The Incorporation of the Light Green Clay in the Textile Polyamide Residues

M. N. Sartori, D. P. Castro, F. R. Valenzuela-Diaz, and L. G. A. Silva

Abstract The aim of this work is to evaluate the possibility to use textile residues of polyamide with elastane that are discarded by the industry as a matrix of a new polymer-clay composite material, evaluated on a manometric scale, and to propose a way of recycling for these materials. At the same time, with nanocomposite technology, value is added to this material. In this work, polyamide of textile residues from industry was used. These materials were first processed in a compacter machine. Composites at 1, 2, and 3% by weight of Light Green clay/polyamide were prepared by double screw extrusion. The properties of the composite were characterized by X-ray diffraction (XRD), tensile, flexural, impact tests, and thermogravimetric analysis (TGA). Results obtained were compared with the neat textile polyamide properties. It was concluded that it is feasible to recycle the textile residues of polyamide, and that the addition of clay, at the doses studied in this work, could lead to the obtaining of composite materials with better mechanical than untreated ones.

Keywords Recycling · Textile residues · Polyamide · Clay

Introduction

In Brazil, the textile, industry is relevant to the generation of wealth and jobs. This manufacturing activity consolidated strongly, making the country a major world producer of textile, the 5th largest producer in the world, with an approximate production of 1.8 million tons of made-up articles [1, 2].

M. N. Sartori (✉) · D. P. Castro · L. G. A. Silva
Nuclear and Energy Research Institute, IPEN, CNEN/SP, Av. Prof. Lineu Prestes, 2242, São Paulo, SP 05508-000, Brazil
e-mail: marianasartori@usp.br

F. R. Valenzuela-Diaz
Dep. de Eng. Metalúrgica E de Materiais, Universidade de São Paulo, Escola Politécnica, Av. Prof. Mello de Moraes, 2463, São Paulo, SP 05508-030, Brazil

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With such a large manufacturing activity, the generation of waste is unavoidable, around 175 thousand tons of textile shavings per year coming only from cuts in the mold of clothing in Brazil [3].

The study of polymer waste is a current and important theme, considering its increasing presence in solid urban waste and being recyclable materials with high potential for reuse.

Polyamides have been on the market for nearly 80 years. Fibers made of PA6 and PA 6.6 were the first commercialized polyamide products. Until to-day, these two polyamides have played a dominant role in the production and on the Market [4, 5].

These two types of polyamides belonging to the group of polymer thermoplastic fibers have a very wide spectrum of applications, especially in the field of thermal underwear and hosiery products, in which, plain stitch knitwear plays a predominant role and are produced in the form of filaments and staple fibers. Polyamide fibers show very good mechanical properties, and the high abrasion resistance is the most valuable feature of these fibers [6, 7].

Polymer–clay nanocomposites, have attracted much attention from both industry and academia over the past decade because they frequently exhibit unexpected properties. In contrast to the traditional fillers, nanofillers, in particular, nanoclay is found to be effective. The addition of a small amount (< 5 wt%) can show significant improvement in mechanical, thermal and barrier properties, flammability resistance, and electrical/electronic properties of the final polymer nanocomposite without requiring special processing techniques [8, 9].

Experimental

Materials

The materials used in this work were the polyamide textile residues from postindustrial supplied by NZ Cooperpolymer Thermoplastic Engineering and Brazilian bentonite Light Green clay from Boa Vista−PB. This clay did not undergo any purification process and was only strained ($D = 0.074$ mm) to exclude larger particles.

Methodology

Firstly, the polyamide textile residues were processed in a compacting machine for volume reduction. Before the extrusion process, the polyamide compacts and Light Green clay were kept in an oven for 4 h at 100 °C to remove moisture. The clay was mixed with the polymer matrix manually.

The incorporation of Light Green clay into the polyamide was carried out in a twin screw extruder using temperatures from 200 to 250 °C and thread rotation speed

Table 1 Formulations of textile polyamide with Light Green clay (%, by weight)

Samples	Textile polyamide	% clay
PA 0	100	0
PA1	99	1
PA2	98	2
PA3	97	3

of 60 rpm. The extruded material was dried, pelletized by a pelletizer, fed into an injection molding machine and specimen test samples were obtained. The mergers were made according to Table 1.

The aim of this work is to develop a method for recycling the polyamide textile residues and analyses the mechanical properties. As an important part of the paper, the experimental parts are shown in steps in Fig. 1 below, to demonstrate how the samples were obtained. The step (1) shows the polyamide textile residues from postindustrial that were used in this work. Step (2) present the material after the compaction process. Is it possible to notice reductions in the total volume of the material, small particles were obtained in this process. The granules obtained in the extrusion process are shown in step (3). Step (4) is the final of the experimental part, the samples of the materials.

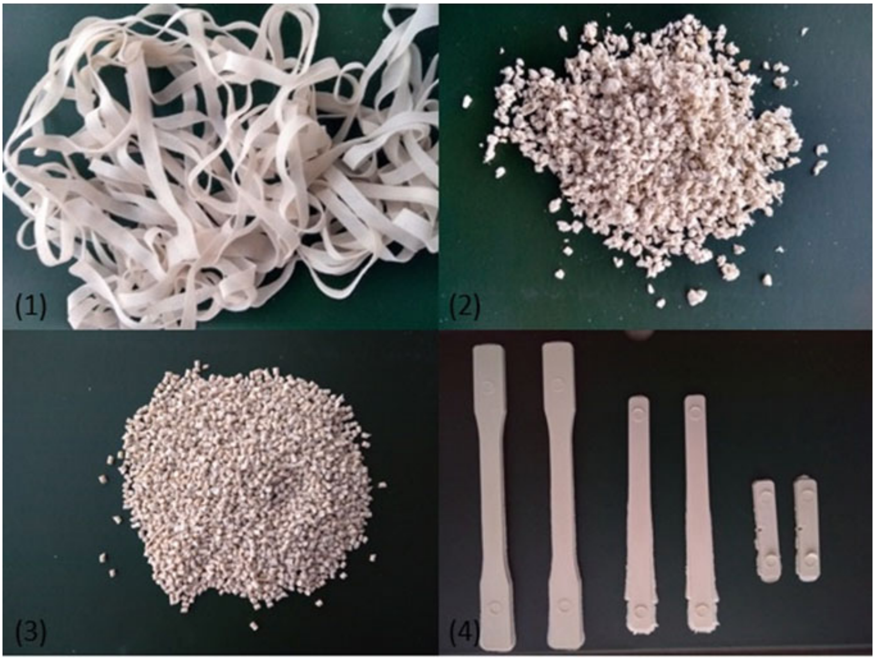

Fig. 1 Steps of the experimental part. **1** polyamide textile residues; **2** compacted polyamide textile residues; **3** polyamide extruded; **4** samples of polyamide textile residues. (Color figure online)

The formulations were evaluated by tensile strength at rupture (ASTM D 638) and flexural resistance (ASTM D 790) for both tests were used ten specimens for each formulation. The Izod impact resistance (ASTM D 256) was also examined and seven specimens were used for each composition.

The X-ray diffraction study was performed using the Rigaku DMAX 2100 equipment with CuKα (λ = 1.54 nm) operated at 40 kV and 40 mA, with 2θ varying between 2nd and 50th. This technique was performed to evaluate the formation of nanocomposites.

To perform the thermogravimetric analysis (TGA) in an inert nitrogen atmosphere using a heating rate of 20 °C/min, the samples were warmed from room temperature to 800 °C.

Results and Discussion

X-Ray Diffraction (XRD)

Figure 2 show the results of diffraction of samples of pure polyamide and systems with the addition of 1%, 2%, and 3%.

The results showed a change in the intensity and inclination of the peaks, which indicates that the clay was interspersed with the polyamide matrix. No completely exfoliated structures were obtained, as the appearance of the d_{001} peaks indicates at least a certain degree of intercalation.

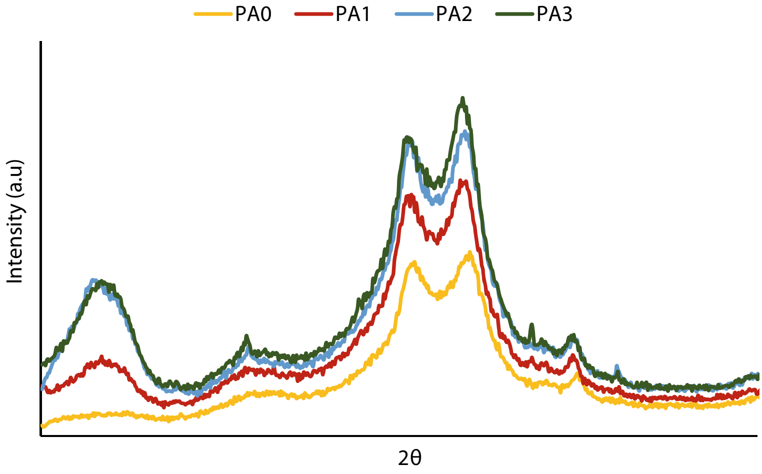

Fig. 2 X-ray diffraction patterns of PA0, PA1, PA2, and PA3 samples. (Color figure online)

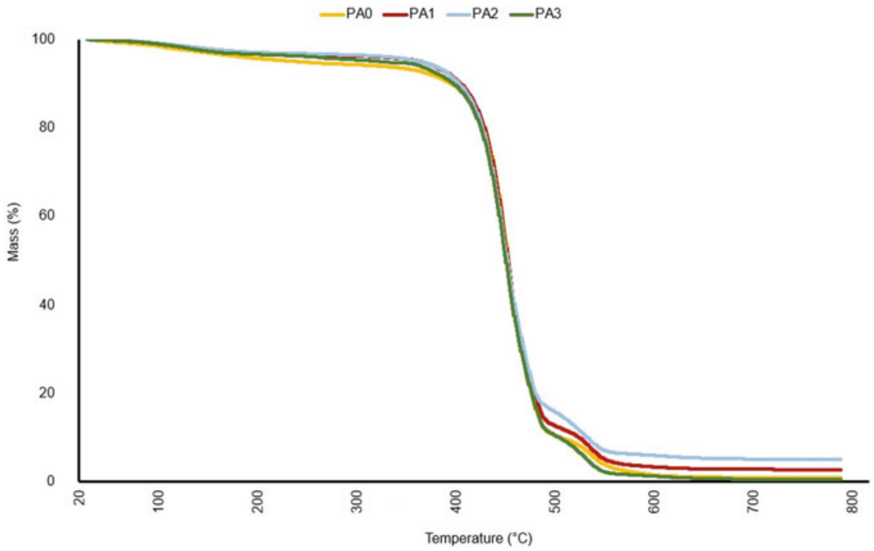

Fig. 3 Thermogravimetric curves of the PA0, PA1, PA2, and PA3 samples. (Color figure online)

Thermogravimetric Analysis (TGA)

Some works [10, 11] in the literature have found no difference in the thermal stability of polyamide/clay nanocomposites. In this work, the same behavior was observed (Fig. 3). No system obtained with clay showed thermal stability superior to that of pure polymer, regardless of the clay content used. The analysis showed that the thermal stability was the same both for the pure polymer and for the nanocomposites produced with the unmodified clays.

Mechanical Tests Results

Mechanical test results are shown in Table 2.

Table 2 Mechanical test results for PA0, PA1, PA2, and PA3

	Tensile strength at break (MPa)	Elongation (%)	Izod impact (J/m)	Flexural strength (MPa)
PA 0	29.31 ± 1.64	4.17 ± 1.21	109.38 ± 9.81	283.90 ± 24.16
PA 1	48.86 ± 3.65	5.96 ± 1.65	124.40 ± 2.87	278.03 ± 11.38
PA 2	65.58 ± 4.88	9.04 ± 0.52	120.92 ± 2.52	284.57 ± 16.75
PA 3	31.95 ± 4.81	5.39 ± 0.34	119.80 ± 2.18	283.66 ± 13.91

The addition of 1% of clay promoted an increase in tensile strength at break of 67% when compared to neat polymer. In the formulation with 3%, this increase was about 120% (Table 2). This improvement in the mechanical property of tensile, when compared to the properties of polyamide without the addition of clay, indicates that the clay acted as a reinforcing load increasing the sample stiffness.

The addition of clay, in all formulations, promoted an increase bigger than 10% in the impact resistance of the material (Table 2). This improvement can be attributed to the absorption of impact energy by the clay with the consequent reduction in the propagation of micro-cracks.

The flexural strength values found for PA0, PA1, PA2, and PA3 were the same, considering the measurement error, which indicates that the clay, in the percentages added does not interfere with the flexural strength of the recycled textile polyamide. In addition, some nanocomposites dissipated small deviations, being smaller than pure material, which gives greater reliability to the results (Table 2).

For a recycled material reinforced with clay without modification, the result is considered significant, showing it a real possibility of use.

Conclusions

The objective of the present study was to develop a method for recycling the polyamide textile residues and to evaluate the contribution of the natural Brazilian bentonite Light Green clay on the properties of the polyamide textile residues. As for processing, the materials formulated with clay showed a behavior according to that used by the recycled polymer industry. This particularity observed in the process was a positive point for the material formed, suggesting that the method used can be repeated by the industry on a regular basis. The results showed that the incorporation of nanoclay represented a significant gain in tensile strength at break and also an improvement in impact resistance. The superior mechanical properties of nanocomposite observed in this study can be attributed to the stiffness of Light Green clay, to the degree of the intercalation, and good dispersion of the clay layers in the polyamide residues.

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