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Fatty acid esters-based composite phase change materials for thermal energy storage in buildings

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In this study, fatty acid esters-based composite phase change materials (PCMs) for thermal energy storage were prepared by blending erythritol tetrapalmitate (ETP) and erythritol tetrastearate (ETS) with diatomite and expanded perlite (EP). The maximum incorporation percentage for ETP and ETS into diatomite and EP was found to be 57 wt% and 62 wt%, respectively without melted PCM seepage from the composites. The morphologies and compatibilities of the composite PCMs were structurally characterized using scanning electron microscope (SEM) and Fourier transformation infrared (FT–IR) analysis techniques. Thermal energy storage properties of the composite PCMs were determined by differential scanning calorimetry (DSC) analysis. The DSC analyses results indicated that the composite PCMs were good candidates for building applications in terms of their large latent heat values and suitable phase change temperatures. The thermal cycling test including 1000 melting and freezing cycling showed that composite PCMs had good thermal reliability and chemical stability. TG analysis revealed that the composite PCMs had good thermal durability above their working temperature ranges. Moreover, in order to improve the thermal conductivity of the composite PCMs, the expanded graphite (EG) was added to them at different mass fractions (2%, 5%, and 10%). The best results were obtained for the composite PCMs including 5wt% EG content in terms of the increase in thermal conductivity values and the decrease amount in latent heat capacity. The improvement in thermal conductivity values of ETP/Diatomite, ETS/Diatomite, ETP/EP and ETS/EP were found to be about 68%, 57%, 73% and 75%, respectively.

1. Introduction

The energy demand to provide a comfortable environment for humans in buildings has continuously increased worldwide. But, the energy use for heating, cooling and air conditioning increase the level of greenhouse gas emissions and decrease fossil fuel sources [1,2]. Therefore, energy storage becomes a key issue in engineering application. Thermal energy storage plays an important role in an effective use of energy in buildings not only by reducing the mismatch between supply and demand but also improving the performance and reliability of energy systems. Among all of thermal energy storage methods (sensible, latent and thermochemical heat), latent heat thermal energy storage employing a phase change material (PCM) is particularly effective technique due to its advantages of high energy storage density and its isothermal operating characteristics [3–6].

The application of PCMs in buildings is well known and has been subject to considerable interest since the first reported application in the 1940s [7,8]. Researches on the application of PCMs in buildings have been focused on three fields in recent years. The first one is the reduction of temperature fluctuations of lightweight buildings by increasing their thermal mass [9–11]. This is done by incorporation of PCM into building materials. The second one is the cooling of buildings through intermediate storage of cold from the night or other cheap cold sources. If the cold is for free, as with cold from night air, this is also called free cooling and very promising with respect to energy saving [12,13]. A third application field is for heat storage in space heating systems [14].

The PCMs can be used by integration with different building's structure such as gypsum board, plaster, concrete, clay minerals or other wall-covering material. But, there are some difficulties in fabrication of building materials containing PCMs. One of them is incorporation of PCM in construction material. PCMs in building materials are usually enclosed in metallic or polymeric capsules. The encapsulation of the PCM is expensive and it may affect the mechanical strength of the building material as well as it may lead

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