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IMPACT OF SURFACE CURVATURE ON SPECTRAL BRDF OF EFFECT COATINGS

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Abstract

The development of effect pigments (or flake pigments) by industry has allowed new eye-catching visual effect for products. Unlike the traditional absorption pigments, they generate colour perceptions extremely angle dependent, which are function of both the illumination and observation directions. As a consequence of their appealing appearance, the market of effect pigments is steadily increasing and has become very popular in automotive, cosmetics, coatings, packaging, printing inks, ceramic tiles, building materials, textile, etc.

Effect pigments known as metallic pigments consist of a metal or an alloy of metal and their optical properties are described essentially by geometrical optics. They display a **metallic effect** which is mainly due to the specular reflection at the surface of these pigments. When embedded in a material or binder, called hereafter effect coating, the effect is determined by the optical properties of pigments and material and by the pigments orientation in the material. In this case, due to the non-perfectly horizontal inclination of the flakes in the binder, the effect can be observed for directions close to the specular directions. Since this effect is mostly observable around specular directions, it must present variations in appreciable extent when the coating is applied on a curved surface, for which specular reflection is dimmed.

In the context of the EMRP Project "Multidimensional reflectometry for industry" (xDReflect), we applied the same effect coating with metallic pigments to three surfaces of different convex curvatures, with curvature radii of infinity (flat), 300 mm (moderately curved) and 150 mm (very curved), and their spectral BRDF was measured at different illumination and observation directions, both in and out of the incidence plane. The measurements of the spectral BRDF of the three surfaces with the same effect coating will be presented and discussed in this contribution. They were performed with the goniospectrophotometer GEFE at IO-CSIC. For normal illumination, the samples are illuminated with a uniform spot of 3 cm in diameter, but the measurement area is only of 7 mm in diameter. The apparent dimensions change for different geometries. The half-angle of the solid angles of illumination and detection was around 0.5°.

We found that, **at** specular directions, the higher the curvature of the sample the lower the spectrally-averaged BRDF, and that, **around** the specular directions, the higher the curvature the higher the spectrally-averaged BRDF. Both observations were expected as a result of the divergence introduced by the curvature in the reflection at the first surface (convolution by curvature). In terms of colour, it can be interpreted as a "lightness flop" between curved and flat samples, being lighter the flat sample **at** specular directions and the curved samples **around** the specular directions. But, in addition, we have found another effect of curvature, which is not spectrally neutral and hardly can be explained by simple convolution. It is observed at some in-plane geometries with high incidence angles, and it can be described as an increase of the spectrally-averaged BRDF and a variation in the spectral distribution when comparing flat and curved samples. We may say here that there is "colour flop" between samples. This suggests a different contribution of the effect pigments to the spectral BRDF at those geometries for flat and curved samples. In these cases, the colour of the curved sample

is slightly more chromatic, which points out that the effect pigments contribute in higher extent to the spectral BRDF.

A possible explanation might be that, when irradiating a curved surface, incident light is refracted into the coating not only in a single direction but in a bunch of directions, as a consequence of the broad distribution of inclinations of the elementary surfaces in the irradiated area. Then the contribution of the effect pigments to the spectral BRDF for certain geometries may vary, because, unlike flat samples, effect pigments at different inclinations would now contribute. If this is correct, the variation at a given geometry of the contribution of the effect pigments to the spectral BRDF of curved samples with respect to flat samples would depend on the number of effect pigments contributing for every sample.

However, this hypothesis must be experimentally tested yet, and will likely require to reproducing the same procedure with concave curvatures samples. We must notice that both curvatures are usually present in car bodies, with sharp and smooth curvature.

The methodology applied in this work could be an interesting starting point to systematically study the effect of surface curvature in effect coatings, which could give insight into the impact of curvature of the effect pigment types (metallic, interference, pearlescent or diffraction pigments), the number of coating layers, the application process, etc.