

Development of Super-brilliant Silver Metallic Coating

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ABSTRACT

A technique has been developed to achieve increased brilliance in a silver metallic automotive coating. Super-brilliant coatings have been employed in the past, but the necessity for special pigments and complex paint shop processes has made it difficult to use them in mass production. The new technique exploits characteristics of the paint to achieve optimum orientation of the brilliance pigment. This results in increased brilliance when using conventional pigments and paint shop processes. The new technology produces two times the brilliance of conventional silver metallic paints, and the pigment particles cannot be individually seen, resulting in a superior finish.

1. Introduction

Figure 1 shows recent trends in colors of automotive coatings, highlighting the high level of interest in the marketplace for silver metallic coatings and the steady sales percentage for vehicles of this color. In recent years sales percentages of silver metallic vehicles have increased significantly, indicating an increase in the market demand. Figure 2 shows design changes in the silver

metallic color. From this diagram, it can be seen that design has evolved to emphasize the brilliance and the contrast between brilliant surface areas and shadowed areas. Colors are being developed that approach the appearance of true metals. It is thought that this design evolution has contributed to the strong support that this color has received in the market.

In recent years, an evolved silver metallic color has been used on display models at motor shows and in other demonstrations,

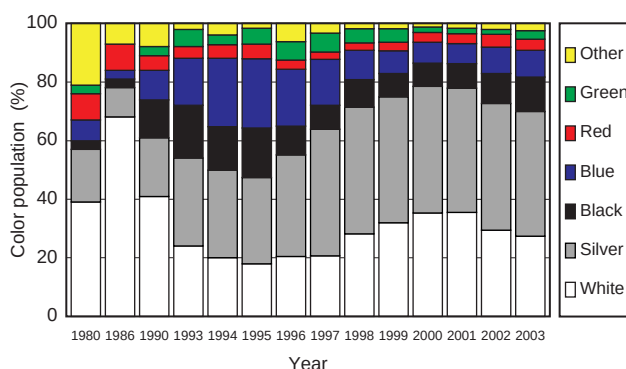


Fig. 1 Domestic (Japan) color trend for automotive bodies

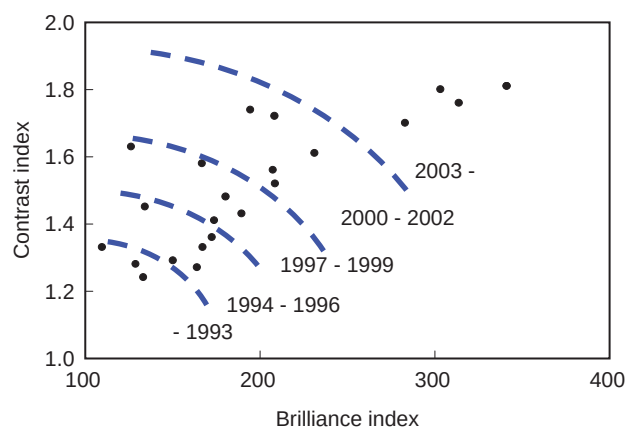


Fig. 2 Evolution of silver metallic color at Honda

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and on a limited number of production vehicles. In addition to the brilliance and high contrast of the coatings, the pigment seams (particle appearance) no longer stand out. However, there are two hurdles with respect to the mass production of brilliant silver metallic coatings with a reduced particle appearance—such coatings require complex coating processes⁽¹⁾ and special pigments^{(2), (3)}.

This report explains a coating system that has enabled the production of a highly brilliant silver metallic color with reduced particle appearance on a mass production line.

2. Current Status and Issues Concerning Production Using Silver Metallic Colors

The coating for automotive bodies is generally applied in four layers, as shown in Fig. 3. The brilliance of the silver metallic color comes from the reflection of light by the aluminum pigment included in the base coat layer. To demonstrate the orientation of the aluminum pigment coating, surface pictures of a standard coating and a coating where aluminum pigment has been oriented are shown in Fig. 4. In this picture, pigment oriented horizontally appears white, while pigment that is not oriented appears grey. It can be seen that there is a random alignment of pigment in the standard coating. The pigment in the other coating is aligned uniformly, has achieved higher brilliance and reduced particle appearance. It can be concluded the random pigment orientation in current coating systems prevents the aluminum pigment from achieving higher brilliance characteristics.

The volume reduction effect in coatings is widely known to achieve uniform orientation of aluminum pigment. After coating, the solvent, which is water, vaporizes, reducing volume. The orientation of scale-shaped pigments is restricted and becomes

uniform (Fig. 5). Increasing the solvent content of the base coat (reducing paint viscosity) results in a condition in which it is easier for the paint to move. Also, the pigment in the paint is in a state where it can move freely, making it hard to obtain a uniform pigment orientation.

Because this tradeoff relationship between volume reduction and paint viscosity exists, generating a uniform pigment orientation has been a challenge.

This report describes a technology that achieves both a volume reduction effect and paint viscosity maintenance through penetration of the solvent to the lower layer.

3. Development of Aluminum Pigment High Orientation Technology

3.1. System Settings

To reduce paint volume and maintain paint viscosity, the base coat, which has conventionally been one layer, has been changed

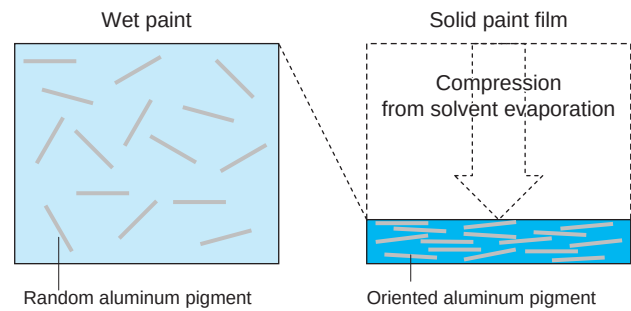


Fig. 5 Effect of shrinkage of paint layer

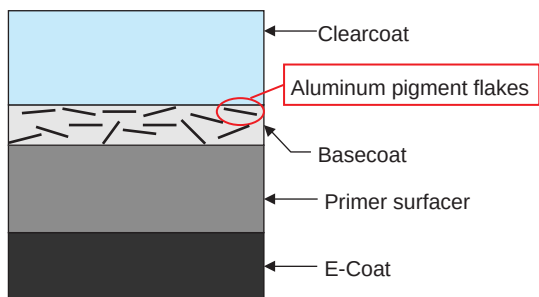


Fig. 3 Standard layer structure of body paint

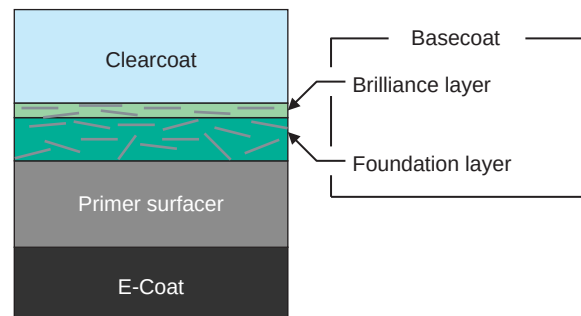


Fig. 6 Layer structure of new basecoat system

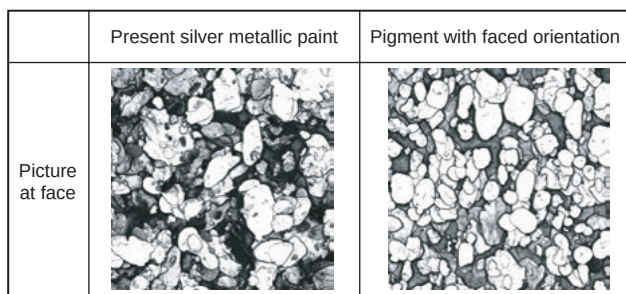


Fig. 4 Arrangement of aluminum pigment flakes in basecoat

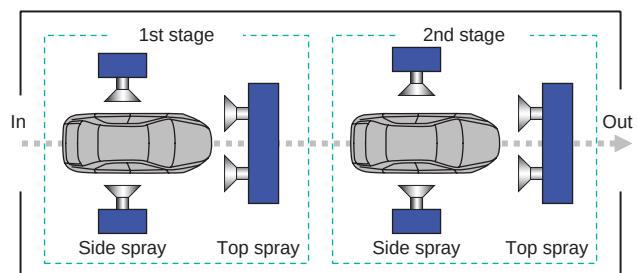


Fig. 7 Paint facility layout in basecoat booth

to two layers with different functions (Fig. 6). In the conventional process, the base coat coating is divided into two stages, as shown in Fig. 7, with the same coating being applied in each stage to ensure coating thickness. Using 2 distinct base coat materials does not decrease productivity. In this system, the base coats applied in the first and second stages are called the foundation base coat and the brilliance base coat, respectively.

The function of the brilliance base coat is to express design. To significantly reduce the paint volume previously described in the aluminum pigment orientation theory, reduction of the solid content in the paint was investigated. To enable the foundation base coat to suppress movement of the aluminum pigment in the brilliance base coat, a method of controlling viscosity was also investigated. A foundation base coat with a high solids content and a brilliance base coat with a low solids content are combined to create a differential of solid content between the two coats. This enables transfer of the water content from the brilliance base coat to the foundation base coat, increasing the solid content of the brilliance base coat. As the viscosity in the brilliance base increases, movement of the aluminum pigment is suppressed.

When considering the theory of this system, the primary paint setting parameters are the foundation base coat solid content and brilliance base coat viscosity. However, as a result of other paint parameters investigated in preliminary testing, it was found that the aluminum pigment content of the brilliance base coat and the difference in solubility parameters between the foundation base coat and the brilliance base coat needed to be further defined. The high orientation of pigment could not be achieved through independent application of the brilliance base coat. The four paint parameters were evaluated using the complete layered system. The results are described below.

3.2. Foundation Base Coat Solid Content

First, the phase transfer phenomenon that accompanies changes of paint solid content in water soluble paint is shown in Fig. 8. While water in the water-rich condition (hydrophilic phase) of the paint is vaporized and the paint solid content is increased before baking, a phase transfer point exists at which the paint condition changes to a solvent-rich condition (hydrophobic phase). Water absorption is considered to be high at this phase transfer point.

To determine the optimal foundation base coat solid content, the amount of water absorbed was measured. As shown in Fig. 9, a capillary tube filled with water was placed in contact with a wet foundation base coating of uniform thickness and the amount of water absorbed was determined. Figure 10 shows the measurement

results for the amount of water absorbed. Contrary to expected results, water was absorbed most efficiently at a solid content of 60%, which is lower than the phase transfer point. It is theorized that at the phase transfer point, the viscosity has increased so much that diffusion of water is inhibited. In addition, the brilliance index after applying the brilliance base, measured at the same time, showed the highest value at the point of maximum water absorption. It was therefore possible to confirm that water transfer, one of the design enhancement theories, was functioning effectively.

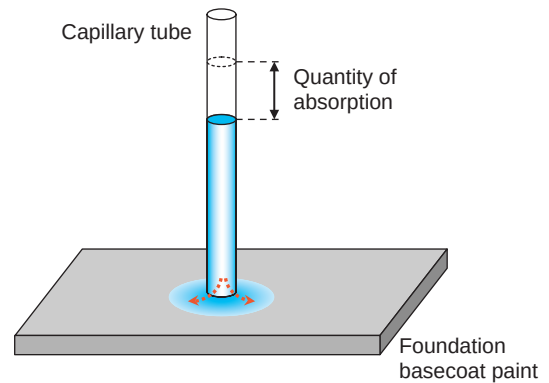


Fig. 9 Measurement of water absorption of foundation basecoat

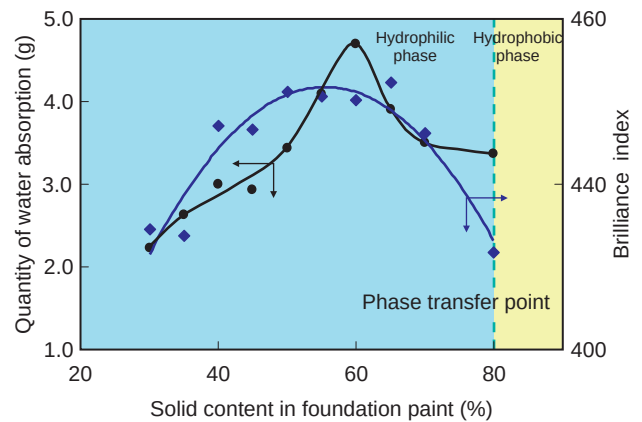


Fig.10 Solid content in foundation paint vs. water absorption and brilliance index

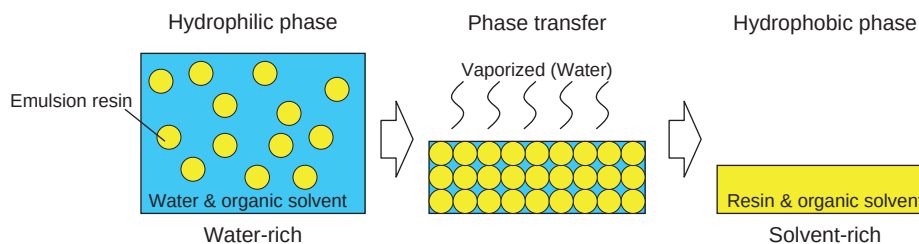


Fig. 8 Phase transfer in water-borne paint

3.3. Brilliance Base Coat Viscosity

Figure 11 shows the measurement results of the viscosity region where movement of the aluminum pigment is suppressed in the brilliance base coating only. It was confirmed that the paint viscosity needed to suppress movement of aluminum pigment was 10 Pa·s or more. The paint solid content was 30% or more. As the optimal paint solid content for the foundation base coat is 60%, to achieve a solid content for the brilliance base coat of 30% or more after absorption of water, it is calculated that the brilliance base coat needs 10% or more solid content. To verify this effect, a viscosity measurement of the brilliance base after application was attempted. Because the whole base coat system is a very thin film of 15 μm thickness, and two types of paint are overlaid, it was hard to measure only the brilliance base coat. Therefore, the brilliance index versus the solid content of the brilliance base coat was measured, and

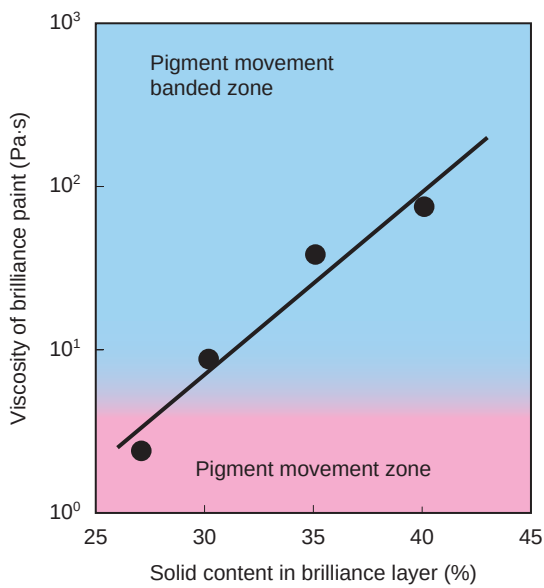


Fig. 11 Solid content in brilliance layer vs. viscosity

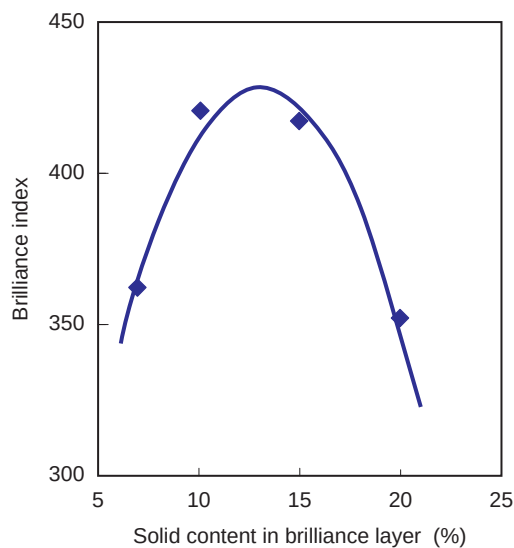


Fig. 12 Solid content in brilliance layer vs. brilliance

Fig. 12 shows the results. It was found that, as expected, a 10% solid content was favorable for orientation of the aluminum pigment. It is thought that the brilliance index decreases because the volume reduction effect is reduced for a brilliance base coat solid content of 15% or higher. The increase in viscosity is insufficient for a brilliance base coat solid content of 10% or less.

3.4. Aluminum Pigment Concentration in the Brilliance Base Coat

To analyze why aluminum pigment concentration has an effect on design, observation pictures of the aluminum pigment orientation for the coating surface were taken (Fig. 13). In these pictures, it can be observed that when the pigment concentration is at a low 10%, the pigment surface coverage is insufficient, leaving gaps. It is thought this causes the foundation base coat to show through, diminishing the design. In the high range of pigment concentration (40%), the surface is covered with pigment. Due to the interference of aluminum pigment particles, the orientation of the pigment is random. Therefore, it is necessary to exclude gaps in the aluminum pigment and randomness of the orientation caused by interference, and it was found that pigment concentration is a factor.

Following confirmation of the optimal pigment concentration in the brilliance base coat, brilliance was measured; however, the change was not significant enough. Figure 14 shows measurement results of contrast values instead. Best results were achieved using a pigment concentration between 15 – 30%. When the aluminum pigment condition is confirmed using an enlarged picture of the surface, existence of gaps are found at a pigment concentration of 20%. However, there is no interference between pigment particles and the condition is favorable.

Pigment content	Picture at face
10%	
20%	
40%	

Fig. 13 Effect of aluminum pigment content

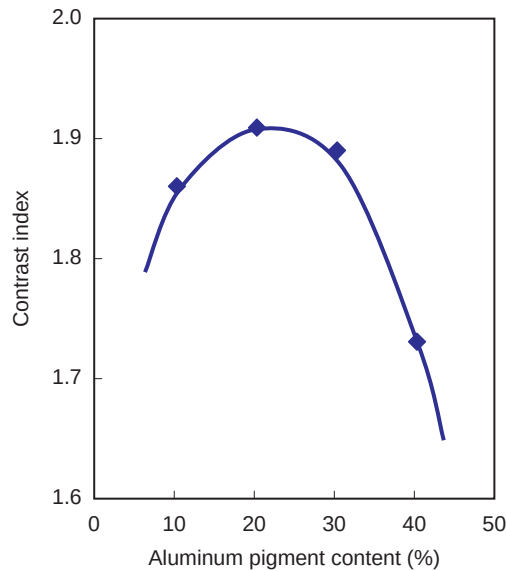


Fig. 14 Effect of aluminum pigment content vs. contrast

3.5. The Difference of Solubility Parameters between the Foundation Base Coat and the Brilliance Base Coat

The solubility parameter is an index that shows the ease of mixing the organic solvents into the coating resins. If these parameters are close, the two materials mix easily. If the values differ significantly, it is not easy for them to mix. When overlaying a foundation base coat with a brilliance base coat that has the same solubility parameter, as shown in Fig. 15, mixture of the layers occurs. The coating system begins to flow thus disturbing the orientation of the aluminum flake particles.

The difference between the foundation base coat and brilliance base coat solubility parameter (ΔSP) was changed and the appearance was confirmed. Figure 16 shows the results. The effect of ΔSP was confirmed as the brilliance index increased with greater ΔSP values. On the other hand, the compatibility between the layers is reduced as ΔSP is increased resulting in an adhesion reduction between the foundation base coat and the brilliance base coat. The result of measuring the adherence between the coatings by cutting the coating indicated that adherence was reduced for areas where ΔSP was greater than 1.0.

To achieve both appearance and adherence of the coating, the ΔSP between the foundation base coat and the brilliance base coat was set to a range of 0.9 – 1.0 by adjusting the solubility parameter for the foundation base.

3.6. Design of the Completed Coating

A silver metallic coating was created by applying the results of this research. Table 1 shows the results confirmed for the design effects. When compared to silver metallic color (satin silver metallic) currently being applied, the frontal surface achieved a brilliance value more than double that of conventional coatings. The contrast value was also increased significantly.

4. Conclusion

A new coating system with enhanced frontal brilliance and contrast compared to conventional coatings, and with reduced pigment particle appearance has been developed by dividing the

Table 1 Comparison of color characteristic values

Item	Color characteristic value	
	Brilliance index	Contrast index
New system silver met.	520	1.87
Satin silver met.	196	1.49

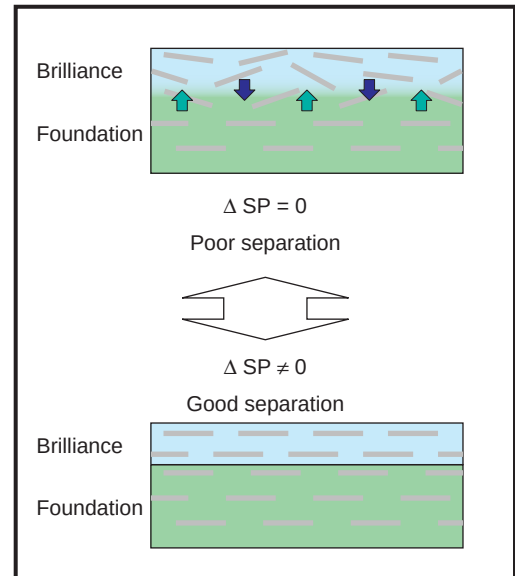


Fig.15 Influence of difference in solubility parameter

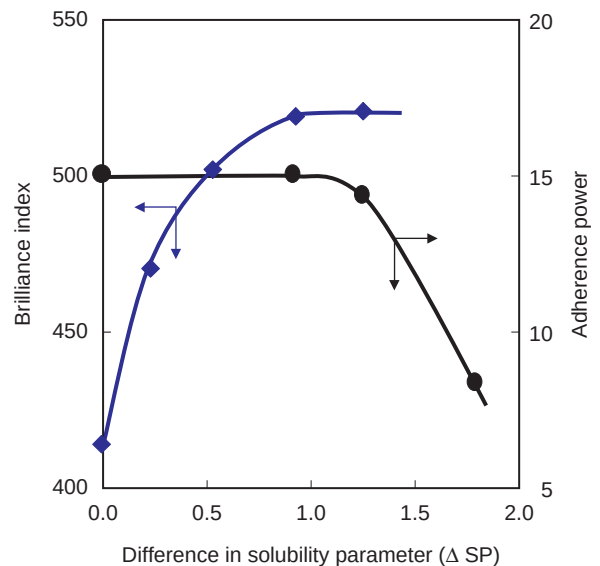


Fig. 16 Influence of difference in solubility parameter vs. brilliance and adherence power

base coat into two layers and adjusting the characteristics for the foundation and brilliance base coats. This new coating system is applied to the new model CIVIC (Fig. 17). The new coating does not require special coating resins, aluminum pigment, and does not slow down the production process. It can be smoothly introduced into a current production line.

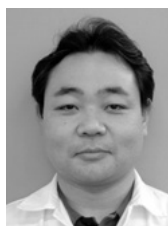


Fig. 17 This System was applied to the New Honda CIVIC (domestic version)

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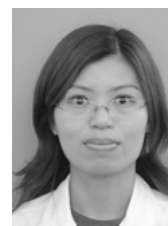
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