Original Research Paper
J. Jpn. Soc. Colour Mater., **96** [3], 108-112 (2023)

Enhancement of the Adsorbed Amount of Ferulic Acid on Mesoporous Silica for Use as an Ultraviolet Radiation Absorber in Cosmetics

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(Received December 15, 2022; Accepted February 8, 2023)

Abstract

To increase the amount of ferulic acid adsorbed on a ferulic acid-silica composite, which is expected to be applied as a UV-protection material, a method for preparing the composite by using an anti-solvent precipitation method was investigated. Mesoporous silica was dispersed in a 50% ethanol solution of ferulic acid, and water was added as the poor solvent; the resultant adsorption amount was five times higher with water added. The diffuse reflectance spectrum of the prepared ferulic acid-mesoporous silica composite only showed the absorption of ultraviolet light and no absorption of visible light. This confirmed that ferulic acid was adsorbed into the pores of the powder, and not on its surface.

Key-words: *Ferulic acid, MCM-41 mesoporous silica, Pore adsorption, Compositing, UV absorption*

1. Introduction

Compositing organic materials, such as plant pigments with inorganic carriers, can increase the dispersion, stability, and leaching resistance of pigments into solvents. Layered clay minerals are commonly used as inorganic carriers[1,2]. Conversely, mesoporous silica, porous silica with uniform nano-sized pores, has a pore size close to the molecular size of plant pigments and a high surface area (>1,000 m^2/g). Therefore, porous silica is expected to adsorb a larger number of pigments with high stability compared to clay minerals. We have previously reported that the adsorption of anthocyanin dyes into the pores of MCM-41 mesoporous silica can enhance their stability against light and heat[3].

Polymethoxyflavonoids, a type of flavonoid-like anthocyanin pigment, are polyphenols found in the citrus fruit sheckwasa. Although polymethoxyflavonoids are colorless, they have UV-absorption ability. Therefore, the use of polymethoxyflavonoids as UV-absorbing powders has been investigated by adsorbing and compositing them into the pores of mesoporous silica[4].

Ferulic acid, a derivative of silicic acid found in rice and wheat seeds, is a plant-derived ultraviolet (UV) absorber. The structural formula of ferulic acid is shown in Fig. 1. Like polymethoxyflavonoids, it is also desirable to composite ferulic acid with mesoporous silica. However, compositing it in the same way as anthocyanin pigments and polymethoxyflavonoids is presumed to be difficult because it is insoluble in water.

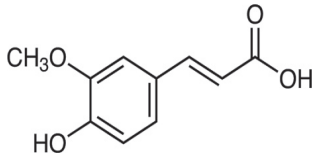

Fig. 1 Structural formula of ferulic acid.

In this study, we investigated an anti-solvent precipitation method, which is an adsorption method utilizing solubility differences among solvent species[5], to adsorb ferulic acid, which is insoluble in water but soluble in ethanol, in the pores of mesoporous silica[6]. In this method, a high-concentration solution was prepared using a good solvent, the carrier was dispersed in the solution, and the solubility of the solute was decreased by adding a poor solvent. Thus far, adsorption on carbon nanotubes using the solubility difference of ofloxacin[7], and on silica using the solubility difference of carbofuran[8], have been reported.

In this study, ferulic acid composites were prepared by the anti-solvent precipitation method using mesoporous silica as the carrier, an aqueous ethanol solution (50% concentration) as the good solvent, and water as the poor solvent. The adsorption behavior of ferulic acid into the mesoporous silica pores, and the UV absorption capacity of the resulting ferulic acid composites, were compared with those of polymethoxyflavonoid composites.

2. Materials and Methods

Ethanol solutions of various concentrations (50 mL) were prepared using ultrapure water and 99.5% ethanol (FUJIFILM Wako Pure Chemical Co., Ltd.), and 5 g of ferulic acid (Tokyo Kasei Kogyo Co., Ltd.) was added. Next, the solution