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Effect of thermosetting on the physical properties of poly(L-lactic acid) fabric

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1. INSTRUCTIONS

The environmental friendly textile is required to satisfy the high standard of the consumer living style which demands clothing with aesthetic and cultural function. Generally, biodegradable polymers are used for alkyl polyester or short chained polymer. The synthesized biodegradable polymers have limitation of strength and durability for development of textile products. In contrast, natural fibers can be commonly used for replacement of biodegradable synthetic fibers since they have enough strength and durability.[1]

The corn Poly(L-lactic acid) (PLA) fibers completely decompose in six to twenty four months while the commercial plastics, such as polyester and polystyrene, take more than 500 years for decay. Even though the PLA fibers have higher initial modulus and higher melting temperature than any other biodegradable polymer, they are easily fused at the temperature of 175℃ and higher with a commercial iron[2,3] due to their relatively low melting temperature.[2,3]

Synthetic fibers are easily deformed with thermal stimuli since the polymers were drawn under high tension with high internal stress and deformation. Thermal curing is required to fix potential internal deformation and to stable molecular chains with thermal treatment.[4]

In this study, wet curing which is fixation method with jigger and high pressured beam dyeing machine at the temperature higher than 100℃ was used. The PLA fabrics were cured in a batch without tension using saturated vapor pressure for various temperatures. The treated fabrics were analyzed using thermal analysis, extension properties, and dyeability to evaluate the effects of thermal characteristics on physical properties of fabrics.

2. EXPREMENTALS

The 100% PLA fabric (Shinpoong Inc.) with 75 denier and 36 filaments of PLA yarn (75/36 denier) was selected. PLA fabrics were treated at 50, 100, 110, 120, 130, and 140℃ to test out thermal fixation and named as HS50, HS100, HS110, HS120, HS130, and HS140, respectively. Processes include dwelling time of two minutes for curing with temperature rate of 2℃/min, cooling, and then washing.

Thermal properties of treated PLA fabrics were measured with Differential Scanning Calorimeter (DSC, TA 4000/Auto 2910) with temperature increased to 300℃ at 10℃/min. X-ray diffraction device (D/max-Ⅲ-A type, Rigaku Co., Japan) was used with Ni filtered CuKα light. X-ray curves were obtained from test with scanning range of 2θ from 5 to 40°. Instron tester from Textechno Fafegraph-M (Textechno Co., Germany) was used to evaluate physical properties of samples based on a Korean Industrial Standards (KS K 0520-1995). The crease recovery tests of thermosetting fabrics were characterized by a Monsanto type device based on a Korean Industrial Standards (KS K 0550).

3. RESULT AND DISCUSSION

DSC diagram of thermoset PLA fabrics treated at different temperatures was shown in Fig. 1. Since the structural changes in fibers are greater as the temperature increases, the results were shown for 100, 110, 120, 130, and140℃. Endothermic peak from 155℃ and 170℃ were shown as a melting region. In Fig. 1, melting peaks of HS100 of PLA fabrics appeared two and the distance between two peaks of thermosetting temperatures decreased with increasing thermosetting temperature. The result for HS140 shows that the temperatures of the endothermic peaks combine at one endothermic peak. The peak at lower temperature did not change with thermosetting temperatures while the peak at high temperature decreased with increasing the setting temperatures. The untreated PLA fabric shows two endothermic peaks due to the core and sheath separation caused by rapid cooling during fiber formation processes,

known as skin-core structure. The skin-core structures are one of the reasons to which dyeing and finishing are not uniform; therefore, slowing cooling rates for thermosetting of PLA fabrics or PLA fiber spinning may reduce problems associated with skin-core structure.

Fig. 2 shows the results of X-ray diffraction for the different thermosetting temperatures using X-line diffraction system (D/max-Ⅲ- A type and Rigaku Co., Japan) under Ni filtered CuKα ray with 2θ = 5 - 40. Peaks for PLA fabrics were found at Bragg angle 2θ from near about 14.8, 16.3 and 18.6° which represents (003), (200) and (240) phase, respectively.[5] The diffraction intensity increases until 100°C of thermosetting temperature because of recrystallization of PLA fiber. The recrystallization may occur in the region where crystallization was not completed because the time required for crystallization was too short. Crystallinity may be decreased by highly oriented unstable structures from fiber drawing process under high tension, which might induce lower diffraction strength at high thermosetting temperature.[6]

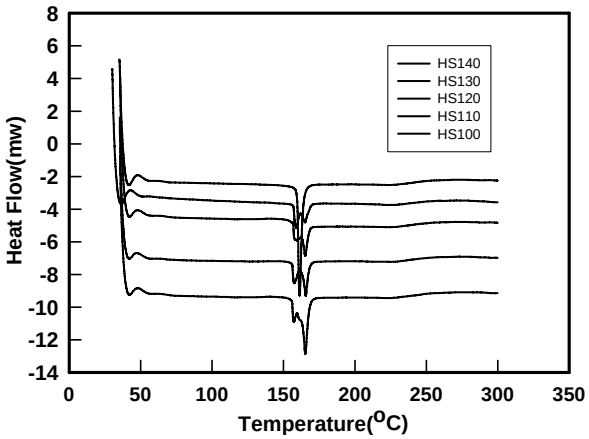

Fig. 1. DSC thermograms of PLA fabrics.

4. REFERENCES

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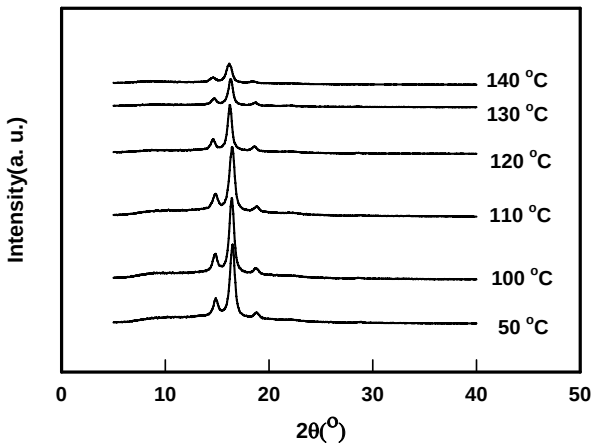

Fig. 2. X-ray diffractograms of PLA fabrics.