In situ Imaging of Automotive Metallic Paints

Visualization of behavior of aluminum-flake reflective materials in paints

Achievements

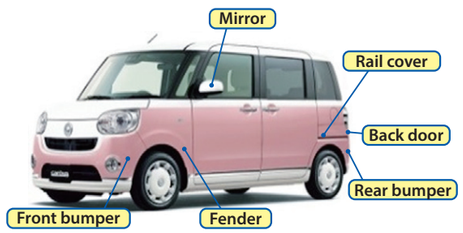
- The formation of coats of automotive **metallic paints*** was observed in the cross-sectional direction.
- It was confirmed through real-time observation that the orientation angle of **aluminum flakes**** changed with time after painting as a result of volumetric shrinkage and change in viscosity, although it remained unchanged immediately after painting.

R&D institution: Daihatsu Motor Co., Ltd.

***Metallic paint:** Automotive paint is roughly classified into three types: metallic, pearlescent, and solid. Metallic and pearlescent paints contain fine aluminum and mica flakes and give characteristic colors that look different depending on the viewing angle.
****Aluminum flakes:** Aluminum flakes are metallic aluminum powder in the form of very thin flakes and one of the reflective materials used in paints. Aluminum flakes mixed with paints reflect light, and the shininess and color of the paints change with their orientation angle.

Example of color mismatch in production preparation stage

Use of resin in car body

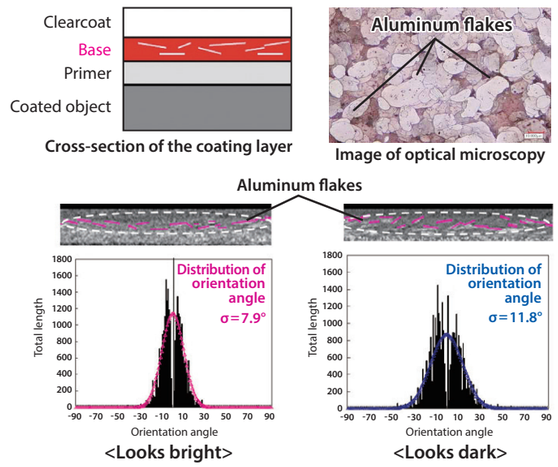


Color matching between door and fender

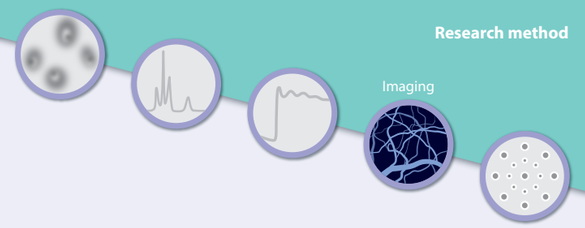
With the widespread use of resin for exterior parts to reduce the weight of car bodies, multiple attempts at painting and color matching have been required for paints containing aluminum-flake reflective materials (aluminum flakes) used on the steel sheets and resin of car bodies, as they are manufactured by different production processes. This is one of the causes of the long preparation time before automotive production.

Observation of cross section of paint by optical microscopy and SEM

SEM image and distribution of orientation angle of aluminum flakes



When the painted region was observed by optical microscopy, the overlapping of aluminum flakes was found but no clear differences in their orientation angle were seen.
Differences in the orientation angle of aluminum flakes were confirmed by SEM. However, there have been no methods for analyzing the behavioral changes of aluminum flakes during the formation of coats.



Role of SPring-8

Background

Recently, resin has been used in the exterior finish of cars in addition to steel sheets. Color matching between steel sheets and resin in metallic paints has been an issue to be addressed. Because the painting processes and materials used for steel sheets and resin differ, the orientation angles of fine aluminum flakes in metallic paints also differ, causing variation in the brightness and color of the paint. Therefore, a scientific approach to analyzing the mechanism underlying the behavior of aluminum flakes in detail has been required.

The difference in the coats cannot be clarified from the planar view obtained by optical microscopy. It has been clarified by scanning electron microscopy (SEM) that a difference in the distribution of the orientation angle affects the brightness of color. However, there have been no methods to analyze the behavioral changes of aluminum flakes during the formation of coats.

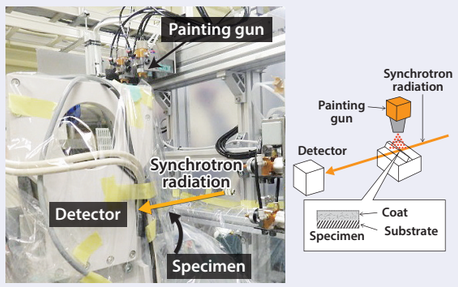
Results

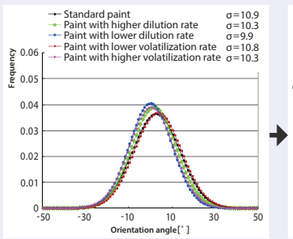
The behavior of aluminum flakes was observed by X-ray imaging at SPring-8 using high-brilliance synchrotron radiation with high temporal and spatial resolutions. To observe the time course of paints under conditions close to those in the actual process, a setup for actual painting was installed at the experimental hutch.

It was found that the coats shrank with time after painting and that the orientation angle of aluminum flakes varied with the dilution and volatilization rates of the solvent, although the orientation angle did not vary immediately after painting. When the behavior of aluminum flakes was observed under the condition of multilayer painting, the viscosity of the paint changed in the painting process, which was considered to affect the behavior of the aluminum flakes. These findings are expected to shorten the preparation time before production in automotive production lines.

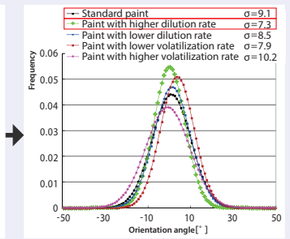
X-ray imaging at SPring-8

Experimental setup for painting installed at the experimental hutch of SPring-8





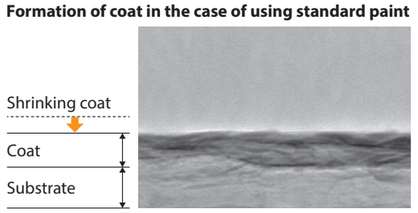
Orientation angle of aluminum flakes 4.8 s after painting



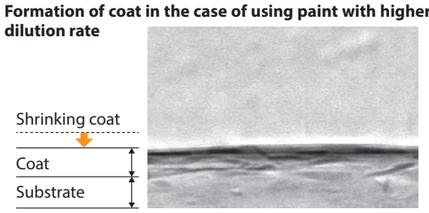
Orientation angle of aluminum flakes 180 s after painting

- **The orientation angle of aluminum flakes changes with time.**
- **The change in the orientation angle depends on the painting conditions.**

Formation of coat in the case of using standard paint



Formation of coat in the case of using paint with higher dilution rate



An experimental setup for painting was installed at the experimental hutch of SPring-8 BL46XU. To observe the dynamic behavior of aluminum flakes during the formation of coats, we applied a standard paint as well as paints with different dilution rates and volatilization rates to the substrate and compared the orientation angles of aluminum flakes 4.8 and 180 s after painting. It was found that the orientation angle of aluminum flakes during the formation of coats depended on the dilution and volatilization rates of the solvent.