Mesoporous Silicate MCM-41 as a Particulate Carrier for Octyl Methoxycinnamate: Sunscreen Release and Photostability

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ABSTRACT: Octyl methoxycinnamate (OMC) is a widely used UV filter characterized by good absorbing properties; however, it shows light susceptibility (photoinstability) and potential skin permeation. This paper describes the application of a new particulate carrier to improve OMC safety and photostability. The UV filter was included into the pores of the mesoporous silicate MCM-41 and then entrapped there by plugging the pore openings. The last step was performed treating the MCM-41 inclusion product with a lipid cosmetic ingredient by the hot-melt method. The loaded samples were characterized by X-ray powder diffraction, Fourier transform infrared spectroscopy, and N_2 adsorption isotherms. Photochemical studies demonstrated that the coated samples allow a broader photoprotection range and remarkable improvement of sunscreen photostability. Finally, they were properly formulated in an emulgel, and the sunscreen release was studied *in vitro* by Franz diffusion cell and compared with those obtained from the same formulation containing the free filter. Sunscreen release from the studied formulations resulted negligible, meaning that the proposed approach represents a valuable strategy for UV filters stabilization toward light and safety improvement. © 2013 Wiley Periodicals, Inc. and the American Pharmacists Association J Pharm Sci 102:1468–1475, 2013

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INTRODUCTION

Octyl methoxycinnamate (OMC, Fig. 1) is a widely used sunscreen in many cosmetic formulations. It is classified as a UV-B filter, as it absorbs in the 290–320-nm wavelength region of the solar UV radiation. Its wide use is because of some specific characteristics such as the potent UV-B absorbing properties, the capacity of imparting water resistance to final preparations, and increasing dibenzoylmethane photostability.[1] OMC is subject to photoisomerization between *cis*-(*Z*) and *trans*-(*E*) isomers. The *E* isomer, with a λ_{max} of 310 nm, predominates by showing a high molar absorption coefficient. When it is exposed to sunlight, the *Z* isomer increases, but its molar absorption coefficient is lower than that of the *E* isomer and consequently a decrease in the efficiency of UV-B filtering is observed.[2] Additionally, the UV absorption spectrum of this filter shows to be affected by solvents and formulations. Several studies demonstrate that *trans*-OMC is unstable upon irradiation, both in solution[3–5] and when formulated as emulsion.[6] Another negative feature is the estrogen-like side effects shown from both *in vitro* and *in vivo* studies.[1]

As OMC displays an interesting sunscreen activity, a strategy that is able to increase the filter photostability to prevent OMC photodegradation as well as to reduce its skin absorption responsible for serious systemic side effects would be useful.[7–12]

Recently, the use of inorganic matrices such as hydrotalcites and zeolites[13–15] has been proposed to increase sunscreen stability and to prevent their absorption across the skin. In this paper, the application, in this field, of another inorganic matrix, the ordered mesoporous silicate MCM-41, was investigated.[16] This compound, characterized by high surface area, narrow pore-size distribution, and one-dimensional

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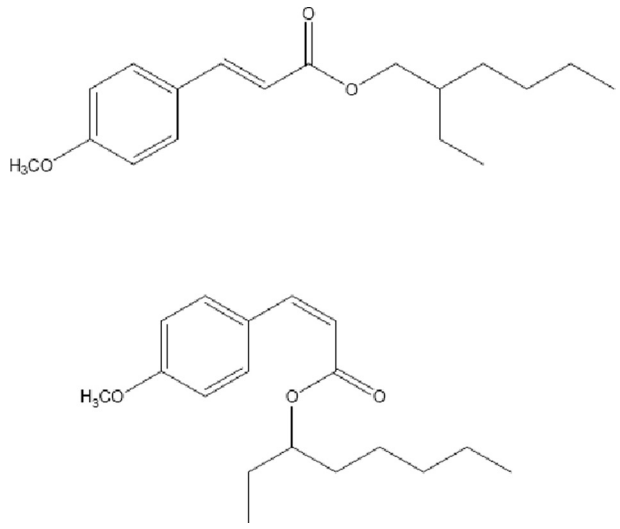

Figure 1. Structure of octyl-*p*-methoxy-*trans*-cinnamate (top) and octyl-*p*-methoxy-*cis*-cinnamate (bottom).

hexagonally ordered pore structure, is suitable to store organic molecules inside the pores.[17–21] In recent papers, MCM-41 has been proposed as a matrix to host UV ray absorbents.[22,23] It was observed that the sunscreen inclusion takes place very easily and a rapid release was observed when the final product was submitted to *in vitro* release studies.[23] This behavior could be explained considering that the light interactions established, during the inclusion process, between the sunscreen and MCM-41 silanol groups, are easily broken when MCM-41 silanol groups come in contact with the dissolution medium. Thus, the aim of this research work was to include OMC into MCM-41and to plug the pores with an appropriate cosmetic ingredient in order to avoid sunscreen rapid desorption. Then, OMC photostability and release from a proper formulation have been studied as well.

MATERIALS AND METHODS

Reagents

Cetyltrimethyl ammonium chloride (CTACl) and sodium metasilicate were purchased from Sigma–Aldrich Chemical (Milan, Italy). Tristearin (TRI) was obtained from Fluka (Milan, Italy). Ceresin (CER), Tinovis ADM (sodium acrylates copolymer and mineral oil and PPG-1 trideceth-6), isopropylmiristate, glycerin, caprylic/capric triglyceride, and stearyl alcohol (STE) were purchased from A.C.E.F. S.p.A. (Fiorenzula D'Arda, Piacenza, Italy). Cyclomethicone was purchased from Dow Corning Parc Industriel (Seneffe, Belgium). OMC (commercial name Uvinul® MC 80) was kindly furnished by BASF (Ludwigshafen, Germany). Other chemicals and solvents were of reagent grade, and were used without further purification.

Inclusion Product Characterization

X-ray powder diffraction (XRPD) spectra were registered by a PW 1710 Philips diffractometer (Philips, Almelo, the Netherlands), using the Ni-filtered Cu Kα radiation.

Fourier transform infrared (FTIR) spectra were recorded in KBr dispersion on a Jasco model FT-IR-410, 420 Herschl series (Jasco Corporation, Tokyo, Japan), using the EasiDiff diffuse reflectance accessory. Samples were prepared by gently grounding KBr with the sunscreen.

The OMC content was determined by using a UV–Vis spectrophotometer (model 8453; Agilent Technologies, Cernusco sul Naviglio, Itaky) at λ_{max} = 310.0 nm, and drug concentration was determined by using the calibration curve in ethanol (EtOH)–caprylic/capric triglyceride (9:1, v/v).

Nitrogen adsorption–desorption isotherms were determined at 77 K by using a computer-controlled Micromeritics ASAP 2010 apparatus (Norcross, Georgia). Prior to adsorption measurements, the samples were outgassed under vacuum overnight at room temperature. The specific surface area was determined by applying the Brunauer, Emmett, and Teller (BET) technique,[24] whereas mesopore size and volume characterization were detected by BJH–KJS method.[25]

Synthesis of Mesoporous MCM-41

MCM-41 was synthesized as previously reported.[26] Briefly, an aqueous solution of sodium metasilicate (30 g) was added to an aqueous solution (1000 mL) of CTACl (68.8 g, 25 wt %). Then, ethyl acetate (30 mL) was quickly added under vigorous stirring, and the mixture was allowed to stay 2 h at room temperature and for 40 h at 80°C. The resulting solid was recovered by filtration, abundantly washed with water and EtOH, dried at room temperature, and at last calcined at 600°C for 20 h to eliminate the surfactant.

OMC Loading in MCM-41

An ethanolic suspension constituted by the solution of OMC (1.5 g in 150 mL of EtOH) and MCM-41 (3 g) was stirred for 24 h at room temperature (the sunscreen amount corresponded to the theoretical final loading of ~33.4%, w/w). Solvent removal was performed by a rotary evaporator to afford a final product, MCM-41–OMC, that was further dried in vacuum at 40°C for 2 days.

Sunscreen Content Determination

Octyl methoxycinnamate content in the matrix was determined by UV determination after contact of a well-known amount of MCM-41–OMC (10 mg) with absolute EtOH (100 mL) for 24 h (λ_{max} = 310.0 nm).