Influence of forming conditions of a spin-bonded nonwoven from Bionolle polymer on their properties

M. Lichocki 1, J. Kruciska 1, K. Sulak 1, A. Gutowa 1, T. Mik 2, M. Chrzanowski 2, M. Puchalski 2

1. Technical University of Lodz, Faculty of Material Technologies and Textile Design, Department of Fiber Physics and Textile Metrology, Zeromskiego 116, 90-624 Lodz, Poland
2. Institute of Biochemical and Chemical Fibres, Department of Synthetic Fibres, M. Sklodowskiej-Curie 16/27, 90-570 Lodz, Poland, e-mail: mliczocki@ibwch.lodz.pl

INTRODUCTION

Spinbonding is a simple step process for converting plastic pellets into nonwoven fabrics. Almost all thermostetting polyesters are processed on a spinnbnding apparatus [1]. One of them is biodegradable aliphatic polyesters of the trade name Bionolle, produced by Shova Highpolymer. Bionolle is manufactured by polylactid condensation with glycols like caprolactone and adipic acid. The raw material is a mixture of polylactide and different adipic acid esters. These nonwoven fabrics are known for their high porosity and good air permeability [2].

MATERIALS AND METHODS

Polymer: Bionolle (granules type #0063), polyethylene succinate adipate copolymer by Shova Highpolymer co.-LFT (lot 4).

Drying of polymers: Polymers were dried in a dryer made by Proxa. Drying temperature was 50°C and dry time 50°C. Drying process was carried out until the weight content in polymer was ≤5% ppm. Weight was measured by 4.50 ppm.

Forming of nonwovens:

Equipment: Laboratory scale spin-bonding technological line model at IBWCh was constructed by POLYMATEX-CEANSO. Spinning conditions: processing temperature 232-249°C, throughput 0.15 g/min.

ANALYTICAL METHODS


Thermal Gravimetric Analysis (TGA):

where: TMax - Temperature of maximum weight loss speed [°C], Wmax - Weight loss at temperature of 238 [°C].

Multiflow index (MI) of polymers - according to method A in accordance with DYNISCO Polymer Test standard crush a specimen hole of 0.2 mm, a temperature of 190°C, and method B as developed at IBWCh for films - forming polymers using a specimen holder of 0.5 mm, within the temperature range of 210°C–250°C.

Viscosity was measured in chloroform at 25°C using viscometer Ubbelohde’s with capillary 0.6/0.0496. The inherent viscosity was calculated from:

where: n – relative viscosity, c – polymer concentration 0.1 g/l.

Ash content in polymer – gravimetric method. Ash content in polymer was calculated from:

where: A is ash content in polymer [%], m – mass of residue (g), W – weight of sample (g).

Moisture content in polymer - calorimetric Karl Fischer method with 5.6% moisture by Mattler Toledo.

Degree of crystallinity – WAXS (wide-angle X-ray scattering) – polymer and nonwoven were analyzed using X’Pert Pro X-ray diffractometer from PANalytical. The diffractograms were obtained by Cu Kα (λ=0.154 nm) X-ray source operating at 30 kV and 30 mA. The samples were studied in the powder form. A degree of crystallinity was estimated by the use of WAXSSW software [4] according to Hildbrand and Johnson’s method and the following equation:

where: A and A0 are calculated area under amorphous and crystalline curves of dezorverted X-ray pattern, respectively.

Molecular weight and polydispersity – size-exclusion chromatography (SEC) coupled with Multiangle Laser Light Scattering (MALLS) detection. SEC-MALLS – was composed of an 1800 Agilent isocratic pump, autosampler, and refractive index detector to detect the columns, a Shimadzu 2450 refractive index detector (Wyatt Technology Cooperation, Santa Barbara, CA), and differential refractometer Optilab RAXETER Astra 49675 Software (Wyatt Technology Corporation) was used for data collection and processing.

Scanning Electron Microscopy (SEM): Qantax 200 by El. The research was performed in low vacuum, in a natural state without coating.

Elongation at break in two directions (lengthwise and crosswise) – PS-EN 20075-3-1994, tear resistance – PS-EN ISO 13370-1:2002, Nonwoven were measured using Instron 5569 apparatus, according to Polish ISO standards.

Sorption rate – research was carried out with a system to evaluate the liquid sorption. For tests we used distilled water. The sorption rate was calculated from:

where: S max – sorption capacity [µl/cm²], M – surface mass [g/m²] (cm²).


CONCLUSIONS

Analysis of spin-bonded nonwoven produced from Bionolle #0063 polymer at different processing temperatures, indicates that temperature has an influence on properties of these fabrics.

Table 1. Selected physicalchemical properties of Bionolle #0063 polyester

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tg</td>
<td>105°C</td>
</tr>
<tr>
<td>Melting point</td>
<td>230°C</td>
</tr>
<tr>
<td>Drying rate</td>
<td>1000 ppm</td>
</tr>
<tr>
<td>Ash content</td>
<td>0.2%</td>
</tr>
<tr>
<td>Moisture content</td>
<td>0.5%</td>
</tr>
<tr>
<td>Degree of crystallinity</td>
<td>30%</td>
</tr>
</tbody>
</table>

REFERENCES

3. Technical data sheet, Shova Highpolymer Co., Ltd.

Table 2. Graphical documentation and SEM images of spinbonded nonwoven manufactured at 25°C, under standard composting conditions.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work of degradation</td>
<td>After 0 weeks</td>
</tr>
<tr>
<td>Photographic documentation</td>
<td>After 1 week</td>
</tr>
<tr>
<td>SEM images</td>
<td>After 1 week</td>
</tr>
</tbody>
</table>

Figure 1. Changes in the Multiflow Index of Bionolle #0063 as a function of temperature. Method B.

Figure 2. Comparison of X-ray diffraction patterns obtained for different forming temperatures.

Figure 3. Influence of the processing temperature on the sorption rate of nonwoven fabrics.

Figure 4. Influence of the processing temperatures on the biodegradation of spin-bonded nonwoven fabrics at a compost environment.

Figure 5. Influence of the processing temperature on the biodegradation of spin-bonded nonwoven fabrics at a compost environment.

Figure 6. Influence of the processing temperatures on the biodegradation of spin-bonded nonwoven fabrics at a compost environment.

Figure 7. Influence of the processing temperatures on the biodegradation of spin-bonded nonwoven fabrics at a compost environment.