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Spectral characterization of wool fabric dyed with indicaxanthin natural dye: Study of the fluorescence property

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ABSTRACT

This study aims to evaluate the fluorescence property of wool fabric dyed with indicaxanthin, natural dye. Fluorescence measurements have been developed on wool samples before and after dyeing. The emission spectrum of the undyed wool fabric does not illustrate any peak and in the contrary, dyed wool sample present interesting photoluminescence property and the highest value was recorded at 576 nm. Aging behavior upon exposure to light irradiation and upon washing was studied and it has been proved that samples keep interesting fluorescence properties.

1. Introduction

Betalains pigments are nitrogenous plant, characteristic of the order Caryophyllales, where they exhibit the yellow betaxanthins and the violet betacyanins (Fig. 1) (Strack et al., 2003; Stintzing et al., 2003). The apparent color of those pigments is attributable to the resonating double bonds present in their structures. The native fluorescence of those pigments was characterized. Excitation and emission spectra were recorded in water and it was be seen, that bethaxanthins, on the contrary of betacyanins, exhibit a strong fluorescence in aqueous medium. Indeed, in case of bethaxanthis, condensation with an amine converts the aldehyde group of the betalamic acid to an imine and shifts the maximum wavelength of the absorbance spectrum from 420 nm (pale yellow) to 480 nm (deep yellow), which implies fluorescence. When condensation is made with *cyclo*-DOPA, the aromatic diphenolic structure resonates with the system responsible for fluorescence and the resonance involves a shift in absorbance from 480 to 540 nm (violet). As a result, fluorescence property is lost in case of betacyanins (Gandía-Herrero et al., 2005).

Recently, the interest of betalains in textile dyeing sector as purified natural colorants was in growing interest, motivating results were produced (Guesmi et al., 2012a, 2012b, 2013a, 2013b). As a complement of those studies, this work was developed in order to characterize the fluorescence property of wool fabric dyed with indicaxanthin, natural dye. Indeed, this character can disappeared as a consequence of the development of new chemical interactions between the dye and the dyed fiber.

2. Experimental

2.1. Materials and equipment

Indicaxanthin dye was purified, as previously mentioned, from fresh orange-yellow fruits of *Opuntia ficus-indica* (Guesmi et al., 2013b).

The wool fabric used was scoured and bleached wool fabric of 205 g/m^2, 72 ends per inch and 64 picks per inch.

Fluorescence spectra of dyed wool fabric were obtained using a Perkine-Elmer LS-3 Fluorescence Spectrophotometer.

2.2. Methods

Fruits were macerated, immediately, in a blender. Juice from cactus pears was subjected to the dye extraction. 50 g of Juice from cactus pears was mix with 80% aqueous ethanol as solvent for dye extraction. Extraction was performed by continuous stirring. The solution was separated from the plant tissue on a Büchner funnel with a filter paper. To achieve complete discoloration of the plant material, the filter residue was rinsed with the extraction solution.

Desalting and separation of betalains have been reported by us (Guesmi et al., 2013b): Filtrate was evaporated in *vacuo* at 40 °C, then, the concentrate was subject to the purification process. The separation of indicaxanthin and betanin dyes was conferred

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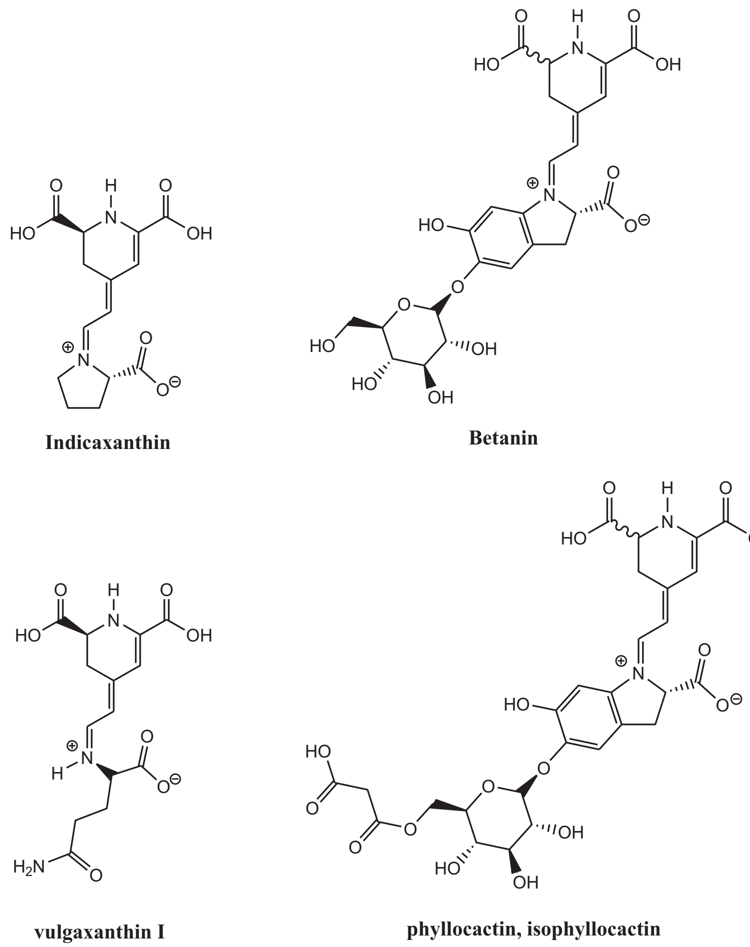

Fig. 1. Predominant betaxanthin (left) and betacyanins (right) in fruits from Cactaceace.

with fractional crystallization using a 8:2 (v/v) ratio of ethyl acetate/ethanol. Purified fraction of indicaxanthin dye was subjected to the dyeing procedure.

In a dye bath containing 20 mg/L of indicaxanthin dye with a liquor ratio of 40:1, wool fabric was dyed at pH 4, in a laboratory dyeing machine (Ahiba Datacolour International, USA), at 70 °C for 90 min. Finally, the dyed samples were rinsed with cold water and finally dried at ambient temperature.

3. Results and discussion

3.1. Spectral characteristics of dyed wool fabric

This section's study was developed in order to analyze the chromatic effects due to the interactions of indicaxanthin dye with wool fiber. The photography of the dyed wool fabric is shown in Fig. 2.

It should be noted that the fluorescence property of the dyed wool fabric was markedly detectable at naked eye. Thereafter, fluorescence measurements have been developed on samples before and after dyeing wool samples. Samples were excited using 450 nm light (maximum of the excitation spectrum), which is both absorbed by the fiber and the dye. Results are exposed in Fig. 3.

As shown in Fig. 3, the emission spectra of the undyed wool fabric does not illustrate any peak in the visible region and the highest registered value was about 1.5 mV. This result was expected. Indeed, it has been proved by *Davidson* that the emission spectrum of colorless wool fiber present just a broad band in the region spread from 250 to 290 nm (Davidson, 1996). In the contrary, dyed wool fiber present interesting photoluminescence property and the highest value was recorded at 576 nm (7 mV). Whereas, according to a previously published study, bethaxanthins colorants show a similar behavior in aqueous medium with a maximal excitation at about 400 nm and a maximal emission at about 500 nm (Gandía-Herrero et al., 2005). The discrepancy may be a consequence of interactions developed between the fiber and the dye. Also, Comparison of the emission spectrums from dyed and undyed samples allowed attributing the ipsochromic emission to wool fiber and the bathochromic one to indicaxanthin dye.

Fig. 2. Photography of dyed wool fabric. Dyeing conditions: $C_{indicaxanthin}$ 20 mg/L, pH 4, LR 40:1, 90 min, and 70 °C.