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A general method for the quantitative assessment of mineral pigments

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ABSTRACT

A general method for the estimation of mineral pigment contents in different bases has been proposed using a sole set of calibration curves, (one for each pigment), calculated for a white standard base, thus elaborating patterns for each utilized base is not necessary. The method can be used in different bases and its validity had ev en been proved in strongly tinted bases. The method consists of a novel procedure that combines diffuse reflectance spectroscopy, second derivatives and the Kubelka–Munk function. This technique has proved to be at least one order of magnitude more sensitive than X-Ray diffraction for colored compounds, since it allowed the determination of the pigment amount in colored samples containing 0.5 wt% of pigment that was not detected by X-Ray Diffraction.

The method can be used to estimate the concentration of mineral pigments in a wide variety of either natural or artificial materials, since it does not requiere the calculation of each pigment pattern in every base. This fact could have important industrial consequences, as the proposed method would be more convenient, faster and cheaper.

1. Introduction

The production of colored materials has a highly industrial importance. Because of that, there are two related issues of great importance when working with pigments: the saturation level and the determination of the minimum amount of pigment necessary to obtain the desired color. For this latter one, there are rudimentary procedures based on printed color charts (with a more or less comprehensive set of concentrations) as well as on spectroscopic studies (that include the entire range of concentrations, from 0 wt% to the saturation level) [1]. Methods based on spectroscopic studies minimize production and business costs, since they permit to obtain the desired color using the minimum of pigment content. It is noteworthy that pigments are more expensive than the bases (mortars, ceramics, et cetera).

Colored mortars and concrete have become popular among engineers and architects for theirs applications. For instance, colored asphalt [2,3] makes traffic safer (guides traffic, shows the way, designates zones and decorates squares), colored mortar [4] and colored concrete [5] are used to accentuate an architectural effect and to increase aesthetic and the visual appeal of buildings, colored paving stones [6,7] are used for bicycle paths, crosswalks, speed bumps, parking lots and approach ramps, colored in-situ concrete [8] is a trend adopted by numerous architects in search of awards for their buildings, et cetera. One main aspect is to get permanent colors without producing adverse effects on mortars and concrete: it is imperative that the coloring agents can be used in a confident and safe manner [6,7,9,10].

Any tinting material can be of great use in many fields thus detecting and estimating the presence and quantity of these substances is of great importance, whether theirs origin is natural or synthetic, organic or inorganic [11–15]. It is highly interesting to notice that not all pigments have the same capacity of tinting [14,15]. The quantity of pigment is inversely proportional to its tinting strength.

The diffuse reflectance spectrum of each sample depends on the different components present in the sample. In fact, by inspecting the spectral shape, the specific component contributing to a particular color mixture can be identified [1,16,17]. Each color mixture has a characteristic curve that depends on its color [17–21]. This fact allows using a reflectance spectrum to quantify individual pigments present in the sample [1,16,22].

The Kubelka–Munk theory [23] has been found to be useful when working with diffuse reflectance and it has been used successfully to describe the color as well as to carry out quantitative studies in different fields: dyes [24], ceramic tiles [15] and ceramic glace [25–27], soils [14,21,28–30], heterogeneous catalysis [31], odontology [32,33], pharmaceutical [34,35], et cetera.

For an infinitely thick, opaque layer the Kubelka–Munk equation may be written:

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