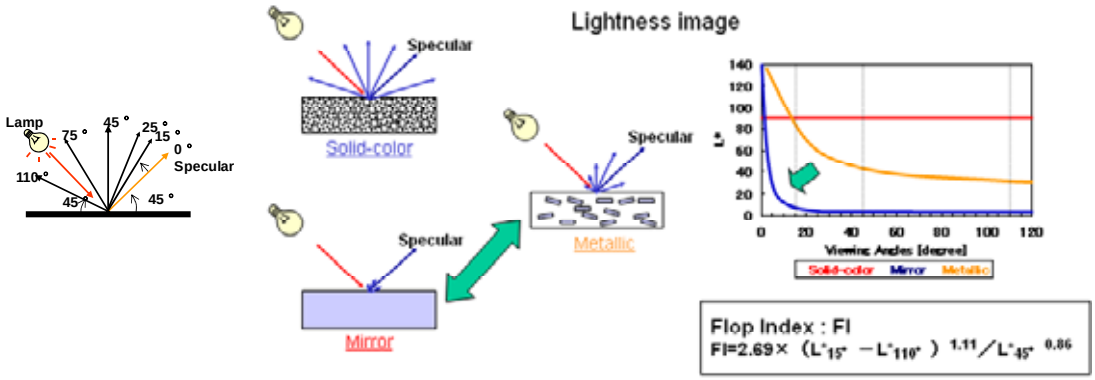


Figure6. Flop index measurement

As shown in Figure 6, the film which is densely stuffed with pigments (Solid color) scatters light. Therefore the amount of reflected light is constant at every angle. In case of a mirror, light reflects completely to the specular direction. So no reflected light is observed in vertical (45°) or near light source (110°) direction. The angular distribution of the metallic film is inferior to the mirror, but quite similar. Good orientation of aluminum pigments provides closer angular distribution to the mirror and the FI value becomes higher. On the contrary, poor orientation scatters light more and the FI value becomes lower. (Figure 7)

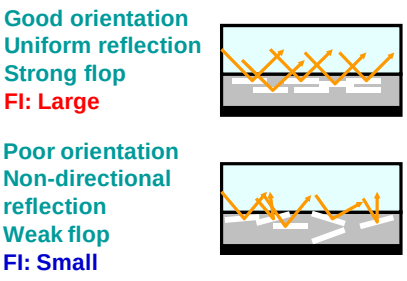


Figure7. Pigment orientation and FI

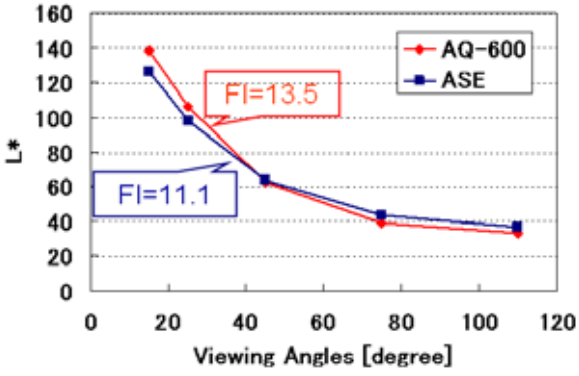


Figure8. FI of metallic films

AQ-600 ASE

Photo4. Comparison of metallic films

Figure 8 shows the FI measurement results. AQ-600 imparted excellent thixotropic properties and improved the aluminum pigment orientation. Therefore, the AQ-600 film provided higher FI values (over 2.0) than ASE. Generally, if the difference of FI is over 2.0, we can recognize the visual difference clearly. Photo 4 is the view of the metallic films from specular side. The AQ-600 film is brighter than the ASE film because of the stronger specular light reflection.

4. Leveling agents for water-borne coatings

1) Mechanism

Leveling agents are additives which spread on the coating surface uniformly, reduce the surface tension and improve leveling and wetting properties.

A conventional acrylic leveling agent is not so effective especially in water-based systems to get sufficient leveling and to prevent surface defects. On the other hand, a modified silicone can cause some troubles such as intercoat adhesion failures and recoat problems. For these reasons, we developed an acrylic-silicone copolymer type. Figure 9 is the model structure of AQ-7120, one of the acrylic-silicone leveling agents. Like this, an acrylic-silicone has several types of side chains. And the balance of the side chains is controlled appropriately to have sufficient leveling/wetting abilities without intercoat issues and surface defects.

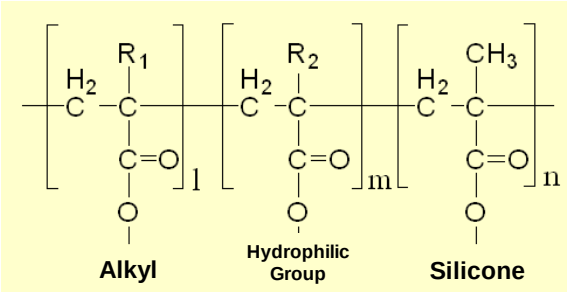


Figure9. Model structure of AQ-7120

Table3. Contact angle (Water)

Additive	Contact angle (Water) / °
Blank	70
AQ-7120	71
Additive C	75
Additive D	79

In general, larger contact angles of water on a coating film mean there is a higher surface tension difference between water and a film and more intercoat problems can occur. In Table 3, a film which contains AQ-7120 shows a smaller contact angle than the conventional modified silicones (Additive C and D) meaning that AQ-7120 will cause less intercoat problems.

2) Anti-cratering in W/B metallic coating

We used a W/B metallic coating (Table 4) to evaluate recoatability (anti-cratering performance) of AQ-7120.

We put hand-cream, DBP and DBA as contaminants on a substrate, and then applied the coating by an air-spray.

AQ-7120 showed an excellent anti-cratering effect. Furthermore, the change in color of the AQ-7120's film was much smaller than the conventional modified silicones (Additive C and D). (Photo 5)

Table4.

W/B metallic coating formulation

Part A	
NeoCryl A-662	60.4
Butylglycol	7.8
Butyldiglycol	3.6
Methoxypropoxypropanol	3.6
Let down	
Water	4.0
Aluminum slurry	13.6
30% AQ-600 MB	10.0
DMEA (pH=8.0)	X
Wetting (Dosage : 0.6%)	Y
Total	103.0

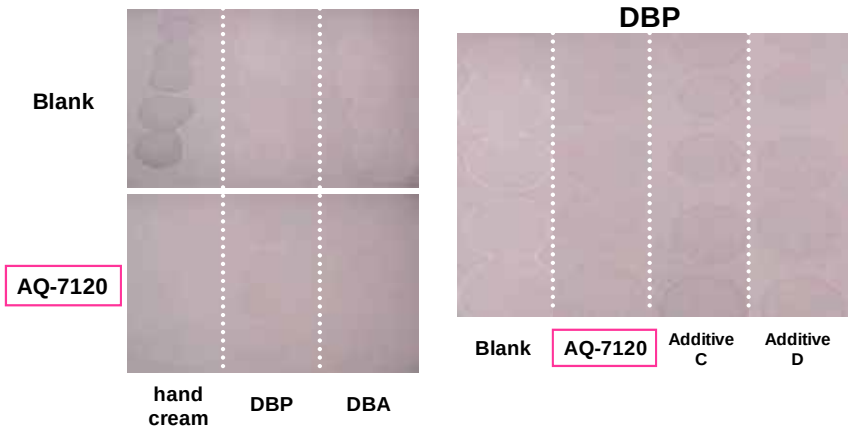


Photo5. Estimation of anti-cratering

As mentioned in this document, for water-borne metallic coatings there are a lot of requirements like aluminum pigment dispersion, anti-settling, improving of metallic orientation, recoatability, levelling (anti-cratering) and we can offer a wide range of additives such as AQ-330, AQ-600 and AQ-7120 to solve these problems.