



Fabrication and characterization of form-stable phase change material/xonotlite microcomposites



Yeliz Konuklu^{a,b,*}, Orkun Ersoy^{b,c}

^a Ömer Halisdemir University, Department of Chemistry, 51240 Nigde, Turkey

^b Ömer Halisdemir University, Nanotechnology Application and Research Center, 51240 Nigde, Turkey

^c Ömer Halisdemir University, Department of Geological Engineering, 51240 Nigde, Turkey

ARTICLE INFO

Keywords:

Phase change material

Xonotlite

Thermal energy storage Microcomposite

ABSTRACT

In this research novel microcomposites composed of phase change materials (PCMs) and xonotlite were fabricated and characterized. Xonotlite mineral and its composites have wide application areas in building materials industry due to their thermo-insulating properties. Lauric acid, decanoic acid and paraffin were used as phase change materials. Xonotlite was prepared as composite matrix. In order to analyse the composite structure and thermal performance of microcomposites, scanning electron microscopy (SEM), energy dispersive spectroscopy (EDS), differential scanning calorimetry (DSC) and X-ray diffraction (XRD) were used. The experimental results demonstrate that paraffin/xonotlite composites were synthesized successfully and paraffin was the most suitable phase change material for preparation of phase change material/xonotlite composites. However, this study emphasized the correct choice of PCM that will be used in xonotlite including composites. Fatty acids have dissolution effect on xonotlite matrix. The melting and freezing temperatures were measured through differential scanning calorimetry analysis and found to be 35.05 and 40.42 °C, respectively. The melting and crystallization heats were determined to be 65.8 and –63.5 kJ/kg. We recommended that the fabricated nanocomposite-PCMs offer proper phase transition temperature range heat enthalpy values for thermal energy storage applications.

1. Introduction

Buildings are major energy consumers and new energy saving policies are produced for efficient energy use in buildings. Thermal energy storage is a key factor in energy efficiency. Among all thermal energy storage systems, latent heat thermal energy storage (LHTES) is a particularly attractive technique because of the advantage of high energy storage density and isothermal characteristics of charging and discharging processes [1,19,5]. LHTES is based on the phase change materials (PCMs) [16]. The choice of suitable phase change material plays an important role in terms of thermal efficiency, economic feasibility and utility life of LHTES system [14,7]. Phase change materials (PCMs) are widely chosen because of their ability to absorb and release large amounts of heat, keeping the temperature constant during the phase change process [2,6]. Therefore, combining construction materials and PCMs is believed to be an efficient way to increase the heat energy storage efficiency of construction elements [13,3].

Natural minerals are widely used as fillers for building materials. Yang et al. [18] prepared paraffin/palygorskite composite for thermal energy storage and they reported that composite PCM had a melting

temperature of 54–56 °C and latent heat of 132.18 J g⁻¹. Wang et al. [16] prepared stearic acid/activated montmorillonite phase change materials and they reported that when the content of stearic acid reached 47.5%, the composite had energy storage characteristics with melting temperature of 59.9 °C and the latent heat of fusion of 84.4 J g⁻¹. Li et al. [11] mixed different fatty acids with each other and prepared capric-lauric acid/diatomite composite with a phase transition temperature of 16.74 °C and latent heat of 66.81 J/g. Konuklu et al. [10] prepared leakage-free, thermally stable diatomite/PCM composites with easy and industrially applicable impregnation process. Diatomite/PCM composites melted at 36.55 °C with latent heat of 53.1 J/g. Konuklu and Ersoy [9] prepared sepiolite/PCM composites and The phase change enthalpies of melting and freezing were about 62.08 J/g and 62.05 J/g for sepiolite/paraffin nanocomposites and 35.69 J/g and 34.55 J/g for sepiolite/decanoic acid nanocomposites, respectively.

Xonotlite (Ca₆Si₆O₁₇(OH)₂) is a calcium silicate hydrate (C-S-H) mineral. Minerals such as xonotlite and related calcium silicate minerals have wide applications, including insulation boards, refractory boards, fireproof materials, ceiling boards, microporous materials,

* Corresponding author at: Ömer Halisdemir University, Department of Chemistry, 51240 Nigde, Turkey.
E-mail address: ykonuklu@ohu.edu.tr (Y. Konuklu).

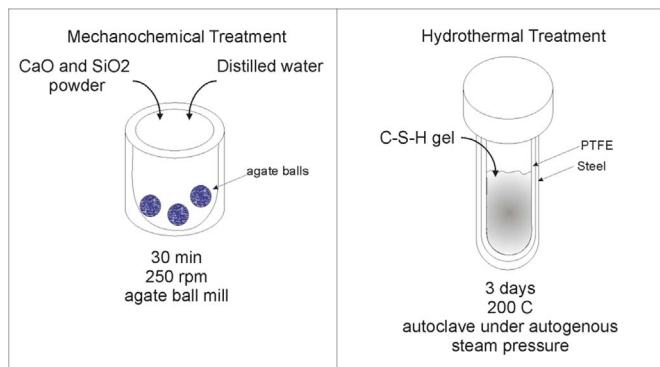


Fig. 1. Schematic illustration of xonotlite synthesis.

architectural boards and light weight boards. Xonotlite is used for its thermo-insulating properties [12,17] and many commercial products can be found containing xonotlite minerals. It is the porosity of xonotlite that is the basis for the industrial applications [8]. Xonotlite is rarely formed in hydrothermal alteration zones in nature. Due to the fact that mining cannot be justified economically and applications need control on purity and mineralogy, synthetic C-S-H minerals are in the centre of interest [4].

The purpose of this study is to prepare granular phase change composite by impregnation methods with large heat storage. For this purpose; novel phase change material/xonotlite microcomposites were fabricated and characterized. Lauric acid, decanoic acid and paraffin were used as phase change materials. Xonotlite was prepared as composite matrix. The structure and properties of microcomposites

have been characterized via scanning electron microscopy (SEM), energy dispersive spectroscopy (EDS), differential scanning calorimetry (DSC) and X-ray diffraction (XRD).

2. Experimental

2.1. Material

In this study lauric acid ($C_{12}H_{24}O_2$), decanoic acid ($C_{10}H_{20}O_2$) and paraffin (melting point 42–44 °C) with purity above 98.0% (Merck, Germany) were selected as the phase change materials. We synthesized xonotlite mineral as porous matrix in an autoclave under autogenous steam pressure using industrial raw materials, calcite and quartz minerals. All chemical materials were used without further purification.

2.2. Preparation of xonotlite

Calcite ($CaCO_3$) and Quartz (SiO_2) were collected from mineral deposits located at Niğde and Diyarbakır regions, respectively, in Turkey. Both the raw materials were ground to obtain finer sizes. Calcium carbonate was sintered at 1000 C for 1 h in order to obtain lime (CaO). A stoichiometric mixture ($Ca/Si=1$) of CaO , SiO_2 and distilled water ($w/s=1.5$) was ground and mixed for 30 min at 250 rpm in the agate ball mill as the precursor of synthesis of xonotlite. The mixture in the agate mill was in off-white gel form after mechanochemical treatment. The gel was treated 3 days at 200 °C in PTFE inserts within a steel autoclave. After hydrothermal treatment, gel was transformed into a white solid. Solid sample was dried at 90 C for 1 day at vacuum drying-oven at 37 mb pressure and characterized as xono-

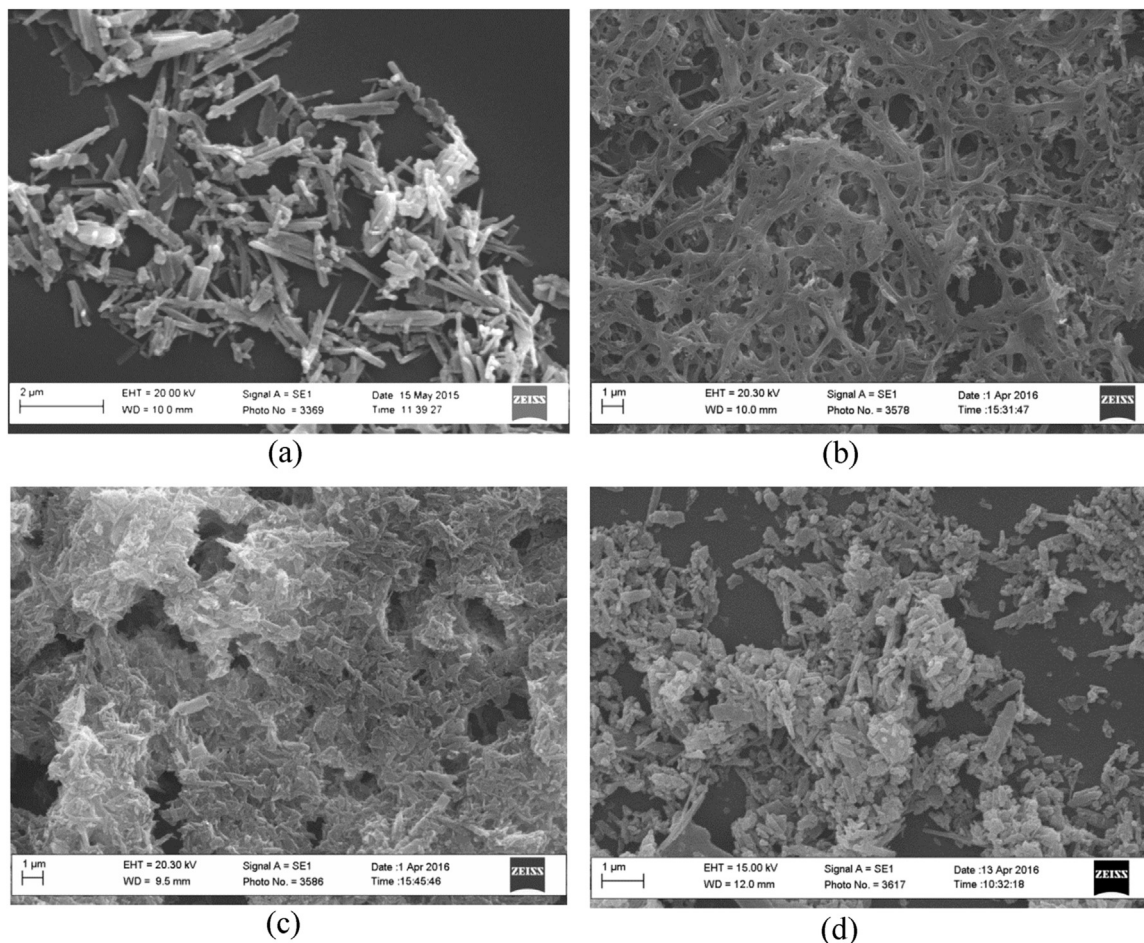


Fig. 2. SEM images of a) pure xonotlite b) lauric acid/xonotlite c) decanoic acid/xonotlite d) paraffin/xonotlite composites.

Download English Version:

<https://daneshyari.com/en/article/4758791>

Download Persian Version:

<https://daneshyari.com/article/4758791>

[Daneshyari.com](https://daneshyari.com)