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RECYCLING AND MECHANICAL TESTING OF POLYURETHANE RESIDUES EXPANDED IN HIGH DENSITY POLYETHYLENE INJECTION PROCESS

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ABSTRACT

This work deals with the processing through mechanical recycling and the process of injection of expanded polyurethane (PU) from residues of polymer blankets of ear plugs, with the intention of partially reuse in the industry this type of waste and decrease the disposal in landfills. For this purpose, physical mixtures of polyurethane (PU) from the ground ear plugs with high density polyethylene (HDPE) polymer (in the form of pellets) were injected. Then, flexural tests were carried out according to ASTM standard on the injected test specimens. The mechanical tests indicated that the addition of PU on HDPE maintains performance for flexural tests, even presenting a higher maximum deformation and flexural modulus when PU residue is added.

Keywords: polyurethane residue, polyethylene, injection process, recycling.

INTRODUCTION

Polyurethanes (PU) are widely applied in medical, automotive, and manufacturing various products in industries (Howard, 2012). PU is obtained from the reaction of a polyol with an isocyanate type. The isocyanates act as precursors for the urethane bonds upon reaction with the hydroxyl groups of the polyols (Cregut, 2013). Other chemical compounds such blowing agents, crosslinking agents, chain extenders, surfactants and additives are used in the preparation of PU foams with the aim of conferring different properties and that make it difficult to recycle PU foams. The PU generated in the ear plugs manufacturing process comes from blending two different types of polyols with a toluene diisocyanate (TDI), as well as water as blowing agent and a catalyst.

The final disposal of PU waste is a difficult for several years. Approximately 90% of all PU residue found in its various manufactures is still shipped to landfill. Studies show that the amount of PU discard is increasing over the years (Yang, 2012).

In case of ear plugs foams, polyurethane (PU) wastes are currently discarded by an industry in the form of polymer blankets from the manufacturing process. These polymer blankets are of primary discards in the amount of approximately 8 tons of PU foam residue per month, only in this process of manufacturing ear plugs. Thus, this work proposed the milling of the PU foams of ear plugs and the physical mixing of these residues with the high density polyethylene (HDPE) for testing in an industrial injection process. An *ARBURG* injector was used, model *ALLROUNDER horizontal S hydraulic*. HDPE was purchased from *Braskem* and is already used by the industry for the molding of various products. The PU of the ear plug

was in the shape of a PU polymeric mat and was subjected to milling in industrial equipment. Subsequently, mixtures of PU ground with the HDPE were placed in the injector, obtaining specimens in the proportions of 2%, 5% and 7% by weight of PU ground in relation to HDPE. Injected test specimens were subjected to flexural tests, according to ASTM D790. A total of 12 specimens were performed for flexural tests on a testing machine, *EMIC* brand. The results obtained were statistically analyzed with software *MINITAB, version 17*. Statistical method of multiple comparisons of Tukey was used.

RESULTS AND CONCLUSIONS

The results from the flexural tests are shown in Table 1. The results indicate a behavior similar to that found in the literature (Lu, 2013) for flexural strength of the HDPE.

Table 1 - Flexural test results

Injected Material	Flexural Strength (MPa)	Maximum Deformation (mm)	Flexural Modulus (MPa)
100% HDPE	21.84 ± 0.54	9.86 ± 0.35	275.88 ± 26.45
HDPE + 2% PU	20.92 ± 0.76	10.42 ± 0.47	381.11 ± 23.01
HDPE + 5% PU	22.18 ± 0.37	10.89 ± 0.44	397.34 ± 43.78
HDPE + 7% PU	21.38 ± 0.29	10.55 ± 0.48	328.51 ± 67.29

Tukey's comparison analysis for the maximum flexural deformation revealed two clusters of results. For this variable-response, there was a significant statistical difference when comparing the virgin material (HDPE) with the other three formulations tested (2%, 5% and 7% PU), revealing that the mixture of PU and HDPE changed its flexural strength, increasing the maximum average. It was also possible to verify that the three formulations containing PU did not present significantly different performance between them.

In the case of the flexural modulus, there was a statistical difference when comparing the virgin material (HDPE) with the other three formulations tested (2%, 5% and 7%), showing that the mixture of PU and HDPE changed its modulus of elasticity in flexion, increasing the mean when PU is present.

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REFERENCES

[1]-Cregut M, Bedas M, Duran M-J, Thouand G. New insights into polyurethane biodegradation and realistic prospects for the development of a sustainable waste recycling process. Biotechnology Advances, 2013, 31, 8, p. 1634-3647.

[2]-Howard GT. Polyurethane biodegradation. In: Singh SN (ed). Microbial Degradation of Xenobiotics. Springer Berlin Heidelberg, 2012. p. 371-394.

[3]-Yang W, Dong Q, Liu S, Xie H, Liu L, Li J. Recycling and Disposal Methods for Polyurethane Foam Wastes. Procedia Environmental Sciences, 2012, 16, p. 167-175.

[4]-Lu N, Oza S. A comparative study of the mechanical properties of hemp fiber with virgin and recycled high density polyethylene matrix. Composites Part B: Engineering, 2013, 45, p. 1651-1656.