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ORIGINAL RESEARCH

Encapsulation of phase change materials with alginate modified by nanostructured sodium carbonate and silicate

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Abstract

The encapsulation of phase change materials (PCMs) as thermal energy storage materials is a big issue. PCM is usually encapsulated to avoid spillage, flammability and its reaction with the surrounding environment to improve its application. In the last decade, various methods have been employed and all kinds of microencapsulated PCM are produced. In this paper, we present a facile route to produce an encapsulated PCM with an organic and inorganic shell. The encapsulated phase change material (PCM) was prepared using a coaxial micro-fluidic system combined with an ionic cross-linking process. The alginate was used as the basic shell and a range of capsules was obtained by modifying the original shell using two inorganic components such as sodium carbonate and sodium silicate. Various samples, each with a different surrounding layer, were prepared by combining alginate calcium (Alg–Ca) as an organic shell with an inorganic component such as alginate calcium carbonate (Alg–$CaCO_3$) and alginate calcium silicate (Alg–$CaSiO_3$). In these experimental works, we have investigated the compatibility and the stability of capsules modified with the inorganic component. The scanning electron microscopy (SEM) technique and optical microscopy were utilized to study the capsule morphology. The chemical composition of the shell was evaluated by Fourier transform infrared spectroscopy (ATR-FTIR), thermogravimetry analysis and SEM coupled with the EDX analysis, and the capsule stability was estimated under an accelerated thermal cycling.

Keywords Microcapsule · Phase change materials · Modified alginate · Sodium silicate · Sodium carbonate

Introduction

Phase change materials (PCMs) have extensive industrial applications, including building wallboards, bedding and sportswear accessories, food conservation, heat recovery, and solar cooling. Their integration as thermal energy storage depends on their melting temperature range [1–3]. The PCM materials have different natures: inorganic, organic and eutectic [4]. Recently, microencapsulation of inorganic and eutectic has obtained increased attention [1, 2].

Several researches have focused on organic PCM for their advantages such as good thermal stability, self-nucleating properties, non-reactivity, and non-toxicity [3]. However, the leaking process in phase transition during heat storage is mainly the barrier to their direct incorporation in some applications. To overcome this problem, a coating or microencapsulation is required to preserve their properties and to protect them against the harmful interaction with the external environment. Various methods have been developed to produce a spherical microcapsule such as the sol–gel method [4], in situ polymerization [5], co-extrusion technology [6], electrospray method [7], interfacial polycondensation [8], and self-assembly method [9]. However, the majority of the synthesized shells are organic and fabricated using a chemical method such as polymerization [1].

Most of the encapsulation processes consume high energy to fabricate a core–shell system (PCM system) and provide a polydisperse particle with poor encapsulation efficiency. The microfluidic technology has been classified as a useful platform that allows the flow control of the inner and the outer solutions by integrating pumps or valves, which are considered as fundamental technologies for any fluidic system [10]. This performance facilitates the preparation and control of the core and shell thickness.

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