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Effect of Micro Phase Change Materials on Thermal Behavior of Lather

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Abstract

Today Scientist has been interested in manufacturing and invention of smart textiles such as PCMs. The process of phase change from solid to liquid and vice versa takes place in such materials. Using materials such as PCM could change properties of Leather for better performance and could applied into many places such as shoes industry. If leather with PCM finishing have a thermo regulating property and saving 10 % energy, costumers whom used that leather in their shoes, could use shoes more than 1 hour in compare of raw leather. For finishing leather with PCM several methods were suggested but just some of them could useful on the leather. First purpose of this study was discovering effect of PCM on leather, and second which technic can useful for better performances during finishing of leather, and last purpose was understanding effect of PCM on comfort of leather after finishing. In this study, first impregnated leather with 5 and 10% of PCM by spray technic, and then characterized raw leather and finished leather by using SEM, DSC. At the end water vapor permeability and physical property of samples were analyzed for understanding of leather comfort, and results reveal that after using 10% PCM significant effect on thermal behavior of samples were observed and finishing had no effect on comfort of leather.

Keywords: PCMs; Micro; Nano; Leather; Thermal Comfort; Thermo Regulating

Introduction

In the two past decades, microencapsulated Phase Change Materials (PCM) has drawn an increasing interest to provide enhanced thermal functionalities in a wide variety of applications. When the encapsulated PCM is heated to the melting point, it absorbs heat as it goes from a solid state to a liquid state. This phase change slows down the temperature increase. It can be applied to clothes technology, building insulation, energy storage as well as to coolant liquids. On a more general basis, it can be used to design a broad variety of thermal transient regimes [1]. The PCMs used for ambient temperature related applications are carbohydrates with different chain lengths or paraffin's. The PCMs are encapsulated in small spheres in order to be contained in a liquid state. The microcapsules possess approximate diameter of 1-10μm and are resistant to abrasion, pressure, heat and chemicals according to the shell chemical compounds Micro-sized capsules are required to provide a large contact area with the environment and ensure an optimal efficiency of the phase change [2]. Among a multitude of possible wall materials for microcapsules, amino resins, more especially melamine-formaldehyde, play a main role, more precisely in the patent literature. Amino resins represent an interesting economical alternative, since these polymer raw materials have been produced on a large scale for many years, and since they have already been practised in many processes like phase separation and interfacial reaction (e.g. dicarboxylic acid dichlorides and di or triamines). Furthermore melamine-formaldehyde microcapsules prepared by in situ polymerisation have impermeable shell [3].

Textiles containing these kinds of materials immediately react when the temperature of the environment changes. When there is an increase PCMs react while absorbing energy keeping them in the phase of liquid. Then when temperature decreases, the stored energy is set free and microcapsules change into solid phase [3].

For costumes which must be protected against the coldness, thermal insulation by attracting microcapsules is a solution.

These capsules contain a little amount of PCMs. With the help of PCMs, industry produces clothes with different comfort and heat properties. Nowadays with the application of heat properties, absorption and release of the PCMs' energy in textiles, patching is done through different methods: direct connection, connecting by foam, or other coating methods [4] (Figure 1). Heat exchange with environment plays a key role in human body's heat balance. Heat comfort can be defined as psychological satisfaction with body temperature and its surrounding environment [5]. General dissatisfaction is caused by coldness or warmth [6]. In this study, micro PCM`s technology has been applied to raw leathers and methods of application were investigated by morphological analysis; the thermal performances of samples were evaluated by differential scanning calorimeter and SEM. Marius Butuc et al. in 2010 published paper titled as Research Regarding Textile Articles with Thermoregulating Properties and shows advantage of PCMs on knitted fabric. Fen Gan et al study on micro capsule with properties of thermo regulating was made of Poly Ethylene Glycol (PEG) on leather and concluded that this finishing can be improve thermal behavior of leather.

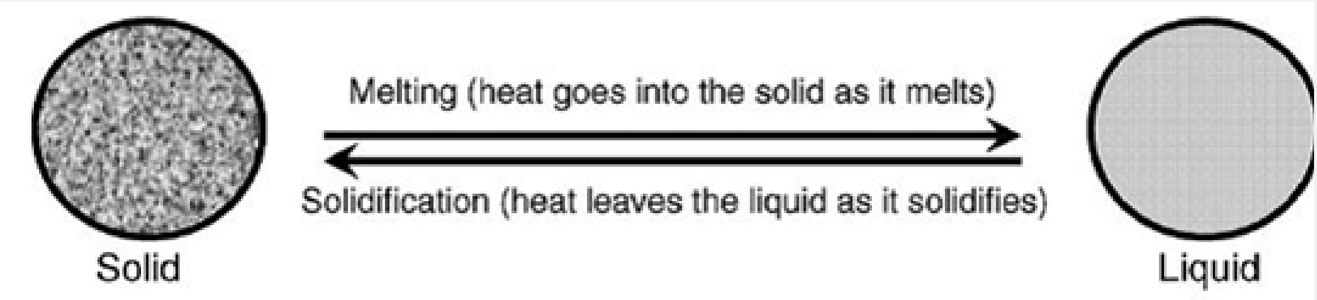

Figure1: Phase change phenomena.

Fabien Salaun Et al study on Polymer nanoparticles to decrease thermal conductivity of phase change materials and prove that the polymer nanoparticles do not affect the latent heat and even improve the phase change behavior as well as the mechanical properties.

Materials and Process

a. PCMs with Hexadecane core a melamine formaldehyde sheet purchased from Razi chemical co, Iran

b. Surfactant: sulfinate ester as surfactant, provided by Simab Rezin Ltd Iran

c. Disperse agent: the application of Sodium Hexa Meta Phosphate (SHMP). Purchased from Simab Rezin Ltd Iran

d. Thickening agent:TH-110 (commercial name) crosslinked acrylic emulsion copolymer provided by Simab Rezin Ltd Iran

e. Binder: the application three binders, provided by Simab Rezin Ltd Iran Company respectively named as CH-618, CH-71 and CH-65 (commercial names)

f. Antifoam: supplied by Simab Rezin Ltd Iran

g. Water: boiled for 15 minutes

h. SEM microscope(model: KYKY-EM3200)

i. DSC machine (NETZSCH DSC 200F3)

j. The tensile strength was measured using a universal material testing machine (Model H10K-S, Tinius Olsen, America) according to ASTM D5034 -09(2013).

k. The rubbing fastness was measured using a MFG. By TABER INSTRUMENT CORPORATION NORTH TONANANDA, N.Y. USA model 174 according to AATCC Test Method 8-2007.

l. The air permeability was measured using gas permeability tester (SDL (SHIRLEY) model MO215) according to ASTM D737-96.

Methods

First, disperse PCMs by using us patent no 6514362 b1 methods, that comprises coatings for fabrics and methods for manufacturing the same. A preferred coating includes wetted microspheres containing a phase change material dispersed throughout a polymer latex binder, and including a surfactant, a dispersant, an antifoam agent and a thickener. Preferred phase change materials include paraffinic hydrocarbons. To prepare a preferred coating composition of the present invention, microspheres containing phase change material are dispersed in an aqueous solution of a surfactant, a dispersant, and an antifoam agent mixture, followed by dispersion in a polymer mixture to form a coating composition. In an alternative embodiment, a substrate is coated with an extensible binder containing microencapsulated phase change material to form an extensible, coated fabric. A preferred binder contains latex and a preferred substrate is an extensible fabric. The coated substrate is optionally flocked. When the coated product is an extensible fabric, transfer coating techniques are preferably employed. Then add binder with 5 and 10% ratio weight/weight, impregnated raw leather using spray method for impregnated leather [7]. And for comparison raw leather and PCM Leather through SEM, DSC,

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tensile strength, rubbing fastness and water vapor permeability test results reported in this paper.

Discussion and Conclusion

Figure 2 shows comparison of raw leather and leather finishing with 5 and 10 % of PCM. Result shows that after finishing leather pores of raw leather filling with PCM and this phenomenon caused loose breathability of leather, and size of PCM shows in this figure, and understand from that micro and Nano particles were filling in leather. As it is evident from Figure 2 there is no sign of haring process on the hide and PCMs have covered each pore completely. For better analyze Figure 3 shows compression of raw leather, leather finishing by 5% PCM and leather finishing by 10% PCM. Figure 3b and figure 3c shows proper distribution and more number of microcapsules. The first point addresses the correct method of dispersing and the second one shows the existence of more PCMs on the leather [8]. Another point that can be drawn from the figure is the dimensions of PCMs in micron. After SEM testing and proving the fact that PCMs are properly laid on leather with proper disperse, DSC testing is done to observe thermal behavior of PCMs prior to the laying. With the charts as the result of the outcome of this experiment, this examine can proved how much energy is saved before and after laying PCMs. And show this technic was good for using. Firstly, examined the finished sample by using microcapsule powders to observe that the PCM using in this process had an effective performance on heat properties of absorption and energy utilization of sample. The results are shown as below.

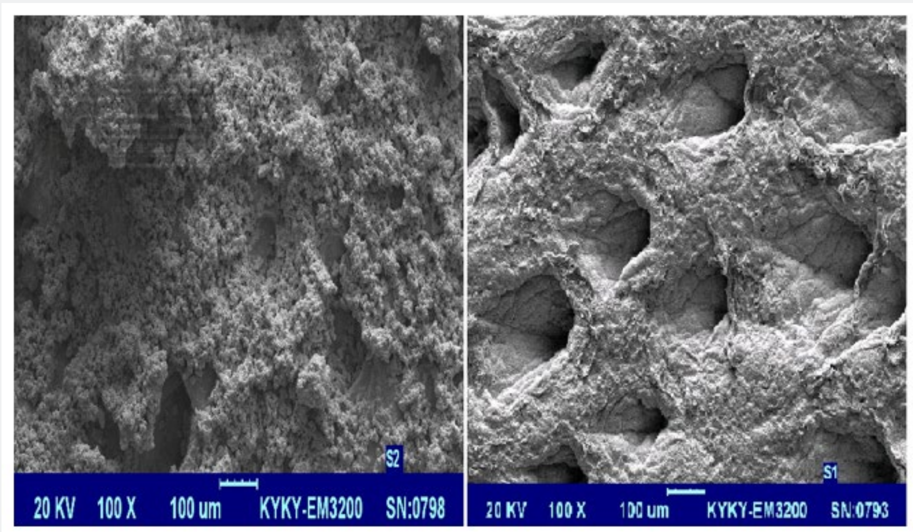

Figure 2: SEM S1-raw leather S2- leather finished by PCM.

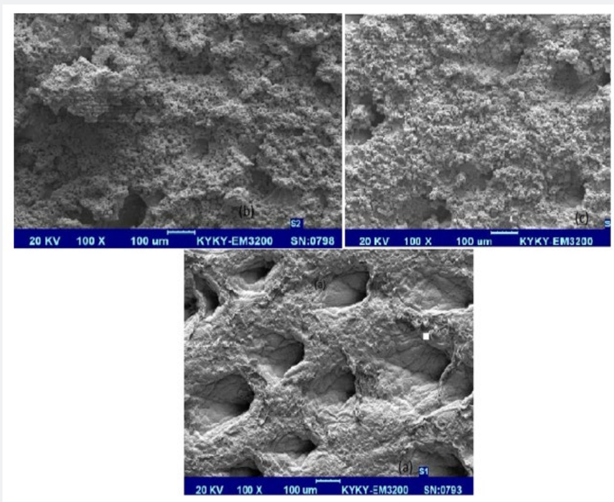

Figure 3: SEM S1-raw leather S2- leather finished by PCM.
comparison of a) raw leather
b) leather finishing by 5% PCM
c) Leather finishing by 10% leather.

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As seen in the Figure 4 the melting point of PCMs is 18.7oC. The area under the curve represents the amount of energy absorption which is 43.66J for 1 gram of PCMs. The reverse chart shows the crystallization point 10.7C. The area under the curve shows PCMs release energy 23.77J for one gram of PCMs. This proves that the materials do the absorption and release of the target properties properly. With the application of aforementioned data, then for a better state of comparison first examine Natural leather with DSC machine. The Figure 5 shows the result. As it is evident from Figure 5 there is no peak in the thermal area, which proves that leather has no absorption or release of energy in this area. And if sample were applied PCMs on it, it has to obtain their heat properties, namely energy absorption and release. Through the same procedure sample were impregnated with the 10% PCM sprayed on leather. DSC results are shown in Figure 6. The chart depicts that PCMs have led to a peak of 15.4C in the temperature, which shows the melting point of PCMs. The area under the curve shows the fact that for every gram of PCMs, 0.1285J energy is saved in leather. This energy can be release while the environment is getting colder. This can make the consumer feel warmer. For analyze comfort of leather after finishing water vapor permeability test were done. Table 1 shows results of water vapor permeability of raw leather, leather finishing by 5% PCM and leather finishing by 10% PCM. Table 1 shows that PCM finishing influenced the leather, but this effect was neglectable. Table 2 shows physical properties of samples.

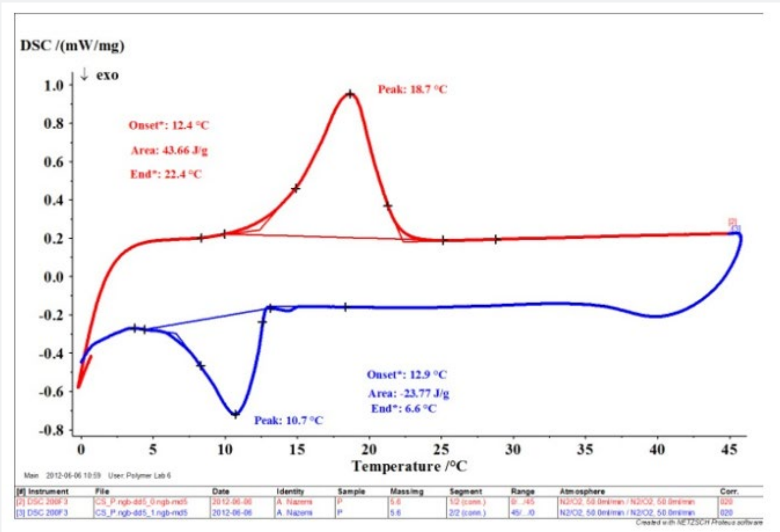

Figure 4: DSC chart of PCMs.

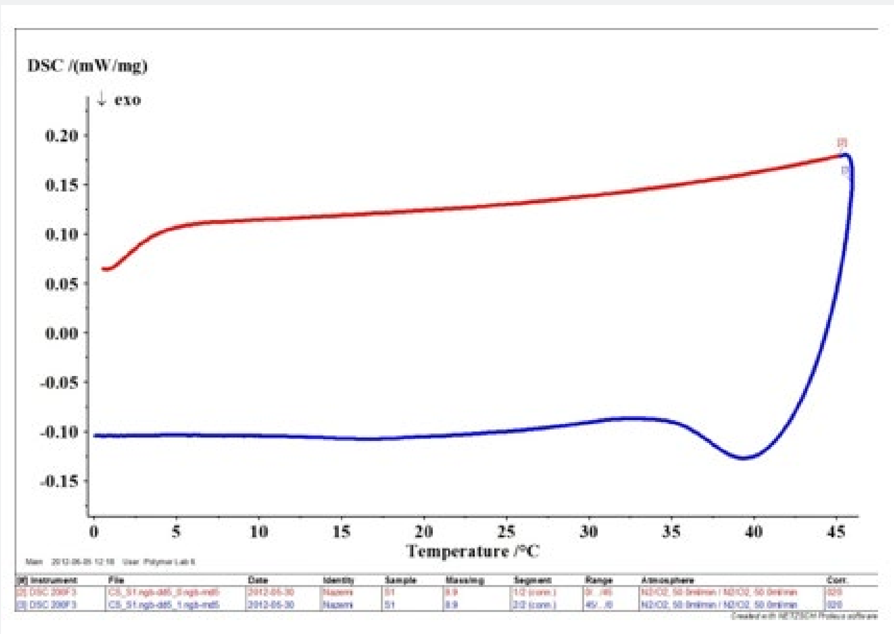

Figure 5: DSC chart, raw leather.

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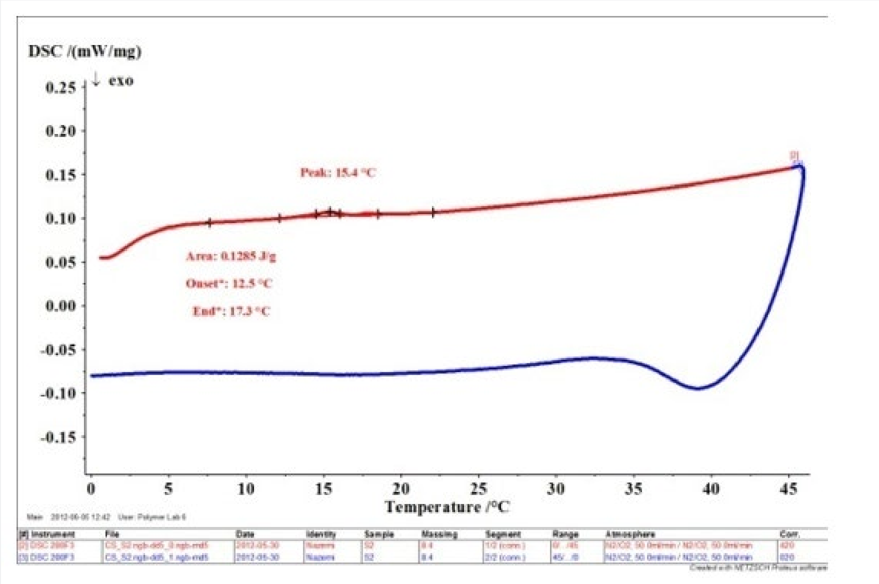

Figure 6: sprayed leather, 10% PCMs.

Table 1: Water vapor permeability test.

Title	Sample 1 natural leather	Sample 210%	Sample 35%	Sample 4 with pigment
Weight of sample before test	4.09gr	4.14gr	4.55gr	4.52gr
Total Weight of sample before test	207.91	204.87	201.19	205.18
Total Weight of sample after	199.26	197.36	193.17	199.32
Weight of sample after	4.03	4.42	4.77	4.89
Total transition	8.65gr	7.51gr	8.02gr	5.86gr
Absorption	0.21gr	0.28gr	0.22 gr	0.37gr
Water vapor permeability (WVP)	437.26gr/m^{2}day	379.63gr/m^{2}day	405.41gr/m^{2}day	296.22gr/m^{2}day

Table 2: Physical properties of sample.

	Sample 210%	Sample 35%	Sample 4 with pigment	Raw leather
Dry rubbing fastness	3	3.5	4	5
Wet rubbing fastness	2.5	2	3	5

Conclusion

In this paper first investigated that PCM can improve thermal behavior of leather, for this factor DSC used and from output of this examine understand that just in 10% concentration PCM worked on leather, this understanding indicated that for more efficiency in finishing leather by PCM high concentration of PCM should be used. Another factor that investigated in this paper was leather comfort after finishing and from study water and air permeability of leather after finishing understand that by using higher concentration of PCM reduce comfort of leather, but in 10% PCM used amount of reduction was neglected.

Further suggestions

The suggestion-considering the experiments undertaken in this study- for similar projects are apply PCMs in the lining of textiles and PCMs must be applied in the tanning process. The last point is considering financial capabilities to optimize the use of PCMs in processing leather and other textiles.

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