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Review

An easy method to estimate the concentration of mineral pigments in colored mortars

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ABSTRACT

The goal of this work is to propose an easy method for the estimation of mineral pigment contents in different mortars. The accurate estimation of mineral pigment contents is very important to reduce the cost of production of the colored mortars, especially taking into account that small discrete changes in composition do not always produce noticeable color changes by the human eye. The Kubelka–Munk function in its derivative form provides a highly useful tool for characterizing pigment mixtures in mortars. It has been effective at concentration levels where XRD detection had proved to be ineffective. Calibration curves have been calculated from one mortar only. The partial overlapping of the bands, the different tinting strength and the different concentration of the pigment have been analyzed. The accuracy of the estimation of the pigment content improves when there is a slight overlap of the spectra and/or when the amount of the less tinting pigment is in greater proportion.

1. Introduction

Colored mortars and concrete have become popular among engineers and architects for such applications as facades, sidewalks, driveways, floors and other architectural uses. Nowadays and in antiquity, the number of mineral pigments is very high, for example, hematite (reddish, orange, purple, and brown), goethite (yellow), lepidocrocite (brown), calcite (white), dolomite (white), celadonite (green), malachite (green), and quartz (translucent and white). Others pigments have been produced by synthesis in the laboratory: litharge (reddish), massicot (yellow), red lead (orange), chromium oxide (green), black of coal, and Egyptian blue [1]. One very important 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.

Any tinting material can be of great use in many fields: dyes [2,3]; textile applications [3]; ceramic [4–7]; heterogeneous catalysis [8]; marine sediments [9]; mining in order to study and to determine the content or the identification of minerals [10–13]; farmland for studying the amount of iron oxide [14]; archaeological glass [15]; building materials [16–19] restoration and protection [18,20–23]; environmental safety [24,25]; and also in medical [26,27]; pharmaceutical [28,29] and food fields in order to detect and estimate the presence and quantity of substances [30–32].

Not all pigments have the same capacity of tinting [33,34], which means that the same amount of two different pigments will produce a different intensity of color. The quantity of pigment is inversely proportional to its tinting strength.

A diffuse reflectance spectrum of each tinted sample contains a combination of all the colors that are present in the sample. In fact, by inspecting the shape of the spectrum, one can identify the specific pigments contributing to a particular color mixture [1]. Each color mixture has a characteristic curve. This fact allows a reflectance spectrum to be used in order to quantify individual pigments [4,35–38].

The Kubelka–Munk theory [39] has been found to be useful when working with diffuse reflectance. For an infinitely thick, opaque layer the Kubelka-Munk equation may be written:

$$\frac{K}{S} = \frac{(1-R')^2}{2R'} \tag{1}$$

where R' is the absolute reflectance of the layer and K and S are the absorption and scattering coefficients, respectively. The absorption and scattering coefficients for a mixture of pigments can be

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