STUDY OF MECHANICAL BEHAVIOR OF REPROCESSING POLYAMIDE

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Abstract: The effect of reprocessing Polyamide 6 (PA6) has been studied in this paper. To simulate recycled PA, we reprocessed virgin PA through 5 cycles. The PA has been mechanically characterized after the various cycles of reprocessing in order to evaluate their corresponding properties and correlate them with the number of cycles undergone. Our results show that tensile strength, lengthening and hardness remain almost constant, while the Charpy Unnotched Impact decrease as the number of reprocessing cycles increases

1. INTRODUCTION.

Polyamide 6 (PA6) has been extensively applied in many fields because it possesses a lot of excellent properties, and its consumption will keep growth in the future. Therefore, how to recycle and reuse effectively, as well as restrain their degradation during processing will become interesting subjects for polymer scientists and engineers. Consequently, the influence of reprocessing operations on the characterization of PA6 must be reveal in advance.

The problems which arise in the recovery of polymer materials are basically the variations that occur in their properties, due to either thermic degradation or the presence of impurities. Many studies have been carried out on the degradation of polymers, Su [1] analyzed the influence of the reprocessing cycles on the mechanical properties, rheological properties and changes in structure of PA 6.

Further studies on the influence of moisture in the PA 6 are performed by Pedroso [2] and [3]. Pedroso worked with industrial wastes consisting of glass fiber reinforced PA 6 composite were dried for 3, 6 and 9 h before reprocessing. Pedroso showed the reprocessing of this type of composite was viable, because satisfactory physical–mechanical properties are attained thereafter, which make them suitable for several applications where these properties are desirable. The drying period of 6 h was the minimum necessary time for the reprocessed material to present a good visual aspect.

Addition, Pedroso showed, by means of TGA analysis, the drying period has a marked influence over the final moisture content of the ground scraps of PA 6 composites.

Another interesting work to ours is that of Lozano-González [4]. These studies were made in order to know how many times it is possible to recycle the nylon-6 without significant loss of the physical–mechanical properties. The nylon-6 was recycled 10 times, until the eighth cycle the properties of the material did not suffered any change. Changes of 10–15% in the properties between nylon-6 with 10 cycles of injection and virgin material were observed by Lozano. Optical and electronic microscopies were used to evaluate the morphology. Lozano showed the darkness obtained by each one of the 10 cycles of injection.

Maspoch [5] investigated of mechanical and rheological properties of a sample of recycled (comes from fiber grade production waste) and filled (filled with 20% glass beads and 10% glass fiber) PA6, was reported as a function of the number reprocessing operations and of the fraction of recycled material added to the virgin material. Her work showed that the properties of the recycled material remained below the virgin, and the best combination of both appeared to be the mixture with 30 wt.% recycled fraction, which shows a lot of properties similar to three reprocessing operations.

The objective of this present work is mechanically and thermally characterized after the various cycles of reprocessing in order to evaluate their corresponding properties and correlate them with the number of cycles undergone.

2. EXPERIMENTAL

2.1 Materials and preparation of specimens

To develop this study, we used PA6 Heramid S Neg 233 supplied by the company Radici Plastic ®.

For the injection, we used a Meteor 270/75 injector supplied by Mateu & Solé® (Barcelona, Spain) at 240 ºC injection temperature. We carried out five injection cycles (R1, R2, R3, R4 and R5) beginning with virgin PA (V).

2.2 Methods and Measurements.

For the mechanical characterization, we used a universal traction machine ELIB 30 (S.A.E. Iberstest, Madrid, Spain) in compliance with ISO 527 and a universal Charpy Unnotched Impact Strength machine (S.A.E. Iberstest, Madrid, Spain).

4. RESULS AND DISCUSSION.

The mechanical properties of any material are fundamental for its use in any particular application. The traction test is extremely important because it allows us to understand properties such as tensile strength and elongation at break.

Thermal degradation as a consequence of recycling processes causes changes in the internal structure of the polymer and these changes in turn cause variations in its mechanical properties.

In the study carried out on PA, table 1, showing the values of tensile strength with the injection cycles reveals a light decreasing lineal evolution in the values. Likewise, the values of elongation at break, also shows a slight drop in value. However, Hardness values have a loss in the first two cycles, whereas after these injection cycles the values remain constant.

Table 1. Mechanical properties of the virgin material and reprocessed material

Material	V	R1	R2	R3	R4	R5
Tensile strength [MPa]	46.59	44.99	47.20	46.648	44.78	45.93
Elongation at break [%]	207	209	217	216	212	205
Hardness [Shore D]	74.07	73.27	73.07	72.83	72.87	73.00
Charpy Unnotched Impact Strength [KJ/m^2]	45.09	35.77	31.75	31.15	28.70	28.61

With regard to Charpy Unnotched Impact, the values show a very sharp fall in the first two cycles and a slight fall in the remainder.

The Charpy Unnotched Impact Strength of the processed PA6 is shown in figure1 against the number of reprocessing cycles. The impact strength drastically decreases from 45.09 J/m^2 (the Virgin PA6) to 28.61 J/m^2 (the 5th processed PA6), as seen in Table 1. The reduction of impact resistance with reprocessing cycles seems to be correlated with the behavior of molecular chain scission. Shorter molecular chain and broader chain length distribution result in poor chain entanglements, as consequence of a decrement in toughness for the multiple processed PA6. Other factors such as contamination particles and gel particles that produce the defective sites in PA6 matrix 6 should be invoked to account for the reduction in the impact resistance. This behavior has been studied by Su [1]. Su takes 16 cycles of reprocessing of PA 6 and reaches the same conclusion.

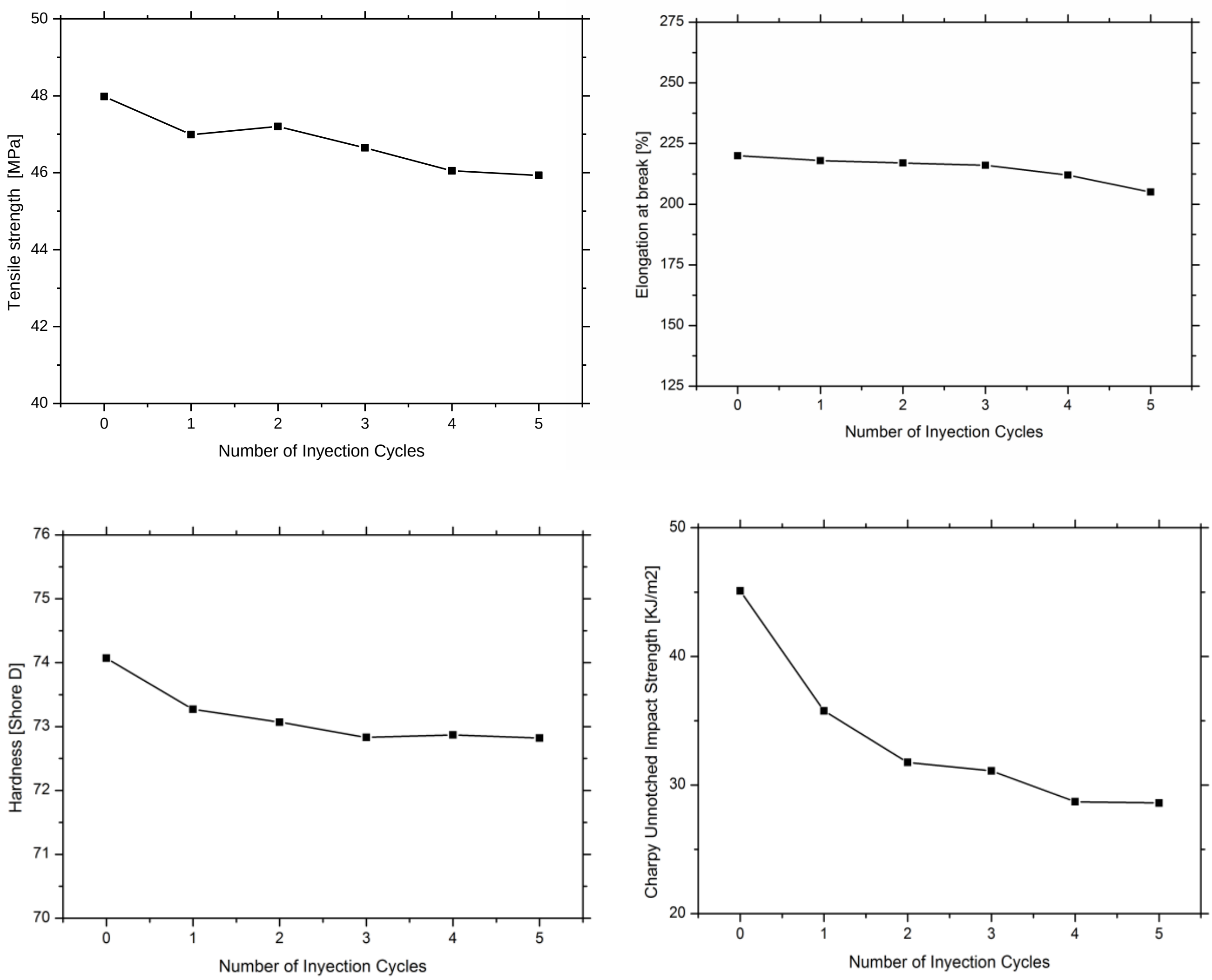

Figure 1 Mechanical properties of the virgin material and reprocessed material

5. CONCLUSIONS

We studied the effects of reprocessing on PA 6 thermoplastic material. Our study was centered on mechanical resistance properties. The results show a slight decrease in their values, exception of Charpy Unnotched Impact Strength, which suffers a significant decline. Tensile strength decreases by around 1.42%, lengthening at break is reduced by 1%, Hardness is reduced by 1.5% while Charpy Unnotched Impact Strength decreases by around 36.5%.

As already commented, this behavior of reduction of impact resistance with reprocessing cycles is caused, seems to be correlated with the behavior of molecular chain scission.

6. References

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