New Composites Based on Polypropylene Reinforced with Biodegradable Fibres for Automotive Applications

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The paper presents, some experimental results obtained with different types and amounts of reinforcement in composite materials based on polypropylene matrix for automotive applications. There were 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).

Key words: composite, polypropylene, flax fibers

Synthetic polymers, manufactured to be resistant at different environmental factors (light, oxygen, humidity, heat, microbial factors), became an important problem due to 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 evolved lately rapidly, due to 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 [1].

For these kinds of materials, are required characteristics like: low weight, easy handling and soundproofing, thermal insulation, resistance to vibration, cheaper manufacturing, lower energy consumption and recyclables [2].

Currently, recycling of such composite materials is made by conventional mechanical or chemical methods, which require additional energy consumption and release harmful gases and pollutants. The materials which are the subject of this paper present a higher degree of degradability, under the influence of some micromycetes [3-5].

Experimental part

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

Thus, have been characterized fourteen experimental samples based on polypropylene (PP) with different percentages 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.

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

Table 1
CODING OF COMPOSITE MATERIALS BY THEIR CHEMICAL COMPOSITION

Symbol	Composition
M_1	Wood powder
M_2	Original PP
M_3	PP+10% wood powder pigmented
M_4	PP+20% wood powder pigmented
M_5	PP+30% wood powder pigmented
M_6	PP+10% wood powder non pigmented
M_7	PP+20% wood powder +5% short flaxes
M_8	PP+20% wood powder +10% short flaxes
M_9	PP+25% wood powder +5% short flaxes
M_{10}	PP+30% glass fiber
M_{11}	PP+30% glass fiber pigmented
M_{12}	PP fireproofed +5% short flaxes pigmented
M_{13}	PP fireproofed
M_{14}	PP + 30 % talc powder

Results and discussions

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

The diffractograms show that:

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

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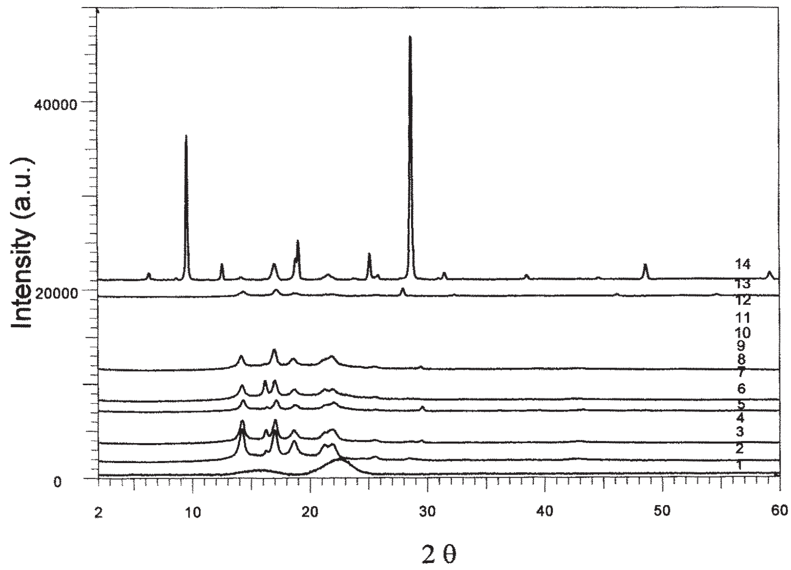

Fig. 1. X Ray diffractograms of the samples

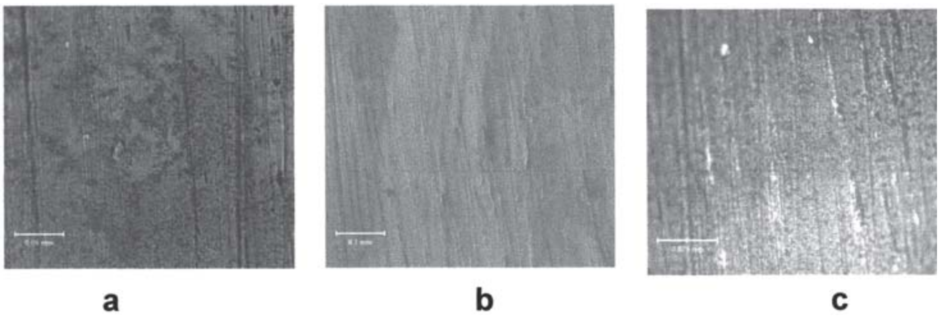

Fig. 2. Optical images of structure for sample M_{12} at different magnifications a) 20x, b) 10 x, c) 50x

-excepting 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. In this figure is shown the intensity variation of incidence angle.

Optical microscopy was used in order to put into 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 an inhomogeneous structure, do to the agglomeration of wood powder and short flaxes caused by their electrostatic charging.

In the case of ignifugated composite (M_{12}), it can be observed a good homogenity and longer fibers, as in the figure 2.

Another two additional samples had been prepared, using PP like matrix, short flaxes and some elastomer, in different mass ratios. 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 M_{16} was measured the bending strength at break by three points bending methods. The obtained values are presented in the table 2. When using reinforced glass fiber bending strength at break increases 10 units, but for others materials there is a decrease. If we consider the fiber reinforced composite materials it can be made the following classification: M_{10}> M_{12}>M_8> M_{11}>M_9>M_7. Hence it was found that the best materials with reinforced glass fiber are PP fireproof 5% flax fibers.

Additionally, for the samples M_2 M_4 M_5 M_8 M_9 and M_{10} there were measured the Vickers micro hardness values. The results are presented in the figure 3.

Table 2
VALUES FOR BENDING STRENGTH AT BREAK

Sample no.	Average of breaking strength (N/mm^2)
M_2	446
M_3	385
M_4	307
M_5	316
M_6	296
M_7	299
M_8	358
M_9	314
M_{10}	456
M_{11}	339
M_{12}	362
M_{13}	409

It might be noticed 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 wood powder allows lowering values of micro hardness with around 25%. The value of micro hardness for sample based on PP with wood powder and short flaxes is higher than a single reinforcement agent. The best values are obtained when a mix of 25% powder wood and 5% short flaxes in PP matrix is used, due the structure of wood fiber structure.

Even if the values of mechanical properties are lower when they are used as reinforcement for biodegradable composite 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.

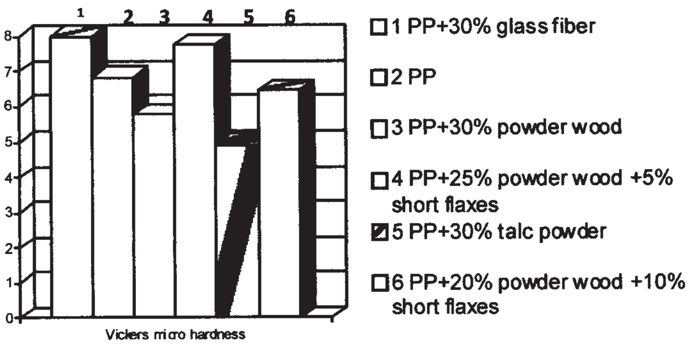

Fig. 3. Distribution of Vickers micro hardness

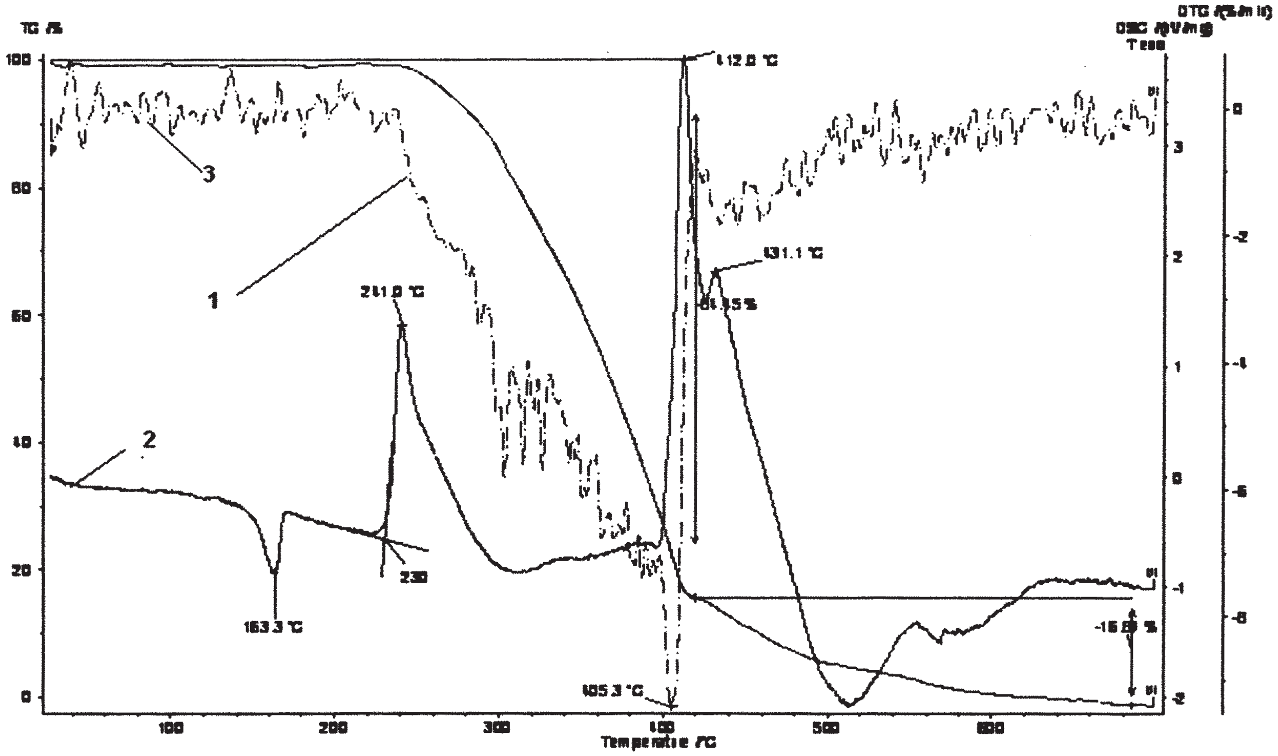

Fig. 4. The thermal behaviour of the composite materials based on PP fireproofed + 5% short flaxes (M_{12})

In the figure 4 below is presented, for exemplification, the experimental curve for sample M_{12}, which was identified as optimal composition for our specific application. This graph presented variation curves TG, DTG and DSC according to temperature variation for M_{12} composite material.

For the investigated samples, the thermal stability decreases in the order: M_2, M_6, $M_{12} \approx M_{10} \approx M_{13} \approx M_5 \approx M_3$, M_2, M_8, M_9, and M_7.

Conclusions

The composite materials which had been characterized, present slight inferior mechanical properties than the composite reinforced with glass fibers, 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 percentage of elastomer) reinforced with short flaxes (sample M_{12}).

The methods used in order to study the behavior of the materials 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 wood powder and flax fibers (with properties close to the polypropylene reinforced with glass fibers) 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.

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