

Waste Recycling in Biaxially Oriented Polypropylene - BOPP

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Abstract: Over time the production of the packaging has grown, incorporating new functions. One of the most found types of packaging in supermarkets is those of Biaxially Oriented Polypropylene (BOPP). This project aims at the recycling and characterization of wastes in Biaxially Oriented Polypropylene, for its recycling. The search seeks to select a problem with a practical goal. The question raised concerns the possibility of characterization and recycling of waste. Through the collection of BOPP packaging, the evaluation of the potentiality of recycling the waste was idealized, establishing a form of the polymer mixture, to obtain a homogeneous mass. They were specifically intended to evaluate the different formulations through essays, to define the best composition, by compounding their properties and checking their possible applications. The theoretical reference focused on the studies on the packaging and the BOPP. The process of metalization of the packaging consists of the combination of a thin layer of aluminium to the plastic film using steam. The methodology consisted of the collection of the material, its separation, and cleanliness. The mixture was made from BOPP and polypropylene (PP) recycled. Formulations made to define the best composition of the material content passed in the extruder. As a result, the combination of the two waste was not possible, because the granulation of the BOPP was not adequate compared to the PP. For the project to be appropriate, it would be necessary to use a binder machine to reduce the volume of BOPP waste.

Keywords: Biaxially Oriented Polypropylene (BOPP), Packaging, Recycled Polypropylene.

I. INTRODUCTION

In times of globalization, there is a clear perception of the need to recycle. The consumption of packaging used by the population has gained more space for recycling, generating new alternatives for its disposal in industries [1]. Even if the products are becoming recyclable, it does not mean that the cooperatives and that the companies that sell their products as recyclable, do so, execute this idea [2].

In Brazil, a large part of the waste consists of packaging. There are 25 thousand tons of this waste, which end up in garbage dumps [3]. Packaging, when consumed exaggeratedly and disposed of regularly or irregularly - instead of being sent for recycling - contributes to the depletion of landfills and dumps, making it difficult for the degradation of other residues and other types of environmental impacts not so seen by consumers. Some materials have difficulties in recycling, making companies not interested in it, and also the investment that they would have to have to carry out the recycling of it [4-5]. Because of this, it's very hard the recycling bioriented polypropylene BOPP plastic used in the manufacture of flexible and light packaging [6].

Polyolefins are being increasingly used for industrial purposes, due to their valuable properties and ability to be recycled [7]. Biaxial-oriented polypropylene (BOPP) film in recent years has become one of the most popular, high growth films in the world market. BOPP film is available in a wide range of film variations targeting the packaging, pressure sensitive tape, label, stationery, metallizing and decorative markets [7-8].

The problem that motivated the elaboration of the study was the large amount of waste, which occurs in post-consumption and improperly disposition. Through characterization, the possibility of recycling occurs. The main objective of the project is to evaluate the potential of recycling BOPP residues used in packaging.

Still, for that, some specific goals will have to be achieved, such as: obtaining a large amount of sample, creating specimens from BOPP residues, and PP to rehearse them, evaluate different formulations of a mixture of residues, evaluate the characteristics and verify possible applications.

II. BIBLIOGRAPHICAL REVIEW

One of the most common types of packaging found in supermarkets is that of BOPP. The packaging metallization process consists of the combination of a skinny layer of metal (aluminum) in the plastic film utilizing aluminum vapor. Thus, the film becomes mirrored with an excellent visual aspect [9]. The BOPP film offers a barrier to oxygen and moisture used as monolayer or multilayer adding value, due to the restriction that provides an adequate packaging of the product [9-10].

Table 1 - Properties of BOPP Biaxially Oriented Polypropylene.

Properties	Methodology	Unity	TMS L82	25 TMS L82
Nominal thickness	DIN 53370	µm	20.0	25
Grammage	ASTM D 4321	g/m ²	18.1	22.6
Yield	ASTM D 4321	m ² /kg	55.2	44.2
Tensile strength	ASTM D882	N/mm ²	140.0 240.0	140.0 240.0
Stretching	ASTM D882	%	180.0 60.0	180.0 60.0
Shrinkage	ASTM D1204	%	3.0 1.0	3.0 1.0
Sealing range	ASTM F 88	°C	82-130	82-130
Coefficient of friction	ASTM D 1894	-	0.35	0.35
TPVA	ASTM F 1249	gH ₂ O/(m ² .day)	≤ 0,5	≤ 0,5
TPO2	ASTM D 3985	cm ³ O ₂ /(m ² .day)	≤ 100	≤ 80
Sealing force	ASTM F 88	g/in	400.0	430.0

III. MATERIALS AND METHODS

The collection of post-consumer BOPP waste occurs at the Univalle cooperative, located in Novo Hamburgo in Brazil. Through sorting, only metallic BOPP packages selected, which were being deposited in a barrel as the conveyor moved and this collection took place, we carried out the group, together with the cooperative employees and with the necessary PPE's. The collection also took place at Escola Planalto Canoense, in the city of Canoas in Brazil, collected by students from the 3rd and 4th grades of elementary school, the purpose of compiling in schools is to raise the awareness of children and students. These separate supplies placed in bags for storage, presented in Figure 1.



Figure 1 - Image of sorted packages.

The collection of a sample of recycled PP occurred by a company located in the city of Esteio. The washing of the residues happened where each package was washed separately, for more precise cleaning. BOPP materials have gone through the process of reducing their volume, as this package has an enormous amount and little mass, and serves to facilitate its passage in the tests, needing to pass through this step.

Occurrence three types of tests to obtain their reduction: knife mill, the process by shear, and by a blender. The knife mill used to perform the grinding of the samples and the packages placed in the machine's feeder, which then went on to the cutting stage.

Another way to obtain the reduction and facilitate in future tests was the scissors process, where standard scissors used for the operation of chopping the material. The packages cut to shape into small squares manually.

We use a domestic blender to crush the material. The packages weighed on a standard scale. Samples of BOPP and recycled PP. The amount of BOPP is 1.379 kg, and recycled PP is 1.5 kg.

Table 2 - Sample composition.

Samples	BOPP	PP
Sample 1	25%	75%
Sample 2	50%	50%
Sample 3	75%	25%

To mix the materials, BOPP and PP, we use an extruder. The machine operation occurs with a preheated around 100 ° C. The formulations pass through a thread that is transported inside a cylinder heated by electrical resistance. Part of this heat provided friction of the material itself with the cylinder walls. It passes through three zones, namely feeding, compression, and dosing. At the end of the cylinder, the mixture of materials comes out in the form of wires, these wires cut by a chipper connected to the machine itself, taking the form of pellets.

The machine has nine gears that emit heat to the extruded material. The temperature of 160 - 165 ° C was used, which is where it enters its melting state and melts the plastic. For the content to pass through the thread, it must be in a suitable granulation, these being pellets or almost powder. Another method used for mixing the waste was the press. We put the mixture in a square press mold, specific for sheet formation, with a temperature around 160 ° C and a closing force of approximately 60 kN.

To decrease the volume of the BOPP residues occurs milling with the knife mill. The high volume and low mass prevented the expected result, where the wastes were not ground and were only oscillating, rotating along with the knives. This process caused the packages to decrease in size gradually; however, it is a very long process, requiring a lot of time to execute, as many boxes as possible cut to carry out the tests.



Figure 2 - Particulate reduction and formation.

The last method we used to decrease the volume was by the blender. In this process, the chopped packages not crushed as expected. They were only oscillating in the blender, and thus, we did not obtain an adequate granulometry for carrying out the other processes.

In the extrusion process, the materials placed in the funnel, took a long time to descend to the feeding zone, because the residues were not in the correct granulometry and caused them to oscillate before falling through the thread and reaching these areas, which cause the melting of the material. The mixtures placed have different proportions to their volumes and consequently, the masses, making it impossible to create a homogeneous mixture of the BOPP and polypropylene.



Figure 3 – Reduction of BOPP residue. a) Thread of the funnel in the extruder; b) Result of the mixture of metallized BOPP and polypropylene in the press.

IV. CONCLUSION

This paper presents a study that consists of recycling BOPP waste. Many of the packages are recyclable, but this recycling does not take place, as companies are not interested in these residues, which in turn end up in landfills. The quantity is so high that it causes depletion, making it difficult for other wastes to decompose, and that, when they do not end up in inappropriate places, such as in the oceans.

To perform the analyzes, it is necessary to use means that are efficient to make the packages turn to dust. The ideal is agglutinate that causes the waste to decrease its volume and become more massive. To making ground in the knife mill possible and then proceeding with other processes such as extrusion, specimen preparation, and, for example, finally, the tests for the characterization, making the packaging recyclable, creating new material for the elaboration of new products.

There were also difficulties in collecting the BOPP, as it is a high volume of waste and requires a significant amount because it is a very light material.

As a result it was observed that the Union of the two waste was not possible, because the granulation of the BOPP was not adequate compared to the PP. In order for the project to be adequate, it would be necessary to use a binder machine in order to reduce the volume of BOPP waste.

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