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Development of Formulations to Recycle Expanded EVA Powder and Scraps, Reducing Environmental Impacts*

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Abstract: By means of a technological extension service using the PRUMO service mode, created and operated by IPT, we have developed new formulations based in the copolymer Ethylene Vinyl Acetate — EVA, incorporating and recycling residues as EVA scraps resulting from the cutting of expanded plates and EVA powder made during the machining of these plates, generated during the forming and manufacturing process of sporting goods, keeping the desired physical properties and, consequently, the quality of the goods manufactured. For such purpose, an EVA-based compound was developed, followed by the development of two new compounds using EVA powder and scraps, which are residues of the production process. These new compounds were properly characterized in laboratory. Such classification showed that these new materials can be used in the production of sporting goods, preserving the quality of the products, reducing costs, and eliminating the need to send EVA powder and scraps to incinerators or landfill sites, thus contributing to the environment.

Key words: expanded EVA, EVA formulations, EVA repairing, EVA residues

1. Introduction

IPT (Institute for Technological Research) is an institution bound to the Secretariat of Economic Development, Science, Technology, and Innovation of the Government of the State of São Paulo that collaborated to the Brazilian development process for over 118 years. The Institute has 38 laboratories qualified in several areas of knowledge, covering the following major areas: innovation, research, development, and technological extension; technological services; metrology; information and education on technology.

NT-MPE (Center for Technological Assistance to Micro and Small Enterprises) is an IPT unit focused on solving technological problems, especially from micro, small, and medium enterprises — MSMEs, using technological extension and development actions, in order to make them increasingly competitive and strengthen them to reach new markets, including international ones.

One of the challenges daily faced by industries is to reduce or recycle waste residues generated during the production process, in order to have a cleaner production, and thus reducing environmental impacts and especially the costs. Decades ago, society did not have easy access to information and, therefore, did not worry about the environment as today, when it is moving towards the application of technologies related to sustainable development.

Thinking about this scenario and to technologically strengthen MSMEs, NT-MPE developed a service methodology called Mobile Units Project — PRUMO, which consists of technological support using a mobile laboratory operated by a technician and an engineer,

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which, in less than two days, seeks to solve the main technological problems regarding raw materials, processes, and products on the plant floor, in real-time operation, creating conditions for the evolution of the production process, improving product quality, increasing productivity, reducing costs, waste, and rework, in addition to recycling or reduce residues, which minimizes environmental impacts.

Tests performed in PRUMO mobile laboratories provide reference data to correct machine and process parameters in industry and machine operating conditions, as well as to improve/develop formulations.

2. Formulation Development

The original expanded rubber formulation used by the company was based on Ethylene Vinyl Acetate or "EVA", as it is popularly known, which, according to Silva and Katayama (2015), is used quite frequently in several applications due to its low density, low cost, easy coloring, flexibility, softness, among other features.

Developing new formulations requires knowledge of the most varied types of additives and mixture components available in the market, which, when properly formulated, allow obtaining the characteristics of the desired product, making it possible to develop customized formulations for each company, in accordance with the technological requirements that should characterize the final product. In this particular case, a black expanded EVA-based compound was developed. Complementarily, from this base compound two formulations were developed, to which EVA powder and scraps were incorporated. Table 1 shows these formulations.

Table 1 Identifications of formulations analyzed in laboratory.

Formulation	Description
Base compound	Black expanded EVA-based rubber compound.
Compound A	Black expanded EVA rubber compound made of 70% of EVA scraps and 30% of EVA-based compound.
Compound B	Black expanded EVA rubber compound made of 70% of EVA powder and 30% of EVA-based compound.

3. Laboratory Work

In order to establish the technical classification of the compounds developed, laboratory work was carried out evaluating the behavior of the compound samples, performing the tests listed in Table 2.

Table 2 Tests performed.

Test	Regulation applied
Durometer Hardness	ASTM D 2240-15e1
Tension Strength	ASTM D 412-16
Tear Strength	ASTM D 624-00 (2012)
Density	ASTM D 297-15

4. Results

The laboratory work provided the results presented in Tables 3, 4, 5, and 6.

Table 3 Durometer hardness type 00.

Compound	Median (Points)	Standard deviation
Base compound (reference)	68	0.69
Compound A	81	0.91
Compound B	89	0.69

Table 4 Tension strength.

Compound	Rupture tension (MPa)	Elongation at break (%)
Base compound (reference)	1.80	152.7
Compound A	1.92	101.7
Compound B	2.84	165.2

Table 5 Tear strength.

Compound	Tear Strength (N/mm)
Base compound (reference)	4.75
Compound A	6.35
Compound B	11.57

Table 6 Density.

Compound	Density (g/cm^3)
Base compound (reference)	0.09
Compound A	0.23
Compound B	0.34

Laboratory results have revealed that, in view of the reference values obtained from the base compound and the characteristics of the products to be manufactured,

both Compounds A and B are adequate to meet the desired technical requirements, including with higher quality in some tests compared to the base compound. Thus, a technological route was created that allowed the reuse of the scraps and powder discarded in the production process by incorporating them into the final products, preserving the quality of the products, reducing costs, and eliminating the need to send EVA powder and scraps to incinerators or landfill sites, thus contributing to the environment.

5. Final Comments

The results of this work mark the importance of research and development institutions having support to expand their technological extension actions, contributing to the development of micro, small, and medium enterprises in any manufacturing segment.

Furthermore, this work contributes to change the entrepreneur culture and to develop the awareness of the need and importance of continuing to improve the production process leading to increased productivity and, consequently, to competitiveness.

In this context, this work verified that the methodology applied serves as a model for other entrepreneurs as, with technological actions, companies are able to reduce costs and, insofar as possible, environmental impacts as demonstrated.

References

[1] ASTM D 624-00 (Reapproved 2012) Standard test methods for tear strength of conventional vulcanized rubber and thermoplastic elastomers.

[2] ASTM D 297-15 Standard test methods for rubber products – Chemical analysis.

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[4] ASTM D 412-16 Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers – Tension.

[5] ASTM D 3182-16 Standard practice for rubber – Materials, equipment, and procedures for mixing standard compounds and preparing standard vulcanized sheets.

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