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Research Article

Facile Synthesis of Curcumin-Loaded Starch-Maleate Nanoparticles

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We have demonstrated the loading of curcumin onto starch maleate (SM) under mild conditions by mixing dissolved curcumin and SM nanoparticles separately in absolute ethanol and ethanol/aqueous (40 : 60 v/v), respectively. Curcumin-loaded starch-maleate (CurSM) nanoparticles were subsequently precipitated from a homogeneous mixture of these solutions in absolute ethanol based on the solvent exchange method. TEM analysis indicated that the diameters of CurSM nanoparticles were ranged between 30 nm and 110 nm with a mean diameter of 50 nm. The curcumin loading capacity of SM as a function of loading duration was investigated using the UV-visible spectrophotometer. The loading of curcumin onto SM increased rapidly initially with loading duration, and the curcumin loading capacity of 15 mg/g was reached within 12 hours. CurSM nanoparticles exhibited substantially higher water solubility of 6.0×10^{-2} mg/mL which is about 300 times higher than that of pure curcumin. With enhanced water solubility and bioaccessibility of curcumin, the potential utility of CurSM nanoparticles in various biomedical applications is therefore envisaged.

1. Introduction

Curcumin, a non-toxic bioactive component of turmeric even at high dosage [1], has attracted considerable attention especially for its pharmacological activities such as anti-carcinogenic [2, 3], anti-inflammatory [4, 5], and antioxidant [6]. However, the utility of curcumin in clinical development and applications is limited by its low water solubility and poor bioavailability [7]. The solubility of curcumin in water is reported to be 1.99×10^{-4} mg/mL [8]. However, the solubility of curcumin is reported to be pH dependence, and it is soluble in both strong acids [9] and dilute alkali of pH 11 [10].

Any drawback due to poor water solubility of hydrophobic bioactive agents such as curcumin could be circumvented via the development of nanoparticle-based drug delivery systems that are dispersible in aqueous media. Intense research efforts have therefore been focused on developing curcumin-loaded polymeric nanoparticles for enhancing the water solubility of curcumin. Anand and co-researchers [11] have reported the synthesis of curcumin-loaded PLGA nanoparticles with enhanced water solubility. Although curcumin is pharmacologically safe for human beings, the efficacy of curcumin-loaded synthetic polymers has remained uncertain.

Various attempts have been made to synthesize polysaccharide-loaded curcumin nanoparticles. Being a type of polyphenolic molecule, curcumin could interact strongly with glucan molecule through hydrogen bonding. Such non-covalent interactions of curcumin might play a decisive role in its mechanism of actions during various pharmacological activities. Cyclodextrin, a type of polysaccharide, is known to form inclusion complexes with curcumin [12–14]. Kaminaga et al. [15] reported the conjugation of glucose molecules with curcumin molecules to form water soluble prodrugs. Gupta et al. [16] reported the encapsulation of curcumin with silk fibroin and chitosan to form curcumin-based nanoparticles using the blending method. Such encapsulation of curcumin by natural biopolymers could eliminate tissue toxicity.

In this paper, we have reported a facile synthesis approach for the preparation of water soluble curcumin-loaded starch-maleate (CurSM) nanoparticles by loading curcumin onto highly water-soluble starch-maleate monoester. The chemical structure, morphology, and mean size of CurSM nanoparticles were characterized by both FTIR and TEM.