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MULTI-ANGLE COLOUR CHARACTERIZATION OF COATINGS WITH DIFFRACTION PIGMENTS

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Abstract

The complex reflectance properties of coatings with effect pigments result in quite strange colour sensation for humans, because our sense has evolved to perceive colours from absorption pigments. As a consequence of their appealing appearances, they have become very popular in the automotive industry, and they are also widely used in other markets, such as packaging or cosmetics industry. The complexity of their spectral reflectance also allows them to be used for more functional purposes, as anti-counterfeiting. The colour of effect pigments is caused by anisotropic optical processes like low-order scattering, interference, or diffraction. This work specifically deals with the reflectance characterization of coatings with diffraction pigments. Its main purpose is to determine the most adequate illumination/observation geometries to characterize the variation of its colour gamut.

Waves are diffracted when they interact with structures of dimensions of the same order of magnitude as their wavelength. This way, light is split up into spectral components by diffractive gratings. Among them, reflective diffraction pigments are the sorts of special interest in industrial colour physics, though they are also present in natural structural colours. They basically consist of a metal substrate with a grating of embossed parallel grooves. This substrate is coated by inorganic substances. The spectral reflectance of diffraction pigments depends on the geometry, because for every pair of illumination and observation directions the optical path difference introduced by the diffraction pigment is different.

In the effect coatings with diffraction pigments, these pigments are embedded in a transparent medium or binder with a refractive index. Within this medium, the flake pigments are randomly oriented and, therefore, the observed diffraction corresponds to the superposition of diffraction patterns produced by the different orientation of the grooves. In addition, the flake pigments are not perfectly parallel to the surface of the coatings, but they are tilted, what should cause a slight blurring in the diffraction pattern. In order to describe the diffraction of these coatings, we will consider this lack of parallelism to the surface as a second-order effect.

The spectral bidirectional reflectance distribution functions (BRDF) of five coatings with SpectraFlair diffraction pigments have been measured using the robot-arm-based goniospectrophotometerer GEFE, designed and developed at CSIC. Principal Components Analysis (PCA) has been applied to study the BRDF data of the studied coatings. From the data evaluation and based in theoretical considerations, we propose a relevant geometrical variable to study the spectral reflectance and colour variation of coatings with diffraction pigments. At fixed values of this geometrical variable, the spectral BRDF due to diffraction is constant. Our measurements and analysis have revealed that commercially-available portable goniospectrophotometers, extensively used in several industries (automotive and others), are not adequate to characterize goniochromatic coatings based on diffraction pigments, because assessment at more aspecular angles than available (according to current ASTM and DIN normatives) is required.