



RESEARCH REGARDING OPTIMAL RESISTANCE AT IMPACT OF A BINARY BIOPOLYMER BLEND AND OPTIMAL PLA/PBAT BLENDS PERCENTAGE

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Abstract: Bioplastics (defined either as bio-based or biodegradable), industry and agriculture are closely connected. On one side, renewable resources from agriculture are basic feedstock for bioplastics manufacturing. On the other side, products made from bioplastic materials have many applications in agriculture, in packaging for food industry, in construction and in automotive industry. If bioplastics are biodegradable, the life cycle can be closed by degrading them in industrial or home composters. Two polymers were used, PLA and PBAT. PLA (polylactide) is a bio-based polymer produced by Nature Works, designed for injection moulding applications. PBAT (ecoflex F BX 7011) is an oil-based, biodegradable polymer designed for film extrusion and extrusion coating, produced by BASF. Relationship between blend composition, morphology and impact strength will be given.

Key words: biopolymers, renewable resources, binary blend, mechanical proprieties, resistance at impact

1. INTRODUCTION

Biopolymers represent an area where biodegradability would be a tremendous asset to a variety of casings elements, insulation and packaging products. Starch, it's a key component of these renewable raw materials and is becoming an increasingly important input to activities outside the food industry due to the variety of ways in which it can be modified to find applications in industry.

Biopolymer blending is a convenient and attractive route for obtaining new biopolymeric materials with great proprieties, adapted to different applications. Making a parallel between the developments of a new biopolymer, making blends of currently available biopolymers offers significant savings in time and cost, and the blend properties may be tuned by changing the composition [1, 2]. Therefore, achieving compatibilization of immiscible polymer blends it was a long-standing academic and technological challenge.

In the last period, in despite of the very large number of studies on the compatibilization of binary biopolymer blends, some studies have

considered ternary or multi-component biopolymer blends [4, 5].

2. METHODS

The materials used in this experiment was PLA polymer 3051D (polylactide) produced by Nature Works [7] and PBAT (ecoflex F BX 7011) produced by BASF [8]. The characteristics of PLA 3051D, supplied by Nature Works are shown in Tab.1.

PLA (polylactide) polymer 3051D is designed for injection moulding applications where the requirements are clarity with heat deflection temperatures lower than 55°C.

Table 1

PLA 3051D material proprieties

Property	Property Value	Test Method
Mass Density	1.25	D-792
Melt Index, g/10min (210°C/2.15Kg)	10 to 25	D-1238
Melting Point, °C	200°C	DSC
Relative Viscosity	3.0-3.5	
Tensile Strength, psi (MPa)	48	D638
Elongation, %	2.5	D638
Notched Impact, ft-lb/in	0.3 (0.16)	D256

(J/m)

The variety of products made with PLA continues to grow rapidly. Applications include cutlery, cups, plates, saucers and outdoor parts. The characteristics of PBAT (ecoflex F BX 7011) used, supplied by BASF are shown in table 2.

Table 2

PBAT (ecoflex F BX 7011) material proprieties		
Property	Property Value	Test Method
Mass Density	1.25 to 1.27	D-792
Melt Index, g/10min (190°C/2.16Kg)	2.7 to 4.9	D-1238
Melting Point, °C	110 to 120	DSC
Tensile Strength, psi (MPa)	34	D638
Elongation, %	700	ISO 527
Water Permeation Rate, g/(m ² *d)	140	DIN 53122

Ecoflex F BX 7011 comes closer than any other biodegradable plastic to the processing properties of a classic polymer. A flexible plastic designed for film extrusion and extrusion coating. Blown film extrusion is a particular area where PBAT shows well-balanced processing properties and the resin can be used in extrusion coating applications.

A laboratory internal mixer type Haake Rheomix R600 (figure 1) with mixing chamber volume of 50 cm³ was use to conduct the extrusions. Like we can see in the Fig. 1, this extruder has two contra-rotates rotors and allows to impose a tangential kneading type at a shear rate given. This device can also measure the temperature of the material and the engine torque exerted by the fluid on the rotor blades.

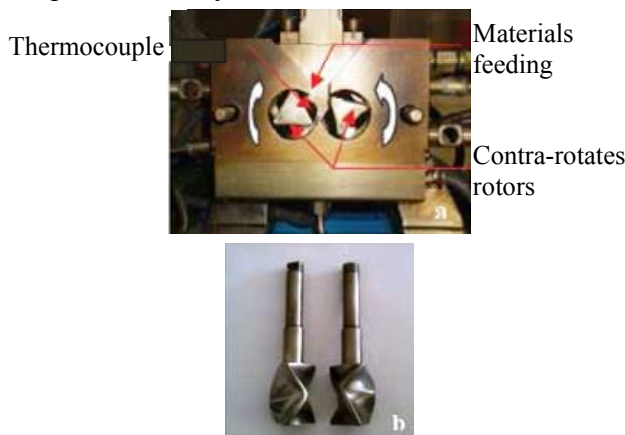


Fig. 1 Internal mixer Haake Rheomix 600 (a) mixing chamber, (b) Contra rotates rotors, profiles.

The chamber of extruder was feed at 80 % from full capacity. The volume ratio PLA/PBAT blends was: 60/40, 70/30, 80/20, 90/10, 95/5, 100/0. Before blending all feeding material was dried in the oven at 80 °C, minimum 4 hours. All blends was mixed 12 min. at 180 °C having a rotors speed of 80 rpm. After blending, the material it was collected in one use bags, crushed in small pieces and formed in bars by compression moulding. The compression moulding process (Fig. 2) was made at 180 °C for all bars.



Fig. 2 Compression moulding machine used to form the test bars.

From each blend it was formed 3÷4 bars. After that each bar was tested separately at resistance at impact. The dimensions of the bars were 80 x 10 x 3 mm. The depth under the notch of the specimen is 8 mm.

3. APPLICATION AND RESULTS

The determined parameter from resistance at impact tests is impact strength that conform ISO is expressed in kJ/m². Impact strength is calculated by dividing impact energy in J by the area under the notch. The machine used for determination of impact strength is CESAT 9050 Impact Pendulum (Fig. 3). This machine is designed for determining the resilience of thermoplastic materials to impact. Tests conform to internationally recognized standards belonging to Charpy, Izod, Pipe and Tensile Impact methods, ranging in energy from 0.5 - 50J.

A graphic interpretation of experimental data is presented in figure 4.

Taking in consideration the obtained experimental data, it's obvious to conclude that the most efficient (from the impact strength

side), volume ratio of the biopolymers blend is 70% PLA / 30% PBAT.

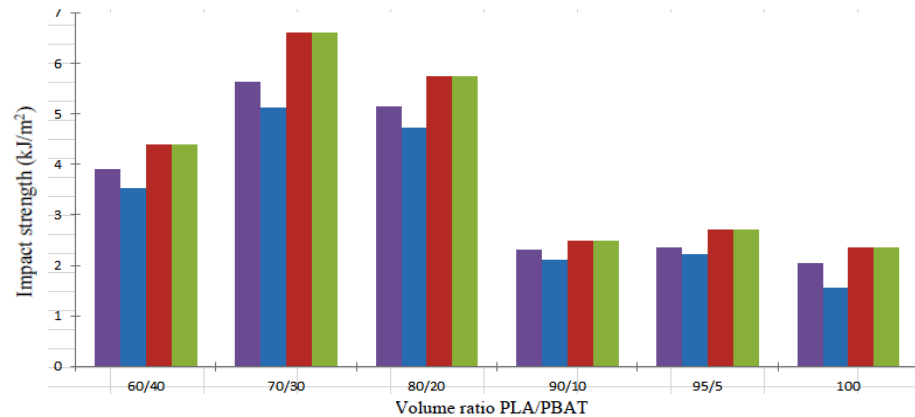


Fig. 4 Graphic representation of impact strength for PLA/PBAT binary blends.



Fig. 3 Resistance at impact testing machine CE SAT 9050.

In parallel it was made a morphology study of the mixed blends. The obtained morphology is presented in the figure 5.

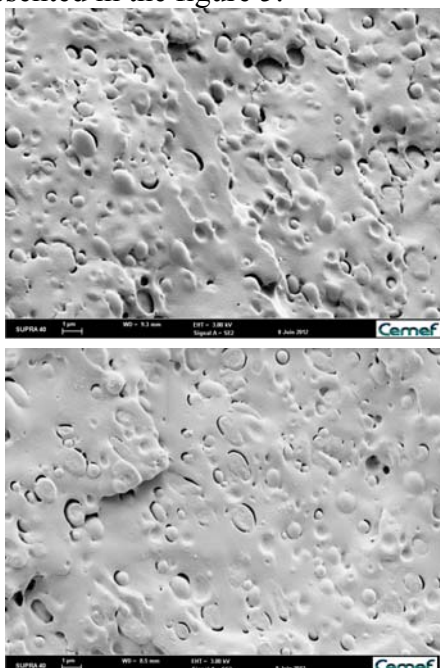


Fig. 5 Photos with obtained morphology for 80% PLA / 20% PBAT.

The samples for microscope observations was prepared by cryo fracture by cooling in liquid azote, after that deposit a thin layer of platinum on the studied surface.

For microscope observation it was used ESEM laboratory equipment ZEISS SUPRA 40 with GEMINI column.

After all this experimental studies we can say that the best volume ratio between PLA/PBAT binary blends is 70/30 for obtaining the best resistance at impact.

The increasing of mechanical proprieties it's limited in case of binary blends having in composition PLA and PBAT.

4. CONCLUSIONS

By combining two biopolymers, we can obtain a biopolymer blend with new properties. By changing the matrix volume ratio in the blend, we can obtain different materials with different mechanical properties, adapted to each application. In the present study, we used two biodegradable polymers.

If the goal is to design a material with good mechanical properties, an option is to use PLA as the matrix and PBAT as the inclusion. This leads to good impact properties. To use, for example, this polymer blend to make foil would require to increase the volume ratio of the PBAT in the blend.

In general, to increase mechanical properties will require adding compatibilizing agents or a third component, or both.

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Cercetări privitoare la rezistența optimă la impact a unui amestec binar de biopolimeri și procentajul optim de PLA/PBAT din amestec

Rezumat : Masele plastice biodegradabile (definite fie ca biodegradabile), industria și agricultura sunt strâns legate. Pe de o parte, resursele regenerabile din agricultură sunt o materie primă de bază pentru fabricarea maselor plastice biodegradabile. Pe de altă parte, produsele fabricate din materiale bioplastice au multe aplicații în agricultură, în industria ambalajelor (pentru industria alimentară), în construcții și în industria auto. În cazul în care materialele plastice biodegradabile sunt regenerabile, ciclul de viață poate fi închis prin degradare în condiții naturale de mediu. Scopul lucrării a fost de a explora relația dintre compoziția unui amestec binar biopolimeric și proprietățile sale mecanice. Doi polimeri au fost utilizați, PLA și PBAT (polilactidă). PLA este un polimer pe bază de bio-produs fabricat de Natura Works, dezvoltat pentru aplicații de injecție sau turnare. PBAT (ECOFLEX F BX 7011) este un polimer biodegradabil conceput pentru procese de extrudare și formare a foliilor pentru ambalare, produs de BASF. În această lucrare s-a analizat relația dintre compoziția amestecului, morfologia obținută și rezistența la impact a monstrelor de material obținute.

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