Coventry University and
The University of Wisconsin Milwaukee Centre for By-products Utilization,
Second International Conference on Sustainable Construction Materials and Technologies
June 28 - June 30, 2010, Università Politecnica delle Marche, Ancona, Italy.
Special Technical Proceedings ed. P Claisse, E Ganjian, F Canpolat and T Naik
ISBN 978-1-4507-1488-4 http://www.claisse.info/Proceedings.htm

Characterization Methods of Composites Based on Polypropylene Reinforced with Biodegradable Fibers

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ABSTRACT

The paper presents, some experimental results obtained with different types and amounts of reinforcement in composite materials based on polypropylene matrix for automotive applications. Were been characterized fourteen experimental samples. The reinforcing agents utilized were: particulate reinforcement (organic and biodegradable – powder wood and inorganic and non-biodegradable – talc powder) and fibrous reinforcement (organic biodegradable-short flax fibers).

INTRODUCTION

Synthetic polymers, manufactured to be resistant at different environmental factors (light, oxygen, humidity, heat, microbial factors), became an important problem due their accumulation in the environment, after the end of the life time. The new challenges regarding the preservation in good conditions of the environment have imposed some new approaches in the field of biodegradable materials.

Composite materials used in automotive industry have seen lately rapidly evolving, due the need of adapting to regulations in the field of conservation and protecting the environment. Thus, must be developed those kinds of materials giving both excellent qualities for specific domain applications and high degree of biodegradability

For these kinds of materials, are followed characteristics like: low weight, easy handling and soundproofing, thermal insulation, resistance to vibration, cheaper manufacturing, lower energy consumption and recyclables

Currently, recycling of such composite material is made by conventional mechanical or chemical methods, which require additional energy consumption and emit noxious gases and pollutants. The materials which are the subject of this paper present a higher degree of degradability, under the influence of some micromycetes

EXPERIMENTAL

The main goal of the experiments was to determine the behavior of different samples of composite material, with a higher degree of biodegradability, for applications in automotive industry.

Thus, were been characterized fourteen experimental samples based on on polypropylene (PP) with different percents of reinforcing agents and noted from M_1 to M_{14}. Sample M_2 represents the original PP.

The reinforcing agents were added in mass percentage ranging between 10% and 30%/PP, using one, two or even three types of agents for each combination.
The composition of the samples is made in the Table 1 below:

Table 1. Chemical composition of the composite materials

Symbol	Composition
M1	Powder wood
M2	Original PP
M3	PP+10% powder wood pigmented
M4	PP+20% powder wood
M5	PP+30% powder wood
M6	PP+10% powder wood non pigmented
M7	PP+20% powder wood +5% short flaxes
M8	PP+20% powder wood +10% short flaxes
M9	PP+25% powder wood +5% short flaxes
M10	PP+30% glass fiber
M11	PP+30% glass fiber pigmented
M12	PP fireproofed +5% short flaxes pigmented
M13	PP fireproofed
M14	PP + 30 % talc powder

The characterization methods used were:

- Structural analysis by X Ray Diffraction
- Optical microscopy
- Tensile strenght
- Micro hardness
- Determination of life time through thermal analysis coupled techniques

RESULTS AND DISCUSSIONS

The X Ray diffraction analysis gave information regarding the crystallization system on presented crystalline phases.
The difractogrames show that:

- The peak intensities are different due the texture of the materials.
- The main component is sindiotactic polypropylene.

- Except sample M_{14} which crystallizes in triclinic system, all the studied materials present orthorhombic crystalline structure.
- Between composite materials reinforced with powder wood and short flaxes, the largest crystalline zones are observed in the case of sample M_8 , with higher amount of short flaxes

The results are presented in the Figure 1 below:

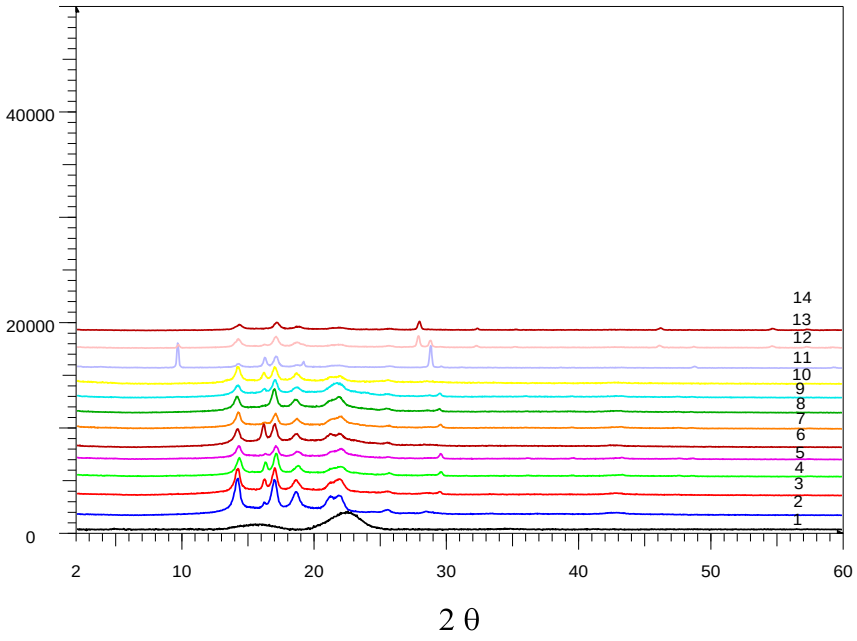

Figure1. X Ray difractogrames of the samples

Optical microscopy was used in order to put in evidence the morphology of the samples surface. The investigations have shown that in the case of composites with two reinforcing materials (like samples M_7, M_8 and M_9) it is observed a inhomogeneous structure, do the agglomeration of powder wood and short flaxes caused by them electrostatic charging.

In the case of ignifugated composite (M_{12}), it can observe a good homogenity and longer fibers, like is shown in the Figure 2 below:

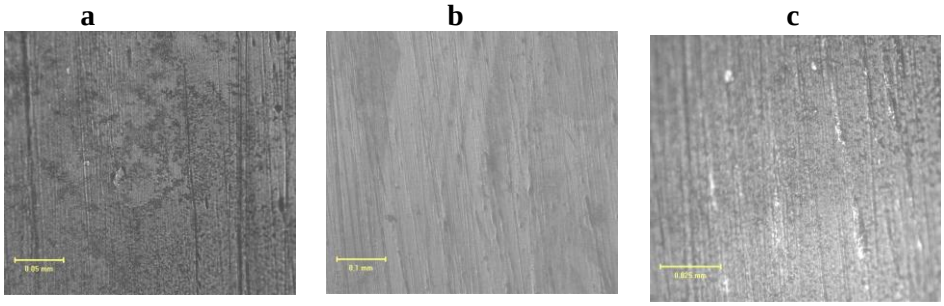

Figure 2. Optical images of structure for sample M_{12} at different magnifications a) 20x, b) 10 x, c) 50x

Another two additional samples were been prepared, using PP like matrix and short flaxes + some elastomer, in different mass percents. The new samples, noted M_{15} and M_{16} appeared due technological requests regarding the machinability of the material.

For samples no. M_2, M_4, M_5, M_6, M_8, M_9, M_{10}, M_{12}, M_{13}, M_{14}, M_{15} and M16 was measured the breaking strength by three points bending methods. The obtained values are presented in the Table 2, below:

Table 2.Values for breaking strength

Sample no.	Average of breaking strength (N/mm^2)
M_2	446
M_4	385
M_5	316
M_6	307
M_8	314
M_9	358
M_{10}	456
M_{12}	296
M_{13}	377
M_{14}	356
M_{15}	319
M_{16}	313

Additionally, for the samples M_2, M_4, M_5, M_8, M_9 and M_{10} was measured the Vickers micro hardness values. The results are presented in the Figure 3, below:

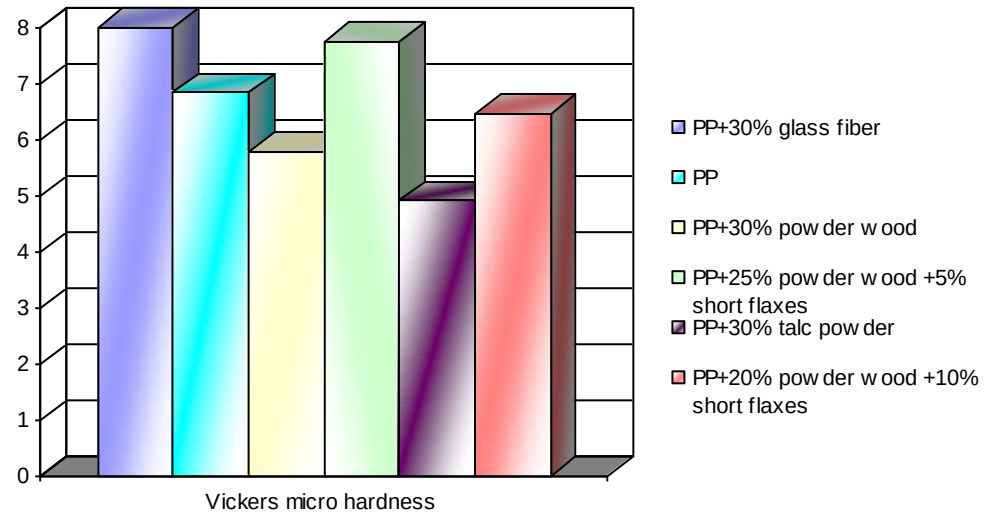

Figure 3.Distribution of Vickers micro hardness

It can observe that the highest value is obtained for composite material based on PP reinforced with glass fiber, due the great hardness of the reinforcement. Addition of talc powder allows lowering values with around 29%, while addition of powder wood allows lowering values of micro harness with around 25%. The value of micro hardness for sample based on PP with powder wood and short flaxes is greater than a single reinforcement agent. The best values are obtained when is used a mix of 25% powder wood and 5% short flaxes in PP matrix, due the structure of wood fiber structure.

Even that the values of mechanical properties are lower when use as reinforcement material biodegradable materials (wood powder, short flaxes), the special applications for interior design in automotive industry are indicated

Determination of life time through thermal analysis coupled techniques (dynamic differential calorimetry+ thermogravimetry analysis) was performed for all the samples.

In the Figure 4 below is presented, for exemplification, the experimental curve for sample M_{12}, which was identified like optimal composition for our specific application.

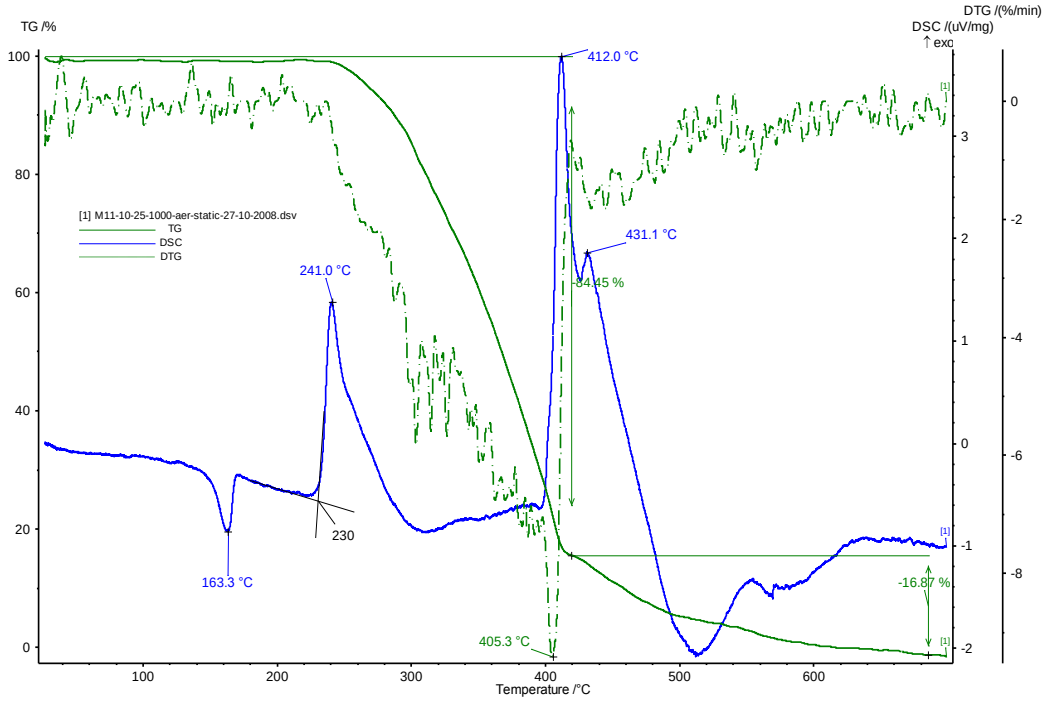

Figure 4.The thermal behavior of the composite material based on PP fireproofed + 5% short flaxes (M_{12})

For the investigated samples, the thermal stability decreases in the order: M_2, M_6, M_{12}≈M_{10}≈M_{13}≈M_5≈ M_3, M_2, $M_{8,}$ M_9, and M_7

CONCLUSIONS

The following general conclusions can be drawn from the study provided in the paper:

- The composite materials which were been characterized, present slight inferior mechanical properties than the composite reinforced with glass fibbers, but additional important characteristics as biodegradability and lightness are induced. These two properties are induced by the utilization of the natural reinforcement agents.
- The best results were obtained for the composite material based on polypropylene (mixed with a small percent of elastomer) reinforced with short flaxes fibers (sample M_{12})
- The methods used in order to study the behavior of the materials studied, are appropriate and according to international standards in the field
- The results of the present research indicate the reliable possibility to use composite materials reinforced with powder wood and flax fibbers (with properties closed to the polypropylene reinforced with glass fibbers) as structural materials in automotive industry
- The composite material based on polypropylene mixed with elastomer and reinforced with flaxes fibers seems to be a good, real and ecological alternative to the classic materials (reinforced with glass fibers) in the local automotive industrial production, especially for manufacture of indoor fittings out, where are not necessary very high values of mechanical properties.

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