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Relationship between Solvent Composition Shifts of Plant-Derived Photochromic Solutions and their Photochromic Performance

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Abstract

A solution composed of 3-deoxyanthocyanidin extracted from sorghum shell, a weakly acidic buffer solution, and dipropylene glycol showed photochromism. For the industrial use of this natural photochromic dye, solidification or pigmentation is necessary. However, there is a concern that the photochromic performance may deteriorate due to the change in solution composition through the process.

In this study, we investigated the effect of composition shifts of the dye solution, namely solvent volatilization, water loading, and acid, base or polyvalent cation contamination on the photochromic performance.

Even when most of the water evaporated from the dye solution, neither the pH nor the photochromic properties of the solution changed. In contrast, when a large amount of water, acid, or base was mixed into the solution, the pH of the solution shifted, and deterioration in the photochromic performance was observed. Additionally, a small amount of polyvalent cations contaminating the dye solution shifted the solution to a more acidic solution, and the photochromic performance decreased. In this case, it was possible to recover the photochromic performance by altering the buffer solution used for the solution preparation to a slightly more basic solution.

Key-words: *Photochromic pigment, Sorghum, 3-deoxyanthocyanidins, Composition shifts, pH*

1. Introduction

Although most industrially used photochromic dyes are banned for use in cosmetics or foods[1-3], the natural dye 3-deoxyanthocyanidin extracted from sorghum shells can be used in these fields[4-7].

The 3-deoxyanthocyanin molecule is known to undergo structural change with / without UV irradiation as shown in **Fig. 1**.

Owing to this chemical structural change, the solution of the dye turns red when irradiated with UV light and returns to colorless under dark conditions.

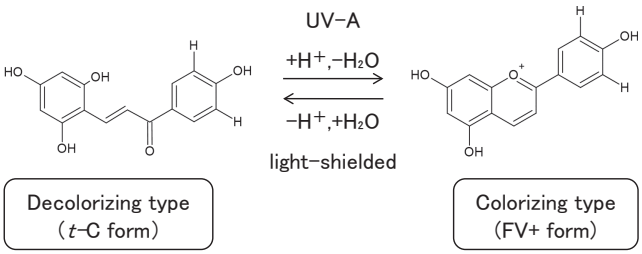

Fig. 1 Chemical structural change by UV irradiation and shading of 3-deoxyanthocyanidin.

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The photochromism of the solution can be estimated by the color difference value between the two conditions.

The value varies drastically with the composition of the dye solution[8]. We have previously reported that the typical composition of the dye solution for excellent photochromic performance is dipropylene glycol: pH 4 aqueous buffer = 80:20 in volume.

This composition offers the most appropriate pH for the dye solution, namely 5.7; more acidic conditions inhibit the decoloration process of the solution, and more basic conditions inhibit the coloration process.

Although this dye is desired for use as a pigment (solid particle) in industrial fields, it exhibits photochromism only in the above solution state, not in the solid state. Hence, we have been trying to solidify the dye solution (powder in appearance) by holding the solution in pores in the porous silica or by gelling the solution[9-10]. It was found that the processes for reforming solutions may shift the composition of the solution.

In this study, we considered several shifts from the appropriate composition, such as solvent volatilization, water increase due to moisture absorption, acid or base contamination, and multivalent cation contamination, and examined whether these compositional changes affected the photochromic performance of the solution.