Renewable and Sustainable Energy Reviews 48 (2015) 500–522

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Properties evaluation and applications of thermal energy storage materials in buildings

Lei Cao, Di Su, Yaojie Tang, Guiyin Fang*, Fang Tang

School of Physics, Nanjing University, Nanjing 210093, China

ARTICLE INFO

Article history:
Received 23 February 2014
Received in revised form
8 March 2015
Accepted 6 April 2015

Keywords:
Thermal energy storage
Phase change materials (PCMs)
Building energy conservation
Thermal performance

ABSTRACT

Thermal energy storage systems have been recognized as one of the most efficient ways to enhance the energy efficiency and sustainability, and have received a growing attention in recent years. The use of phase change materials (PCMs) in building applications can not only improve the indoor thermal comfort but also enhance the energy efficiency. It has been demonstrated that for the development of a latent heat storage system in a building, the choice of the PCM and the incorporation method plays an important role in the thermal performance regulation. In this paper, the fabrication and characterization of the thermal energy storage materials including composite PCMs and microencapsulated PCMs are summarized, and applications of the thermal energy storage materials in buildings are also reviewed from the recent literatures.

Contents

1. Introduction

In recent decades, the continuous growth in energy demand and shortage of conventional energy sources makes it very important to find renewable energy sources, as well as efficient ways of energy conservation. Housing apartments and commercial buildings play an important role in the energy-intensive consumers. About 30% of all energy which has been consumed was used for illumination, heating and air-conditioning of buildings in modern society [1–3]. This shows us how important to use energy effectively in buildings.

Thermal energy storage (TES) is one of the most perspective methods of increasing efficiency in energy recovery and effective

* Corresponding author. Tel.: +86 25 51788228; fax: +86 25 83593707.
E-mail address: gyfang@nju.edu.cn (G. Fang).

http://dx.doi.org/10.1016/j.rser.2015.04.041
1364-0321/

Table 1
Classification of the PCMs.

PCM	Inorganic	Salt hydrates	Salt hydrates
		Metallics	Al–Si, Mg–Cu–Zn, etc
	Organic	Paraffin	Paraffin wax
		Non-paraffin	Esters, fatty acids, polyols
	Eutectic	Inorganic–inorganic	
		Inorganic–organic	
		Organic–organic	

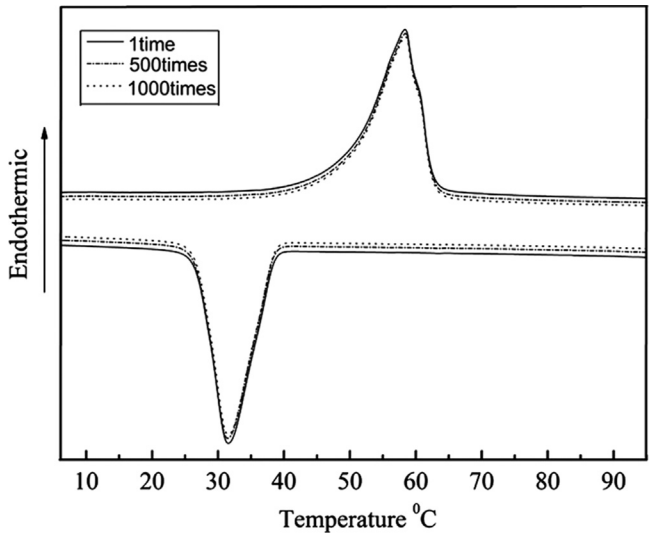

Fig. 1. Heating and cooling DSC cures of TPUPCM after 500 and 1000 thermal cycles [14].

using available sources of heat. It will not only correct the gap between supply and demand but also improves the performance and reliability of energy systems and plays an important role in the energy conservation [4]. Latent heat storage (LHS) is widely used in thermal energy storage systems due to its high energy storage density and nearly isothermal heat storage process, and a variety of phase change materials (PCM) have been investigated and they are commercially produced for different applications so far [5,6]. A classification of PCMs is given in Table 1.

PCM has been employed for thermal energy storage in buildings for several decades. By employed in ceiling boards, Trombe walls, wallboards, shutters and under-floor heating systems, PCM can be used as part of the buildings for heating and cooling applications or solar energy utilization [7,8]. It helps to increase the thermal storage capacity of a building and enhance human comfort by decreasing the frequency of internal air temperature swings so that the indoor air temperature is closer to the desired temperature for a longer period [9]. The main purpose of applying PCM in buildings is to use natural heat for heating or cooling, and to use artificial heat or cold sources in addition. Energy storage should match demand and availability with respect to time and power. So the use of PCM for heating and cooling in buildings basically includes PCM in building walls, PCM in other building components and PCM in heat or cold storage units [10–12].

In recent decades, many efforts have been done to develop PCM in buildings. The aim of this work is to analyze the properties evaluation and applications of thermal energy storage materials in buildings.

2. The properties of thermal energy storage materials

Although a large number of PCMs including solid-liquid PCMs and solid-solid PCMs have been developed for thermal energy

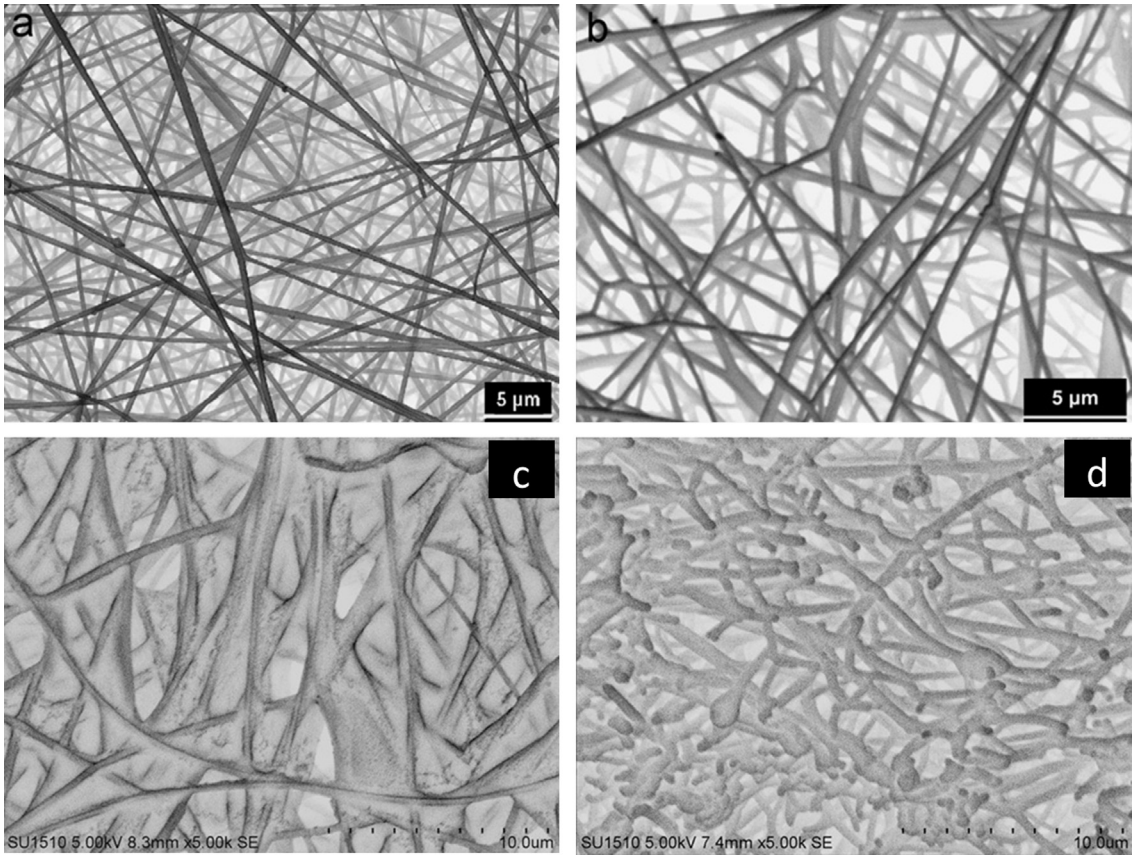

Fig. 2. The SEM images of (a) electrospun PAN, (b) carbon nanofibrous mats, (c) CA–PA/PAN and (d) CA–PA/carbon [16].