Supercooling of Silver Nano Composite PCM Microcapsules

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Abstract: Supercooling effects of novel Phase Change Materials microcapsules incorporated with silver nano particles (NC-MicroPCMs) and conventional PCM microcapsules (MicroPCMs) are compared and evaluated systematically. Melting and crystallization behaviors of microcapsules with different processing parameters are investigated mainly by DSC measurements. Combinations of processing parameters are determined by a full factorial experimental design. The influences of processing parameters are discussed and analyzed by statistical softwares of SPSS and Minitab. The results have shown that the formation of nano composite structure can reduce the effect of supercooling. The possible mechanisms have also been explored.

Keywords: phase Change Materials, Microencapsulation, Silver Nano Composite, Supercooling

1. Introduction

Supercooling is one of the common features of Phase Change Materials (PCMs) whenever it undergoes a phase change from liquid to solid. Higher degree of supercooling has an adverse effect on thermal performance when PCMs crystallize from liquid to solid as energy releasing would be retarded during the process. Therefore, thermal regulation functions cannot be fully utilized.

Decreasing Supercooling for PCMs and MicroPCMs are crucial for the applications of energy storage, researches on them are active. Increasing thermal capacity and decreasing supercooling are main purposes of these researches.

A number of methods and apparatuses are available for determining the degree of supercooling (ΔT) and a number of reports in the literature have generally focused on the thermal features of MicroPCMs. These methods generally involve Differential Scanning Calorimetry (DSC) techniques, by which the degree of supercooling (ΔT) can be measured directly by a thermograph (M.N.A. Hawladera 2003; Mucha 2003; Alvarado 2006).

Yamagishi et al measured latent heat of fusion (ΔH), melting and crystallization temperature points of microencapsulated n-dodecane and n-tetradecane as a function of microcapsule size. The results indicated that the degree of supercooling increases accordingly when the microcapsule size decreases (Yamagishi Y 1996) (B. BOH 2005). That also means that larger microcapsules often have a better performance in depression of supercooling. Yamagishi believed the reason causing the differences in supercooling between the microcapsules with different sizes may be due to the differences of number of nuclei in the capsule core, and the number of nuclei decreases as size reduces. The crystallization inside a microcapsule starts from the generation of small crystalline nuclei (Yamagishi 1996).

Nucleating materials selections are hot research topics in the area of depressing supercooling. Mucha and Krolikowski carefully studied the impact of several nucleating agents or fillers on the crystallization kinetics of polypropylene (Mucha 2003). Avella et al discussed that CaCO3 nano particles at 3 wt% addition could act as an efficient nucleating agent in isotactic polypropylene (Avella 2005). Fan used and tested sodium chloride (3%) (Y.F. Fan. 2004), and X.X. Zhang applied 9 wt%

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octadecanol as nucleating agent in microencapsulated n-octadecane. These approaches have been reported efficiently in decreasing supercooling. However, such amount of nucleating agents have adverse effects on thermal capacity (Alvarado 2006).

There is little information available presently on the effect of processing parameters affecting supercooling during a microencapsulation process. Moreover, MicroPCMs with nano composite structure is a novel thermal storage functional materials. Their properties, especially the relationships between nano composite structures and thermal features, as well as processing parameters, need to be fully investigated and characterized..

In this study, MicroPCMs incorporated with silver nano particles were fabricated with a complex composite structures, where many silver nano particles are found dispersing on a shell and within a core. Silver nano particles may influence the behaviour of melting/crystallization due to the fact that these nano particles are distributed within the structure of the PCM microcapsules.

To fill these knowledge gaps, this paper investigates the effects of processing parameters on the thermal properties of supercooling. NC-MicroPCMs incorporated with silver nano particles and conventional MicroPCMs are compared systematically in terms of a degree of supercooling (ΔT). The possible mechanisms of the nano composite structure are explored.

12 groups of microcapsule were fabricated according to a full experimental design, including 8 groups with silver nano particles addition and 4 groups of conventional types. The sizes of these microcapsules of the 12 groups are in the range around 3.78 μm. There are no significant differences in size and distribution among the 12 groups. Therefore, the influences of microcapsule size on thermal property can be excluded.

We have found that a positive effect of supercooling depression for MicroPCMs with nano composite structures, in which the crystallization process may have been affected as the nano particles may exert a function of nucleating agents in the microcapsule structure.

2. Experimental

2.1 Sample Preparation

Microcapsules with different parameters were prepared according to a 23 experimental design, in which three variables of core/shell ratio (C/S), F/M molar ratio (F/M) and silver nano material addition (ADD %) are the main affecting parameters, which were determined by pre-screening experiments. Surface morphology observation using the 12 MicroPCMs groups were carried out by JSM 6335F (Japan).

The SEM images of the silver nano particles and some of the 12 samples are displayed in Figures. 1, 2 and 3.

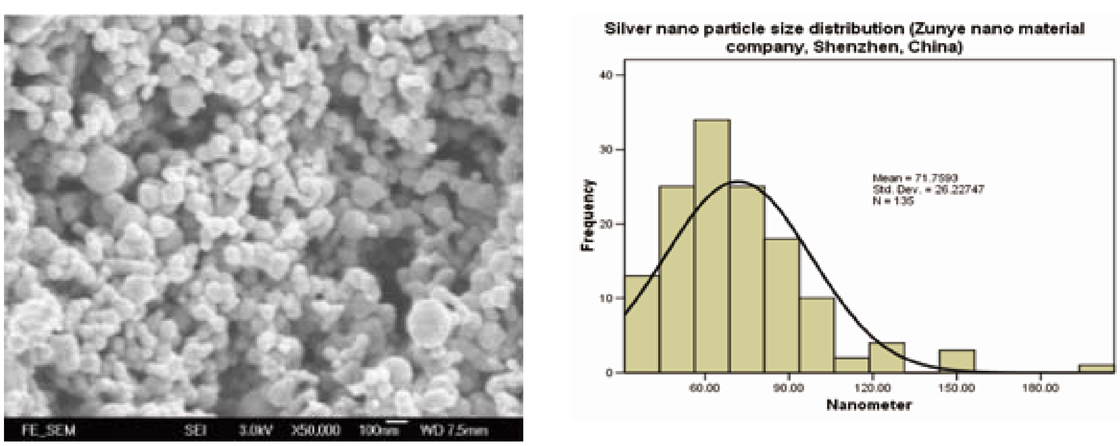

Figure 1 SEM image and size distribution of silver nano particles