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Encapsulation of organic UV ray absorbents into layered double hydroxide for photochemical properties

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ABSTRACT

Organic–inorganic nanohybrids, 3,4-dihydroxycinnamic acid/layered double hydroxide (CA/LDH), 4-hydroxy-3,5-dimethoxycinnamic acid/layered double hydroxide (SA/LDH), and 3-amino-5-triflouromethylbenzoic acid/layered double hydroxide (FBA/LDH) have been synthesized by co-precipitation reaction of organic ultraviolet (UV) ray absorbents such as 3,4-dihydroxycinnamic acid, 4-hydroxy-3,5-dimethoxycinnamic acid, 3-amino-5-triflouromethylbenzoic and Zn_2Al layered double hydroxide (LDH). Detailed structural and absorption properties of the nanohybrids were studied by using X-ray diffraction (XRD), FT-IR and UV-Vis transmittance spectra which revealed that organic UV absorbents have been intercalated into the interlayer spaces of LDH and all nanohybrids showed excellent UV ray absorption. All the nanohybrids showed a lower catalytic activity as compared to the net organic UV ray absorbents by applying air oxidation to castor oil.

1. Introduction

Sunscreen materials have attracted scientific and practical interest in recent years and have been a subject of great research challenge to the scientific community because of human health protection. These materials are able to protect human skin from solar ultraviolet (UV) radiation which is harmful to human health. Solar ultraviolet (UV) radiation poses a great threat and can cause damage to human health. It causes several problems such as photodegradation of organic materials and causing sunburn, suntan, acceleration of aging, cancer, etc. [1–3]. Protection of human health from solar ultraviolet radiation has been a complex problem and thus advanced materials are in demand for the effective treatment and protection of human health. Several organic compounds have been used as sunscreen material because of their excellent UV ray absorption ability [4,5]. However, these substances lose their specific function and pose safety problems when penetrating the skin surface. One solution to this problem may be the incorporation of organic materials in nanospaces of inorganic materials to avoid direct contact of organic molecules with human skin. Thus nanohybridization of organic molecules with inorganic materials provides an interesting route for the preservation of the organic molecules because these inorganic materials prevent direct contact of organic molecules with human skin.

We introduced a 2-dimensional layered nanostructure, layered double hydroxide (LDH), as a potential nano-reservoir for sunscreen materials in order to avoid direct contact of organic molecules with human skin [6]. LDH known as "anionic clays", is a group of synthetic minerals with general formula $[M(II)_{1-x}M(III)_x(OH)_2]^{x+} \cdot A_z^{-x/z} \cdot nH_2O$, and consists of cationic hydrotalcite-like layers and exchangeable interlayer anions [7,8]. The interlayer anions are tightly bound to the interlayer nanospace through electrostatic interaction. Therefore they could acquire chemical stabilization as well as protection.

In this paper, three organic UV ray absorbents, CA, SA and FBA were intercalated into LDH by co-precipitation reaction and characterized by XRD and FTIR. UV ray absorption ability and oxidation catalytic activity of the nanohybrids were investigated.

2. Experimental

2.1. Materials

All the chemicals were purchased from Sigma-Aldrich Co. Ltd. All the chemicals were of reagent grade and used without further purification. Distilled water was used throughout the study.

2.2. Synthesis of nanohybrids

CA, SA, and FBA shown in Fig. 1(a–c) were hybridized with LDH via the co-precipitation method. Mixed aqueous solution containing CA, $Zn(NO_3)_2 \cdot 6H_2O$, and $Al(NO_3)_3 \cdot 9H_2O$ (1.5:2:1 molar ratio) was titrated with 0.1 M NaOH solution until pH = 9 was reached. The reactants were vigorously stirred for 24 h under N_2 atmosphere, and then the resulting white precipitates (CA/LDH nanohybrid) were gathered via

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