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Preparation and characterizations of asphalt/lauric acid blends phase change materials for potential building materials

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HIGHLIGHTS

- LA/asphalt composite was prepared through direct impregnated technology.
- The obtained composite exhibited superior absorbing and releasing heat during phase change process.
- The obtained composite had good thermal stability and reliability.
- The obtained composite show great potential for conserving energy and regulating indoor temperature in building.

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ABSTRACT

Lauric acid (LA) is a common used phase change materials (PCM), and has been attracted considerable attentions for conserving waste energy and improving efficiency of energy utilization in building. In this paper, asphalt/LA blends are obtained through direct impregnated technology. The morphology, compatibility, crystalline properties, phase change properties, thermal reliability and stability of obtained asphalt/LA blends are extensively studied by scanning electron microscope, X-ray diffraction, differential scanning calorimetry, accelerated thermal cycling testing and thermogravimetric analysis, respectively. The asphalt exhibits a good compatibility with LA, and the phase separation is not detected in obtained blends. The obtained asphalt/LA blends demonstrate an excellent performance of storing and releasing heat during phase change process. Meanwhile, accelerated thermal cycling testing results indicate that the modified asphalt exhibit good thermal reliability and LA cannot leak from the blends after 100 times thermal cycling treated. The good thermal stability implied a practical application of blends in the construction industry. The obtained blends show great potential for conserving waste energy and regulating the indoor temperature in the field of construction and building.

1. Introduction

Efficient use of energy has become a significant issue due to the rapid growing demanding of energy and the deterioration of environment [1]. According to previous studies, the energy consumption in building account for about 40% of the global energy consumption [2]. Therefore, it is significant and urgent to develop the sustainable building [3]. Latent heat thermal energy storage (TES) employing phase change materials (PCM) have attracted considerable attentions for conserving waste energy and improving efficiency of energy utilization in the residence [4,5]. PCMs have the ability to store and release a large amount of heat during the phase transition with a slight or no temperature change [6]. Incorporation of PCM into building is capable of not only enhancing the efficiency of energy utilization but improving the internal temperature comport through storing and releasing latent heat during phase transition [7,8].

Asphalt is derived from the crude oil by distillation under high temperature, and it has a complicated internal chemical structure [9]. Asphalt has been widely applicated in building and construction due to its superior waterproof, adhesive properties, low costing and some other merits [10,11]. The composite including the PCM and asphalt have been studied in previous research, Wei Si proposed paraffin as temperature thermoregulations to improve asphalt, and the effect of the PCM type was investigated [12]. Bryan J. Manning employed the lightweight aggregate as medium of PCM modifier and asphalt to extend the pavement life via reducing the magnitude of temperature fluctuations [13]. Biao Ma prepared a composite shape-stabilized phase change materials based on

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tetradecane, silica, ethyl cellulose and dispersant through encapsulate technology to overcome the aggregation during asphalt mixing [14]. In previous studies, PCMs were employed to enhance the temperature resistance capacity of asphalt mixture and improve asphalt mixture's temperature adaptability. Therefore, it is interesting and essential to prepare composite including the PCMs and asphalt for regulating the internal temperature and improving efficiency of energy utilization. Fatty acids are frequently used as the PCM in latent heat TES, and have superior properties over the other organic PCMs such as low cost, high latent heat, little or no super cooling, no or less volume change during the course of phase change, non-toxicity and good thermal and chemical stability after long-term utility period [15]. Lauric acid (LA), a fatty acid, is used as PCM for TES in low temperature, herein LA can be introduced into asphalt for building materials to conserve waste energy and regulate the indoor temperature [16,17]. Moreover, researchers have reported that the grafting modifier with COOH is favor of its dispersion and chemical bonding with asphalt [18].

Table 1
The composition of modified asphalt.

Samples	LA (wt%)	Asphalt (wt%)
1#	40	60
2#	50	50
3#	60	40
4#	70	30
5#	80	20

In this work, the LA was introduced into asphalt through a facile method for building materials. The asphalt/LA blends were prepared through direct impregnated technology. The morphology of obtained blends and compatibility between LA and asphalt were measured by scanning electron microscope (SEM). The crystalline properties, the properties of storing and releasing heat and functional temperature were evaluated by X-ray diffraction (XRD) and Differential scanning calorimetry (DSC). The thermal reliability and thermal stability of the modified asphalt were assessed by accelerated thermal cycling testing and Thermogravimetric analysis (TGA), respectively. In addition, the effect of LA content on the performance of composite was also extensively studied.

2. Experimental

2.1. Materials

Lauric acid (LA) was supplied by Chengdu Kelong Chemical reagent company (Chengdu, China). Asphalt was provided by Maoming oilfield branch of china petroleum and chemical corporation (Maoming, China). The reagents were used as received.

2.2. Preparation of PCM modified asphalt

The PCM/asphalt composite was prepared through direct impregnated technology. The asphalt and LA were added into 250 mL three-necked round-bottomed flask according to different

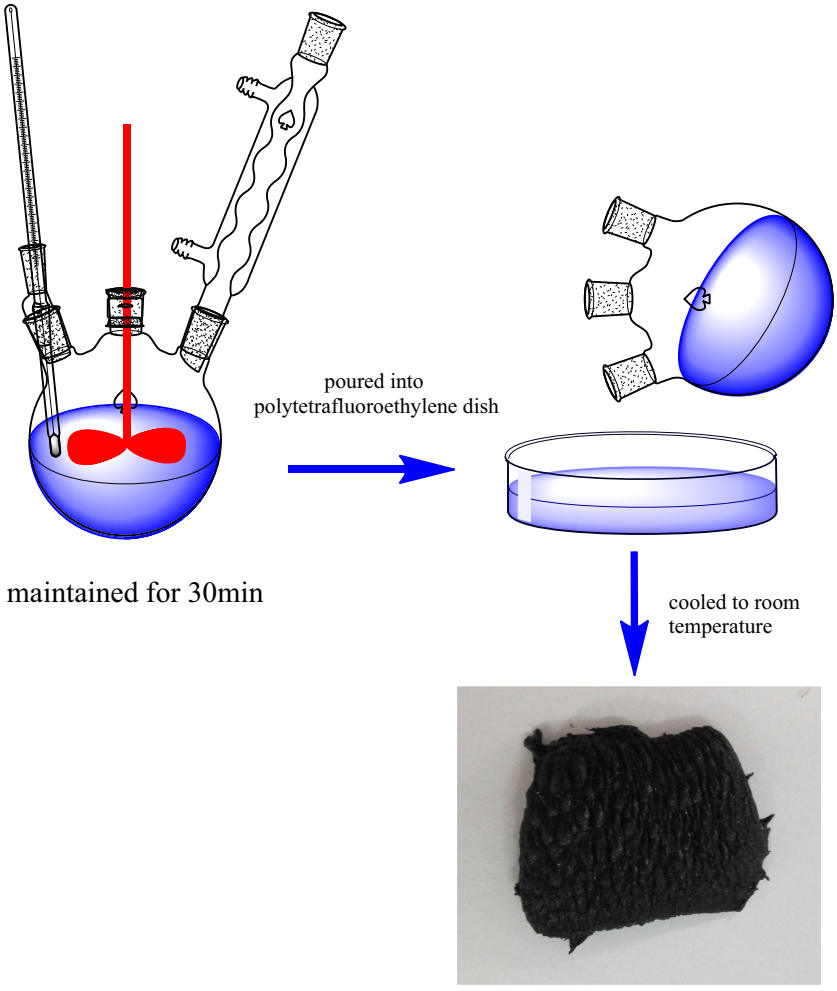

Fig. 1. The schematic diagram of modified asphalt.