USE OF NATURAL FIBERS FOR ENHANCING POLYMERIC MATERIALS

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ABSTRACT: In the framework of the AGROinLOG European Project (Grant Agreement No 727961) from Horizon 2020, the potential to produce biomaterials with the fodder surplus during the agroindustry idle periods has been studied. Different value-added bio-composites based on a matrix of polypropylene and reinforced with natural fibers from wheat and corn straw were produced. Natural fiber percentages of 10%, 15%, 20% and 30% wt have been tested by means extrusion compounding and injection obtaining the optimal process conditions and rheological and mechanical behavior as results. As final stage of the study a preliminary economical evaluation for the production of plastic composites reinforced with natural fibers from the agroindustry point of view were carried out.
Keywords: natural fibers, wheat, corn, straw, bio-composites, polypropylene

1 INTRODUCTION

Over the last few decades biofiber composites have been undergoing a remarkable transformation becoming more sufficient as new compositions. Also new production processes have been intensively researched, developed and consequently applied. In this context, biopolymers are constantly under competitive pressure from the global market, which in turn, necessitates continuous research. The concept of using bio-based plastics as reinforced matrices for bio-composites is gaining more and more approval day by day. Natural fibers are getting attention from researchers and academician to utilize in polymer composites due to their ecofriendly nature (in many cases coming from vegetable sources) and sustainability. There is a growing trend to use biofibers as fillers and/or reinforcement in plastic composites motivated by the application of the European Regulations and for the presence of some advantages with respect to fossil fibers as a higher flexibility during processing, highly specific stiffness, and low cost. These parameters make them attractive to manufacturers. Different physical and chemical fiber treatments are proposed to achieve this goal and between them treatments based on physical transformations seems to be one of the most relevant and suitable due to their low cost and ability to be implement it.

The extrusion-compounding and injection treatments included in this work were aimed to change structural surface, enhancing the interface via an increased mechanical bonding between the natural fiber and the matrix. Using natural fibers within polypropylene polymeric matrix as reinforcement material allows the production of materials with improved features such as low density, less expensive and reduced solidity when compared to synthetic composite products. Based on that point, advantages for utilization in commercial applications (automotive industry, buildings, and constructions) could be considered. In this work mainly the degree of transformation of the natural fibers at different temperatures have been studied, showing interesting differences in the features and behavior of the bio-composites generated, both concerning final application of the products.

2 EXPERIMENTAL METHODOLOGY

2.1 Test specimen preparation

The material used in the process is a PP copolymer (MOPLEN EP540P) from LYONDELLBASELL. The natural fibers consisted of corn stalk (fC) and wheat straw (fW) in the form of pellets. These pellets were milled in order to adequate the material for further processing, obtaining a mixture of different granulometry.

Before its subsequent processing, the natural fibers were dried in air oven at 60ºC for 12 hours to eliminate the moisture. The polymer mixtures with different fibers loads were processed in a Coperion ZS26K semi-industrial equipped with three gravimetric feeders.

Figure 1: Wheat and corn milled and ready for compounding (left). Detailed of extruded material reinforced with fibers (right)

Table I: Summary of prepared materials

Material	% NF	% PP	Amount kg
F(X).10	10	90	3
F(X).15	15	85	3
F(X).20	20	80	3
F(X).30	30	70	2

(X) being stalk or wheat straw (W)

The material was dried for 12 hours at 60ºC in air oven in perforated bags. Before the injection process, the material is dried for 4 hours in dehumidifiers at 65ºC.

To study the properties effect of the material at different additives percentages, both bending and tensile test specimens (Fig 2 and Fig 3) were injected according to UNE179 and UNE527 standards. A total of 20 tensile and 20 flexion specimens were injected for each one of the additives and percentage.

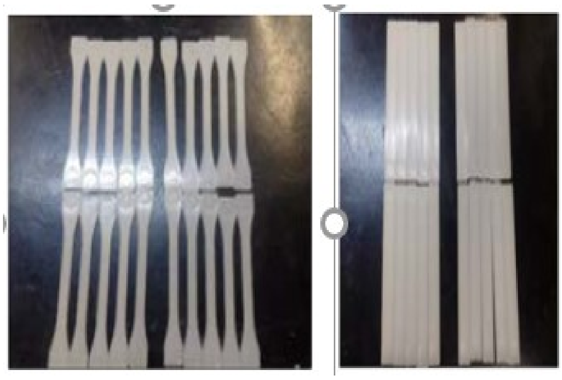

Figure 2: Tensile (left) and Bending (right) specimens of virgin PP.

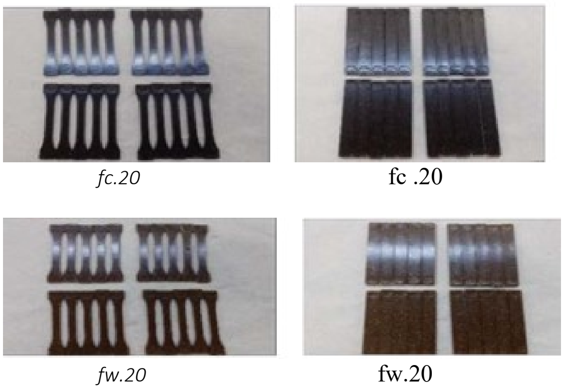

Figure 3. Tensile (left) and Bending (right) specimens of PP reinforced with corn (fc) and wheat fibers (fw)

2.2 Test specimen characterization

In order to measure the shear viscosity and resistance to flow, rheological tests were performed in the working temperature range of material at 190-200ºC. In addition, a complete mechanical characterization of the materials by means of tensile tests and three-point bending tests were carried out in order to study the deformation behavior and evaluate the strength and elongation at fracture respectively. The parameters studied were the flexural module (Ef), bending strengt (rf), flexural strain (ε), Young´s module (Et), tensile strength (rt), yield strength (εt) and elongation (εtb).

3 RESULTS

3.1 Rheology and mechanical characterization

A minimum loss of viscosity effect for the corn-based samples due to the fiber degradation process was reported.

The bending test demonstrates the relationship between the load of a bending beam and its elastic deformation.

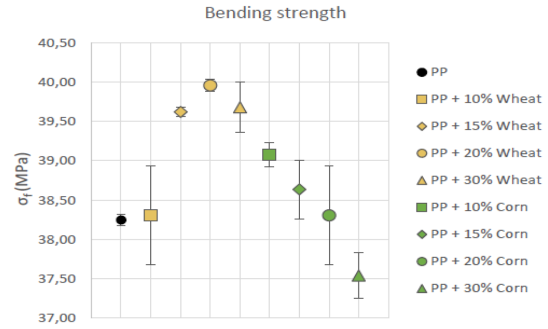

Figure 4. Bending strength (rf).

The bending strength applied (r_f) in the bending test shows different behaviours between both biomasses. Whereas wheat fiber presents a maximum strength value for 20 wt. % wheat fiber load (wheat saturation point), corn shows a steady decrease of maximum strength values with natural fiber content, being the sample saturated at 10 wt. % fiber content. Additionally, corn *samples show lower maximum strength values for all* samples between 15 to 30 wt. % in comparison with wheat samples, except for 10 wt. %, where corn fibers show higher maximum strength than wheat fibers.

The tensile test determines the tensile strength and elongation at fracture.

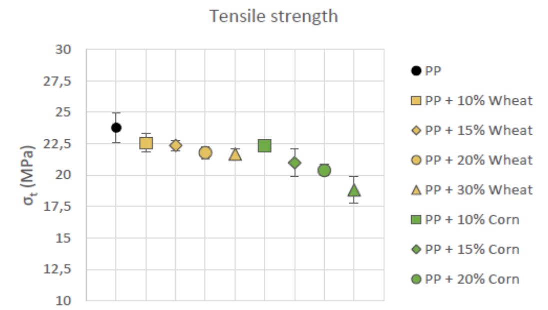

Figure 5. Yield strain (r_t).

Although the yield strength (rt) applied to each of the materials shows a decreasing trend with fiber load, the differences are not significant (varying from 18.8 to 23.78 MPa) and no relationship between tensile strength (rt) and fiber presence can be established.

4 CONCLUSIONS

The production of improved plastic composites as alternative to conventional fossil production have been assessed.

From the rheology characterization, it was determined that these materials are easily processable with an effective compounding but suffer degradation when they are exposed to high temperatures for a long period of time, mainly in the injection process. It can lead to changes in its composition and in their final properties. This effect is more noticeable in the case of corn, showing the samples a dark colour.

Bending mechanical test showed that the wheat-based materials were able to support more strength then the materials with corn, while in the tensile mechanical tests no significant differences were observed between the two types of natural fibers.

Polypropylene with 20 wt. % wheat fiber was considered the most suitable material, given its good rheological and mechanical properties at this level of fiber absorbed. Difficulties were observed at 30 wt. % load due to processability.

Automotive sector was selected as the most promising application based on a market study of applications for composites reinforced with natural fibers. It was based on the weight savings (30%) and cycles times of these materials that can lead to a cost reduction of 20% [3].

5 REFERENCES

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7 PARTNER´S LOGOS