

## Comparison of Automotive Exterior Coating in Europe, Japan and South Korea according to Color and Texture Distribution by Gonio-photometric

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### ABSTRACT

The automotive exterior coating color is one of important elements of design. In recent years, a lot of progressive materials on color appearance, such as metal flake, pearlescent, and diffraction pigments are developed. And advances in coating technology create a wide variety of high quality coatings. For this reason, there is significance to compare the color distribution, including texture parameters, of automotive exterior colors. In this study, databases of automotive repair coatings in three country areas, which reflect the situation of commercial automotive exterior colors, are applied. These databases were measured by portable gonio-photometric spectrophotometer (BYK-mac i, by BYK Gardner GmbH). This study is based on analysis of databases consisting of around 63,000 data of color and texture measured over recent 10 years. These databases also contain information about pigmentation and coating layered structure. Analysis of the databases made on color distributions in terms of value, saturation, hue and flop property showed that European automobiles often have high saturation color distribution features. And parameters on texture such as sparkle and graininess are described. Results of the analysis also showed that white color characteristics are noticeable difference among Europe, Japan, and South Korea.

**KEYWORDS:** Automotive, Exterior Color, Gonio-photometric measurement

### INTRODUCTION

The value of automobile is extremely high among industrial products. Especially, exterior coating color is one of important elements of design and these colors are directly connected to the purchasing will of customers. In recent years, a lot of progressive materials on color appearance, such as metal flake, pearlescent, and diffraction pigments are developed. And advances in coating technology create a wide variety of high quality coatings. The automotive exterior colors can be developed by relatively high cost, and the development is carried out carefully. It can be said that the automobile exterior colors reflect the tastes of the country of origin and cultural background. For this reason, there is significance to compare the color distribution, including texture parameters, of automotive exterior colors.

### EXPERIMENTAL

The databases of automotive repair coatings in three country areas, Europe, South Korea, and Japan which reflect the situation of commercial automotive exterior colors, are applied. These databases were composed with gonio-photometric spectral reflectance, also gonio-photometric surface texture parameter measured by BYK mac i (BYK Gardner GmbH), and layer structure, formulation, car manufacturer information were stored. This instrument measures color at six aspecular angles,  $-15^\circ$ ,  $15^\circ$ ,  $25^\circ$ ,  $45^\circ$ ,  $75^\circ$ ,  $110^\circ$  with a  $45^\circ$  illumination, and has an ability to illustrate black and white images of painted surfaces to measure the parameters of sparkle and grain texture. It uses spot light from vertical direction to simulate sparkle under  $15^\circ$ ,  $45^\circ$  and  $75^\circ$ , diffused illumination for graininess evaluation is created by integrating sphere, and detected by monochrome CCD image sensor applied normal direction of paint surface. (see Fig.1). On the other hand, some part of South Korea data were

measured by 5 angle gonio-spectrophotometer, and  $-15^\circ$  reflectance was applied extrapolation by following equation, and average calculation error were 1.57 by CIE  $\Delta E^*_{ab}$ .

$$R_{\lambda,-15} = 10^{-[0.223 \{ \lg_{10}(R_{\lambda,15}) - \lg_{10}(R_{\lambda,25}) \} + \lg_{10}(R_{\lambda,15})]} \quad (1)$$

In this study, colorimetric parameters such as CIELAB color space coordinate  $L^*$ ,  $C^*$ ,  $h^\circ$  value, flop index, and CIE Whiteness Index are calculated by gonio-photometric spectral reflectance under D65 illuminant  $10^\circ$  observer, and parameters on texture such as sparkle index  $S_i$ ,  $S_a$  of each three angle, and graininess index  $G$  are described. Also some part of South Korea data were calculated from formulation applied computer color matching technique.

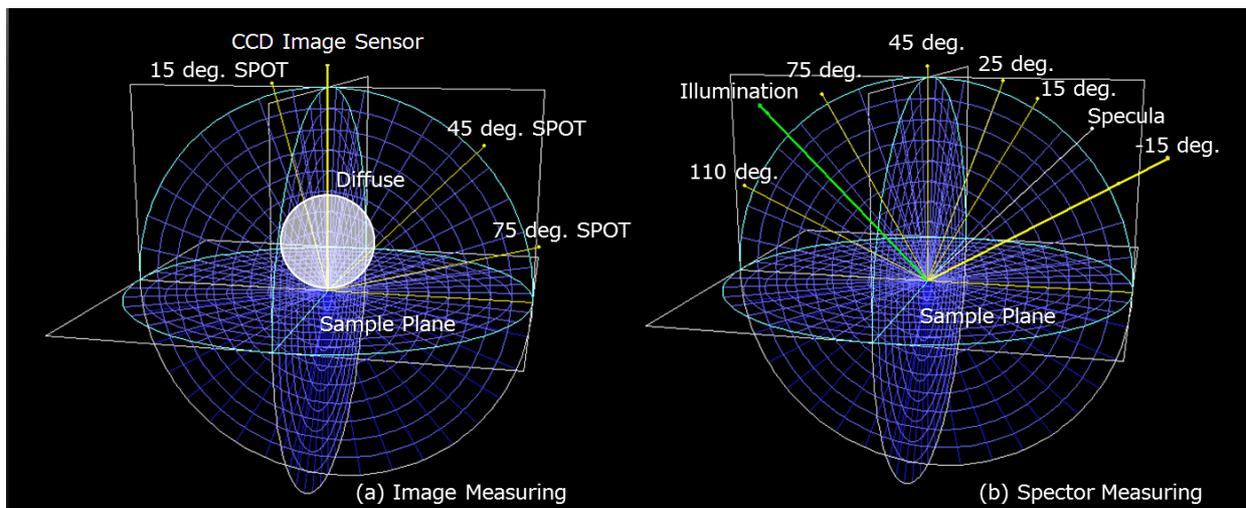


Figure 1: Optical geometry of Measuring System (BYK mac I, BYK Gardner GmbH)

After getting parameter for all data, calculated value are applied 3-Dimension plot on CIE parametric coordinate combined with  $L^*$ -  $h^\circ$  -  $C^*$ , or  $L^*$ -  $h^\circ$  - Flop index. Also Sparkle index are combined to 3-Dimension plot. Dupont Flop Index (F.I.) and CIE Whiteness Index ( $W_{10}$ ) are calculated by following equation.

$$F.I. = 2.69(L^*_{15} - L^*_{110})^{1.11} / (L^*_{45})^{0.85} \quad (2)$$

$$W_{10} = Y_{10} + 800(x_{n,10} - x_{10}) + 1700(y_{n,10} + y_{10}) \quad (3)$$

## RESULTS AND DISCUSSION

This study is based on analysis of databases consisting of around 63,000 data (Europe: 22622, South Korea: 16052, Japan: 24074) of color and texture measured over recent 10 years automotive exterior color. These databases also contain information about pigmentation such as absorption pigment, metal flake, interference mica flake, flop control agent, and coating layered structure such as single coated effect color which composed with metallic or interference mica flake, single coated solid color applied absorption and  $TiO_2$  white pigments, and double coated effect color which composed with solid color layer and effect color layer.

Analysis of the databases made on color distributions in terms of value, saturation and hue showed that European and South Korean automobiles often have high saturation color distribution features (See Fig.2). Regarding overall ratio of single coated solid color, Japanese automobiles are smaller than other area, European and South Korean has 23.3%, but Japanese has only 12.8%. On the other hands, overall ratio of double coated effect color of Japanese automobile have so many amounts compared with other area, Japan is 7.9%, Europe is 1.4%, and South Korea is 1.9%. Especially, South Korean automobile has not high saturation double coated effect color. The majority is white color in this layer structure in South Korea.

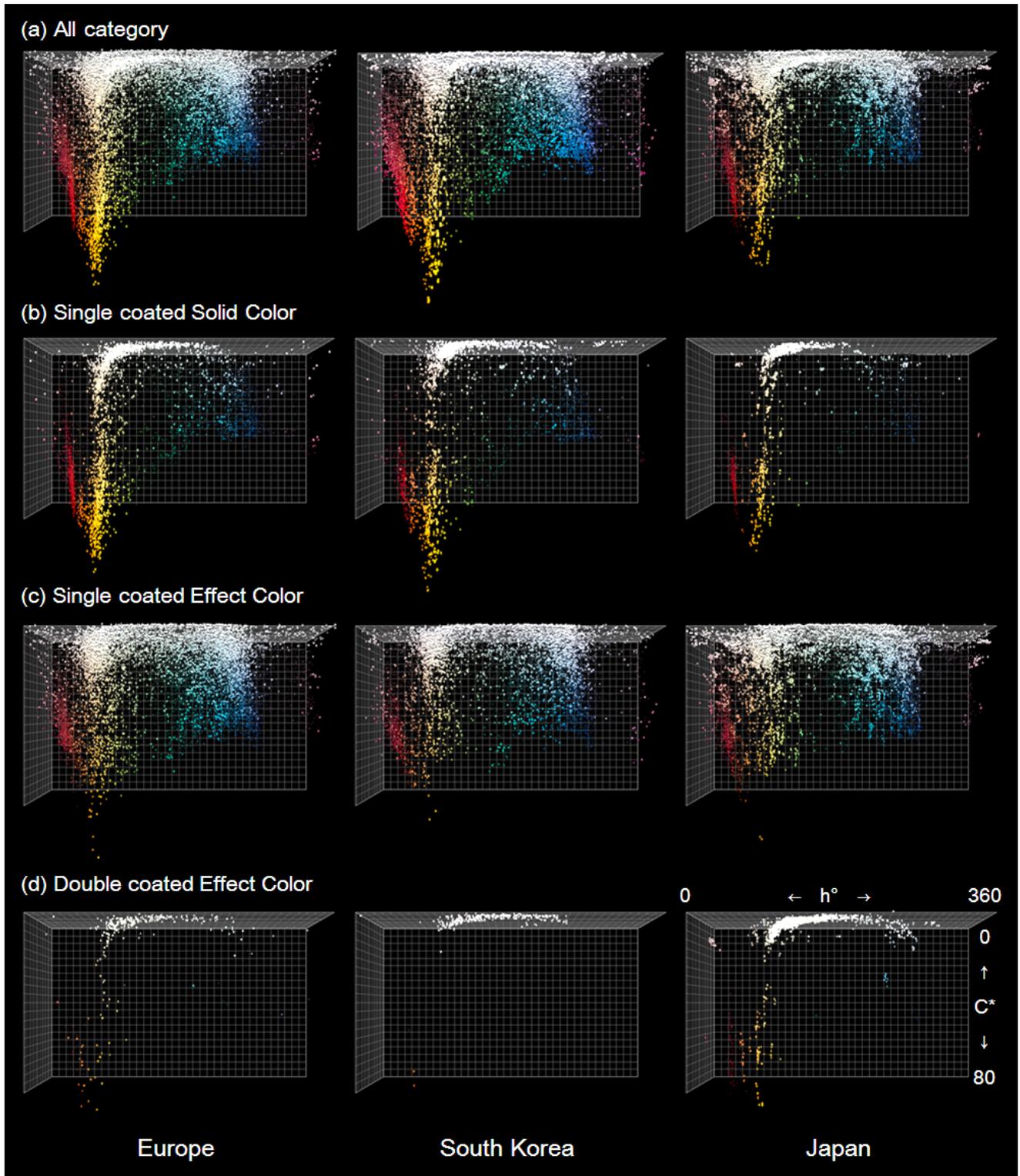


Figure 2: Color Distribution of Three Different Area on CIE  $L^*$ ,  $C^*$ ,  $h^\circ$  Coordinate.

Results of the analysis also showed that white color characteristics are noticeable difference among Europe, South Korea and Japan. The analysis result of white region under condition which  $L^*$  value is more than 70,  $C^*$

value is less than 5 at 25° aspecular angle in each area database, matches data in Europe is around 4%, Korea is also 7%, and Japan is 8%. According to the global automotive color popularity report in resent several years by Axalta coating systems, the most popular color is white, and year 2016 ratio is 37 percent for all of the world. In addition, it is also important to remember that more than 80% of white region is double coated which combined with solid lower layer and effect upper layer in Japan. With attention paid on this respect, the analysis result applied Dupont flop index and CIE whiteness index of Japan was narrow distributed compare with Europe. European automobile of double layer color is very few amounts, but Flop Index distribution is wider than the other area. Regarding CIE whiteness index, South Korean automobile is higher than Europe and Japan. One of the South Korean automotive color trends is high chromatic and high whiteness (See Fig.3).

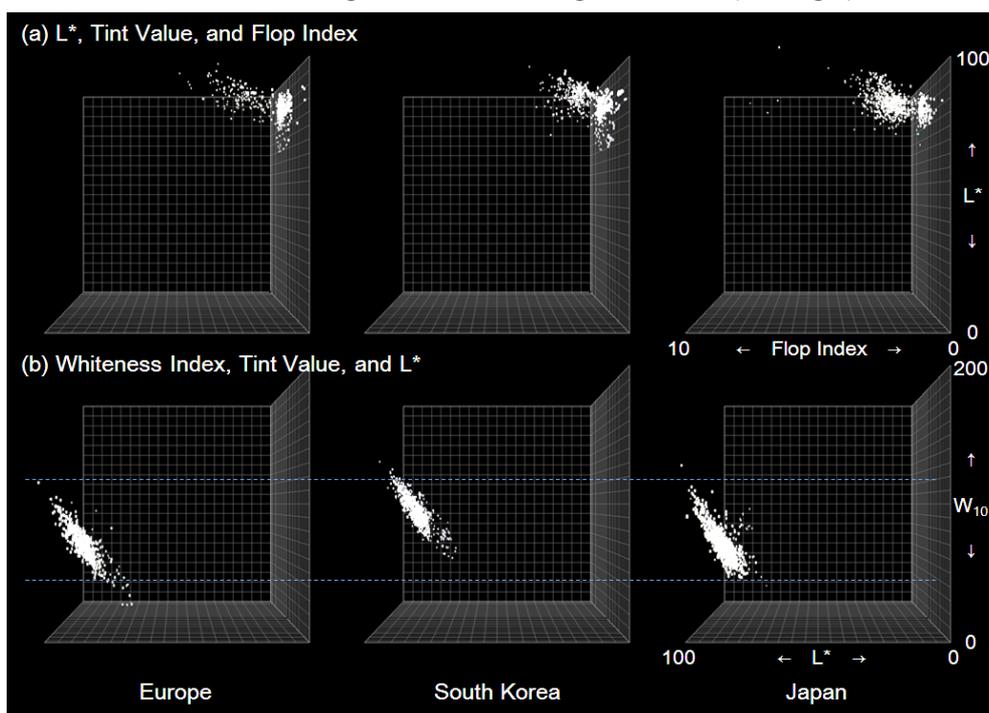


Figure 3: White Color Distribution of Three Different Area on  $L^*$ , Flop Index, and CIE Whiteness Index

## CONCLUSION

In this study, refinishing paint database including around 63,000 automobile colors in three different areas were applied to the analysis using measured color, texture and coating layer structure information. European and South Korean automobile color are high chromatic compared with Japanese. Regarding white color, Japanese automobile has high amount double coated effect color compared with the other area, but distribution of CIE whiteness index and Dupont flop index are not so wider. In this database analysis, South Korea resent 10 years color trend is high chromatic and high whiteness compared with the other area. These automobile color tends reflect cultural and spiritual situation in each area

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