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Thermal Performance of A Multi-layer Composite Containing PEG/laponite as PCMs ⋆

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Abstract

Six phase change materials (PCMs) were prepared by blending polyethylene glycol (PEG) with laponite powders (LP) at different ratios (PEG:LP, 100:0, 97:3, 96:4, 91:9, 88:12 and 85:15) under 100 °C firstly. A multi-layer composite consisting of a PCM loaded layer, a nano barrier layer and a protective layer was used to hold PEG/LP PCMs. SEM was used to observe the morphological structure of multi-layer composites containing PEG/LP composites. DSC revealed the melting temperature, the cooling temperature and the enthalpy of PEG and laponite as PCM. The thermal insulation of all the composites containing PEG/LP was evaluated under 78 °C. The results gave that the multi-layer composite containing PCM was obtained and a better adhesion of between the PCM loaded layer, the nano barrier layer and the protective layer was found. LP functionalized as a nucleating agent to accelerate the crystallization of PEG and 15wt% LP in PCM resulted in a disordered PEG molecular. The composites with more laponite had the higher thermal insulation and highest value reached 0.25.

Keywords: PEG; Laponite; Multi-layer Composite; Nanofibrous Membrane; PA 6

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1 Introduction

Phase change materials (PCMs) are a group of materials with an intrinsic capacity to absorb and release latent heat during the phase change cycle, which is a dynamic heat exchange process [1]. The storage of latent heat or thermal regulation is based on the phase transition of materials including the phase change from solid to liquid, liquid to gas and vice versa [2]. Nowadays, PCMs are aimed to be incorporated with textiles ensure the comfort or protection of wearers under extreme external thermal conditions [3-4]. The thermal behaviour of PCM-incorporated textiles, especially in thermal insulation applications, has been evidently improved [5]. To incorporate the PCMs with textiles, many efforts have been made including preparation of hollow fibers containing PCMs [6], fibers spun with PCMs [7-8], preparation of solid-solid phase change materials [9-10] and coating fabrics with various encapsulated micro-PCMs [11] have been consecutively applied in textiles. Recently, the nanofibrous membranes have also been shown a great potential for these purposes [12]. The quality of these nanofibrous membrane for storing or holding PCMs is related both to their fibrous structure, controllable porosity, and their chemical composition [13]. The overall thermo-insulating efficiency is also strongly influenced by the incorporation of these membranes into textile structures where one of the decisive factors is the thickness and porosity of fibrous component. Hence, the composite made of nanofibrous membranes and PCMs is expected to have the better thermal insulation for textile.

Polyethylene glycol (PEG) is a common PCM and known as its non-flammability, high heat of fusion, low vapor pressure chemical, thermal stability, non-toxicity, non-corrosive [14] and moderate melting temperature intervals suitable for humans [15]. PEG was incorporated with textiles to improve the thermal behaviour [16, 17]. The popular methods of preparation of PCMs based on PEG are physically blending PEG with other supporting materials including SiO2, microcrystalline cellulose and graphene aerogel [18] and so on. Laponite powder (LP) is a relatively uniform disc-shaped synthetic clay with 25nm dia. and 1 nm thickness [19]. It is reported that the PEG and laponite has the excellent thermal properties [20]. However, the details of PEG and laponite as PCM in textiles are not clear.

In this work, we developed a smart heat storage composite based on a multi-layer structure consisting of PCM loaded layer which is supposed to make PCM layer even, barrier nano layers aimed to avoid leakage and protective layers protecting the structure of nano layers. Milife fabric, a non-woven polyester fabric with controlled density and thickness, was used as the PCM loaded layer as well as proactive layers. PA 6 nanofibrous membranes was used as the nano barrier layer. The main purpose was to show the difference in thermal behavior of multi-layer composite containing PEG modified with different laponite contents. Based on the literature review, this work is one of the initial ones that studied the thermal behavior of multi-layer composite containing PCM.

2 Experimental

2.1 Materials

Polyethylene glycol powders ($M_W = 1\,500$) was purchased from Aldrich and Laponite RD powders (LP) were purchased from BYK-Chemie GmbH. All these chemicals were used without further purification during the experiments. The milife fabrics (polyester) with 10 g/m^2 and 0.06 mm