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Energy Storage Properties of Phase Change Materials Prepared from PEG/CPP

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Abstract: New kinds of solid-solid phase change materials have been prepared in our laboratory. In these materials, the rigid polymer chlorinated polypropylene is taken as skeletons and the flexible polymer polyethylene glycol 6000 and polyethylene glycol 10000 are taken as functional chains. Results show that chlorinated polypropylene grafted by polyethylene glycol 10000 has greater enthalpy than chlorinated polypropylene grafted by polyethylene glycol 6000.

Keywords: Polyethylene glycol, chlorinated polypropylene, phase change materials.

Latent heat storage is one of the most efficient ways of storing thermal energy. Unlike the sensible heat storage method, the latent heat storage method provides much higher storage density, with a smaller temperature difference between storing and releasing heat. Phase change materials (PCMs) can be used for energy storage and temperature control[1,2]. Among them, the solid-solid phase change materials are focus of attention [3, 4]. They can be applied in many fields such as solar energy utilization, waste heat recovery, electric appliances with thermostatic regulators and so on[5]. In our laboratory, new kinds of solid-solid phase change materials with netted structure had been prepared. In these materials, chlorinated polypropylene (CPP) was taken as skeletons. Chlorinated polypropylene is chemical stable and mechanical sturdy. Polyethylene glycol (PEG) with average molecular weight 6000 and 10000 were taken as functional branch chains. The results show that the chlorinated polypropylene grafted by polyethylene glycol 10000 has greater enthalpy than chlorinated polypropylene grafted by polyethylene glycol 6000.

Experimental

All reactions were carried out according to the following procedure[6]. Water was separated as toluene azeotrope from the solution of polyethylene glycol 6000 (18 g, [OH]＝0.006 mol) in 80 mL of toluene. Sodium (0.138 g, [Na]＝0.006 mol) was added to this solution. The metalation of hydroxyl group in polyethylene glycol 6000 was carried out

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under reflux with stirring for 20 h under nitrogen at 115 ℃. The reaction solution became dark brown. This reaction mixture was used in the next procedure. In a 250 mL four-necked round –bottled flask, the solution of chlorinated polypropylene (0.82 g, [Cl]=0.006 mol) in 40 mL toluene was added. The dark-brown solution of sodium alkoxide derivative of polyethylene glycol 6000 was added dropwise, and the reaction mixture was stirring vigorously at 85 ℃ in an oil bath under nitrogen for the prescribed time. Then toluene of the solution was removed. The resulted polymer was washed by distilled water and then dried in vacuum at room temperature.

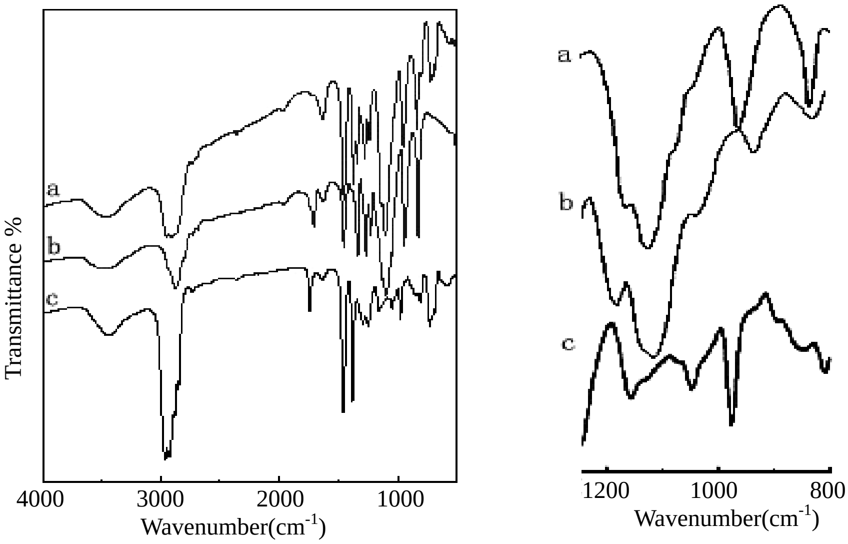
Chlorinated polypropylene grafted by polyethylene glycol 10000 reacted like chlorinated polypropylene grafted by polyethylene glycol 6000.

Results and Discussion

Figure 1 shows the framework vibration FT-IR spectra for chlorinated polypropylene grafted by polyethylene glycol 6000 (a), chlorinated polypropylene grafted by polyethylene glycol 10000 (b), and chlorinated polypropylene (c). It can be seen that the absorption bands due to C—O—C stretching vibration of the ether group are detected at about 1100cm^{-1} in both PEG6000/CPP and PEG10000/CPP phase change materials.

The thermal behaviors of PEG6000/CPP and PEG10000/CPP phase change materials were measured by DSC at the heating and the cooling rate of 5℃/min in nitrogen atmosphere. From **Figure 2,** the enthalpy of chlorinated polypropylene grafted by polyethylene glycol 6000 is 67.5 J/g. From **Figure 3,** the enthalpy of chlorinated polypropylene grafted by polyethylene glycol 10000 is 142.5 J/g. The results showed that chlorinated polypropylene grafted by polyethylene glycol 10000 has greater enthalpy than chlorinated polypropylene grafted by polyethylene glycol 6000. One of the causes

Figure 1 FTIR spectra and partial enlarged FTIR spectra



(a) chlorinated polypropylene grafted by polyethylene glycol 6000, (b) chlorinated polypropylene grafted by polyethylene glycol 10000, (c) chlorinated polypropylene

Figure 2 The DSC curve of chlorinated polypropylene grafted by polyethylene glycol 6000

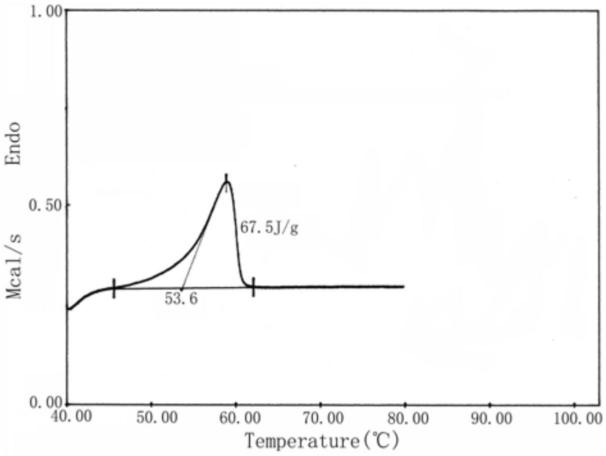
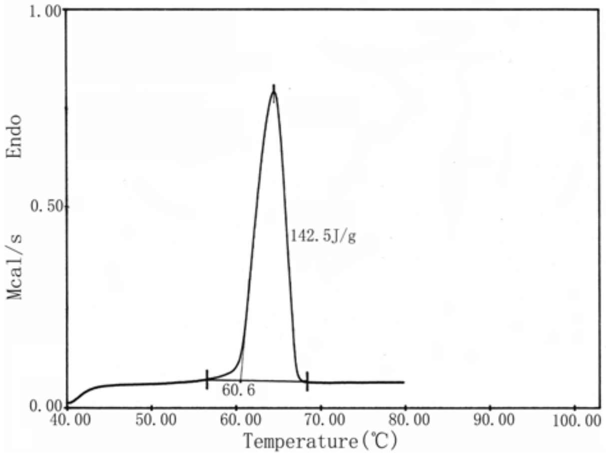


Figure 3 The DSC curve of chlorinated polypropylene grafted by polyethylene glycol 10000



is that the crystallinity reaches the maximum when the molecular weight is 10,000, *i.e.* the number of segments (CH_2–CH_2–O) is about 227[7]. If the number of segments was less than 227, the crystallization of the whole number of segments could decline, so the enthalpy decreased. If the number of the segments was more than 227, the chain was too long, it would tangle together, and impede to form well-defined crystal. Therefore, above two factors work together and lead to crystallinity and the enthalpy reach the maximum when the molecular weight is 10000. So that chlorinated polypropylene grafted by polyethylene glycol 10000 has greater enthalpy.

In conclusion, by chemical methods, the new kinds of phase changed materials were prepared by chemical methods. The results showed that the chlorinated polypropylene grafted by polyethylene glycol 10000 has greater enthalpy than the chlorinated polypropylene grafted by polyethylene glycol 6000.

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