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The physical properties of starch biocomposite containing PLA

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Summary. The paper presents the results of measurements of selected mechanical properties of biodegradable starch film produced from thermoplastic starch with 20% addition of polylactide (PLA). TPS was produced on a single screw extrusion-cooker with L/D = 16. Film blowing was processed on the plastic extruder, with L/D = 36. The measurements of the mechanical properties were performed on the Universal Testing Machine Zwick BDO-FBO0.5TH. The films produced with the addition of PLA were characterized by poor tensile strength, they easily cracked and were brittle.
Key words: PLA, biodegradable, extrusion, TPS.

INTRODUCTION

Initial production of biodegradable polymers dates back to the late twentieth century. The year 1995 can be considered as the date of manufacture of bioplastics for packaging production on a small scale [2, 3, 4, 20]. The price of bioplastics is currently one of the key market barriers that have an impact on their application. A significant and growing position in the production of degradable in the natural environment of packaging materials occupy polysaccharides of vegetable origin, in particular cellulose and starch derivatives [5, 8, 10, 11, 19]. Modification of the polymerization process and the use of new technology allow you to increase the area of applications for biodegradable plastics. Still, on the overall biopolymers market, the strongest in demand are those that are generated by biological processes. This segment is mainly dominated by polylactide (PLA) [6, 7].

Polylactide is an aliphatic polyester obtained by direct condensation of lactic acid [4, 7]. Methods for the preparation of this polymer are different, for example by a biotechnological process, which is analogous to the fermentation production of ethyl alcohol. In the global market there are different types of polylactide called NatureWorks, which produces U.S. company Cargill Dow LLC. These polymers are adapted to be processed by various techniques (injection-moulding, extrusion, thermoforming, blowing) in the typical equipment used in plastics processing [12, 14].

The advantage of packaging made from the PLA is mainly meeting the requirements relating to the environment [3, 4, 9]. The material allows the use of renewable raw materials in biological processes, reducing CO_2 emissions, organic recycling of packaging waste, it is compostable. PLA also has its drawbacks: it is quite brittle and rigid (needs a number of functional additives to be used in the packaging industry) and, most significantly, it is expensive [7, 20]. Its current net price is 4.2 Euro per 1 kg of PLA, an 6,0 Euro for 1 kg of PLA film. Potentially, one of the best solutions can be application of thermoplastic starch mixed with PLA, which has to reduce the cost of production of biodegradable packaging materials. Oniszczuk et al. [13] has described advantages of the TPS in the production of bioplastics using conventional equipment (as in the case of PLA). Application of potato TPS together with pure PLA without other excipients in production of biodegradable film was the main scope of the trials reported.

MATERIALS AND METHODS

The basic raw material for the production of TPS was potato starch (PZPZ Łomża), mixed with a plasticizer – glycerol of 99.5% purity (Odczynniki Chemiczne Lublin), added in an amount of 20 % wt. The bland was processed using a modified single screw food extruder TS-45 (Fig. 1) with L / D = 16, equipped with an additional cooling zone. TPS granules were produced at temperatures of 85 -100 °C with a constant screw rotational speed of 80 r. p. m., and the die hole diameter φ=3 mm.

Polylactide 2003D Ingeo ™ Biopolymer (Nature Works LLC) was added in an amount of 20% by weight to the TPS granules during a film blowing on a plastics extruder Savo

(Polish design) with L / D = 36 (Fig. 2). The film was produced at variable screw rotation (50- 80 r.p.m.), at temperature range from 80 till 140 °C, using a blow die gap of 0.6 mm.

Fig. 1. Food extruder TS-45

Fig. 2. Stand for film blowing

The measurements of selected mechanical properties of the obtained films were done following the Polish standards and methodology described in the literature [1, 15, 16, 17]. The tests were carried out using the Universal Testing Machine Zwick type BDO-FBO0.5®, just as in the studies carried out by Rejak et al. [18]. The film samples were cut longitudinally and transversely to the direction of the film blowing. The results were verified statistically using software – Statistica 6.0.

RESULTS

Tensile strength of films cut transversely decreased with the increasing of the screw speed (Figure 3). In the case of samples cut longitudinally, the applied screw rotation speed had a small effect on the value of the characteristic. Greater differences were observed in the samples which were cut longitudinally.

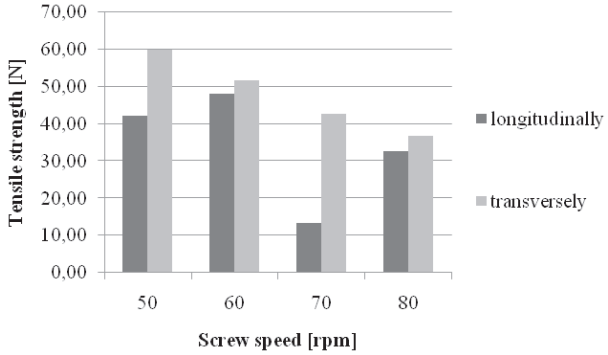

Fig. 3. Tensile strength of the film samples with PLA produced at different screw rotation

The results of measurements on the film elongation susceptibility presented in Fig. 4 showed bad mechanical properties of the obtained products. The statistical analysis showed no correlation between the used screw rotations and the value of the elongation at tensile strength. Destructive tests have confirmed these findings (Figure 5).

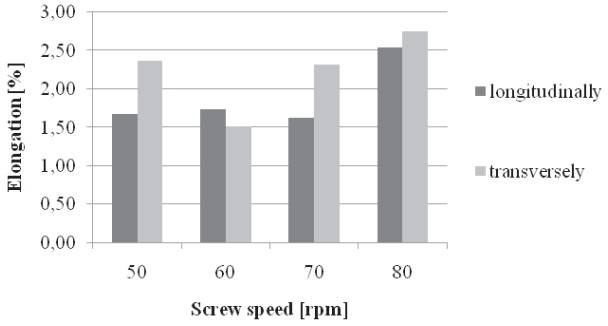

Fig. 4. Elongation at tensile strength of the films samples with PLA produced at different screw rotation

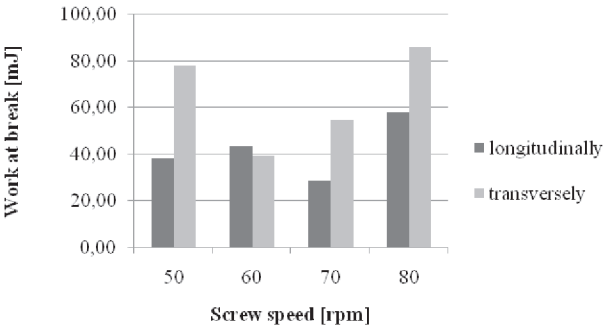

Fig. 5. Work at break of the films in the processed samples with PLA produced at different screw rotation

CONCLUSIONS

The TPS films produced with the addition of PLA were characterized by poor tensile strength, quickly cracked and were brittle. However, the obtained results have confirmed the possibility of thermoplastic starch and polylactide use for the production of biodegradable packaging material. However, it needs additional components such as selective polymers or oligomers in order to achieve a commercially acceptable product. In other words, since the fragility of the obtained film resulted from the properties of PLA pellets, their use would require a variety of other functional additives.

The screw rotation had a slight impact on the measured mechanical properties of the films (except for the measurement of tensile strength).

Further research is needed for proper selection of the bland composition and processing parameters in order to improve the quality of this promising material, to make it more accessible and thus useful for manufacturers of biodegradable packaging.

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WŁAŚCIWOŚCI FIZYCZNE BIOKOMPOZYTU SKROBIOWEGO Z DODATKIEM PLA

Streszczenie. W pracy przedstawiono wyniki pomiarów wybranych właściwości mechanicznych biodegradowalnych folii skrobiowych wytłaczanych ze skrobi termoplastycznej z 20% dodatkiem polilaktydu (PLA). Granulat skrobi termoplastycznej wytworzono na ekstruderze jednoślimakowym o L/D=16. Folie wytłoczono metodą rozdmuchu na wytłaczarce o L/D=36. Badania właściwości mechanicznych przeprowadzono na urządzeniu wytrzymałościowych Zwick typ BDO-FBO0.5TH. Wyprodukowane z dodatkiem PLA folie charakteryzowały się słabą odpornością na rozciąganie, szybko pękały i były kruche.
Słowa kluczowe: PLA, biodegradowalność, ekstruzja, TPS.