Interference Colored Aluminium Pigment

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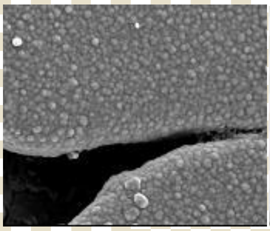


Surface SEM image   Cross-section TEM image

【 1. Introduction 】

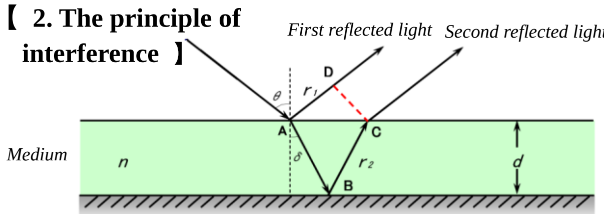
Interference color can be seen in the environment around us, for example, on soap bubbles, peacock feathers and hologram film. These color tones are different to that from pigment or dye, because there is no color in the item itself. The coloring is achieved by a principle that is also called structural coloring. There is interference of the light caused by extremely fine structures having the size of wavelength of visual light or smaller. The viewer recognizes a color when light with a wavelength of the color was amplified by interference reaches the viewer's eyes. Furthermore, it is possible to express different color tones depending upon the viewing angle, as generally, the optical path difference for the light interference change depending upon the reflecting angle.

We,Toyo Aluminium, have developed the interference colored aluminium pigments that have both high chroma and high hiding power, under the concept of "developing a new, global-first, coloring material" in metallic pigments.

The current range of products includes the following three series for different applications.

- "CHROMASHINE®" for automobiles and household electrical goods
- "METAX CHROMA®" for injection molding
- "COSMICOLOR™" for cosmetics

【 2. The principle of interference 】



$dn\cos\delta=(m+1)\lambda/2$ 【 $n=\sin\theta/\sin\delta$, $m=0,1,2\cdots$ 】

Coloring wavelength: $\lambda=2nd\cdot\cos(\sin^{-1}(\sin\theta/n))/(m+1)$

Figure 1 Formula for calculating wavelength of the color

A phase difference is caused by the difference in the optical paths between the light reflected on the surface of the film (the first reflected light) and the light that passes through the medium and is then reflected back (the second reflected light). This causes particular wavelengths of light to be amplified

【 3. Features of the interference color aluminium pigment 】

The features of the interference colored aluminium pigment include: (1) High chroma: a wide variety of colors can be obtained by controlling the thickness of the film, (2) Color flop: the color changes depending upon the viewing angle, (3) High hiding power: superior opacity that was not possible with conventional interference pigments, and (4) Chemical resistance and moisture resistance: the inorganic/organic film formation realizes excellent chemical stability.

This pigment uses aluminium flakes as a base material, onto which a silica layer is coated as an interference/refractive layer. Next, there is an intermediate layer and then a layer of silver nanoparticles is formed. A layer of silica or resin is added finally to protect the silver. This is the whole design of the interference colored aluminium pigment.

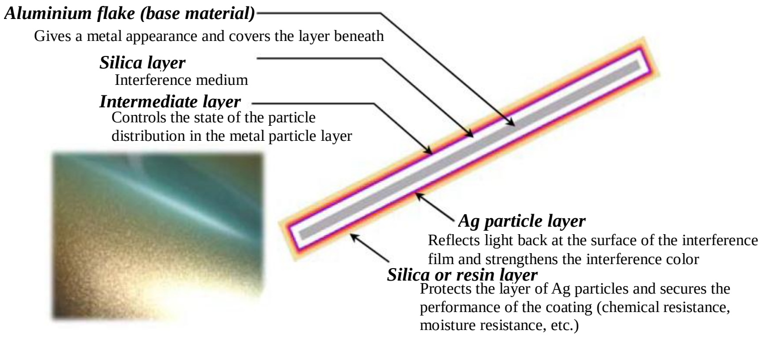


Figure 2 The structure and the function of each layer

It goes without saying that the most distinguishing feature of the interference colored aluminium pigment is that aluminium flakes are used as the base material. Figure 3 shows a comparison with the widely used titania coated mica pigment. By using aluminium flakes as the base material, the light coming in does not pass through, and instead, is reflected at the surface of the aluminium flake. As the light is refracted in the silica layer, color of a particular wavelength is observed. The refractive index of the silica layer is lower than that of a titania layer, so the optical path difference for the light that has entered the layer becomes longer. This means that even greater color flop can be obtained. Also, the reflection of the light at the silver nanoparticles intensifies the interference color. Thus the high chroma interference color that had not been possible before was successfully achieved.

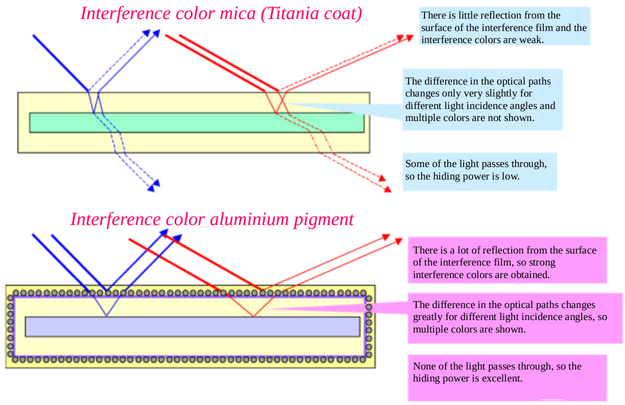


Figure 3 Comparison with interference color mica

【 4. Range of color tones 】

Table 1 shows the COSMICOLOR range of products as an example of the interference colored aluminium pigments. There are various colors for the highlights, including dark blue, pink, orange, gold and green. The highlights are the color tones when the coated surface of the item coated with pigment is viewed straight on. The shades (the colors when the coated surface is viewed at an angle) show different colors to the highlights. The average particle diameter is 20 µm.

Table 1 COSMICOLOR Series

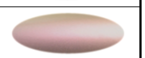
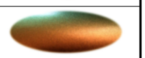
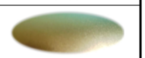
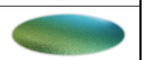
Grade Name	Highlight	Shade	Design Image
Iris Blue	Dark Blue	Violet	
Rose Pink	Pink	Gold	
Cherry Pink	Pink	Yellowish Gold	
Ivy Orange	Orange	Light Green	
Meadow Gold	Gold	Green	
Aqua Green	Light Green	Light Blue	
Frost Silver	Silver	Silver	

Figure 4 takes Meadow Gold as an example and shows the results of measurements of the color change by reflecting angles. A clear semicircle is drawn from the highlight to the shade, showing the change in the color. Interference colored aluminium pigment shows just a moderate degree of color flop to ensure that the possible applications are not limited and we have extended it to various products. Furthermore, another feature of this pigment is that the brightness and color saturation are not reduced when it is combined with other coloring material.

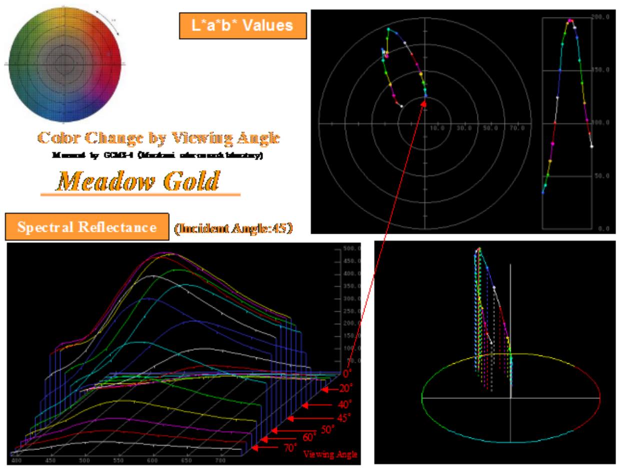


Figure 4 Results of Meadow Gold color measurement

【 5. Future development 】

As an aesthetic material, interference colored aluminium pigment has made it possible for us to develop products for the cosmetics sector, which had not been possible previously. Also, as there has recently been a lack of new pigments for coloring materials, the role that this pigment has played can be described as very important. However, the current situation is that little progress has been made in extending its application to uses other than as an aesthetic material. The function it has in amplifying a particular wavelength gives the product a potential as a functional material. There are expectations that it will be attracting attention as a new material for controlling the infrared and ultraviolet light reflecting characteristics.