Sustainable ABS filament development for 3D printing by Fused Deposition Modeling (FDM)

No. 21

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INTRODUCTION

Acrylonitrile butadiene styrene (ABS) is a thermoplastic terpolymer known for its high rigidity and resistance to impact and deformation. It can be processed through various methods like injection molding and extrusion, making it suitable for FDM (Fused Deposition Modeling) printing due to its low melting point.

ABS is widely used in industries such as automotive, electronics, and medical applications. However, only 7% of polymers are currently recycled, and the recycling process is often unsustainable due to energy consumption and lower quality of recycled materials. This study investigates the development of biodegradable ABS filaments by modifying ABS with organic materials to enhance biodegradability, allowing for better environmental integration after use [1,2] .

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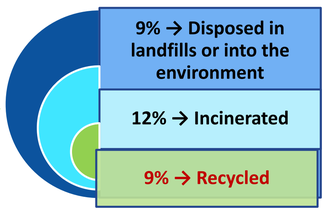
6.3 billion metric tons of waste are generated worldwide



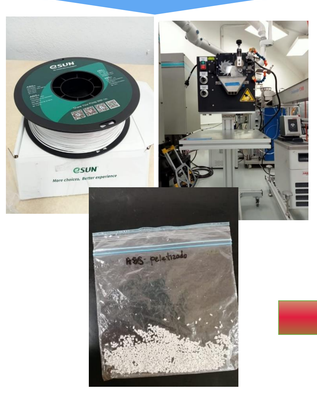
- 9% → Disposed in landfills or into the environment
- 12% → Incinerated
- 9% → Recycled

- ➢ Organic additive created for a new Biodegradable Plastic Technology
- ➢ Biodegradation in plastics through **chemical and biological processes** in a disposal environment

- ✓ Thermical stability
- ✓ No hazardous substance
- ✓ Biodegradability by anaerobic digestion

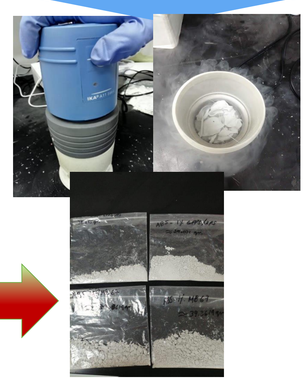
MATERIALS AND METHOD

Pelletizing of ABS filaments

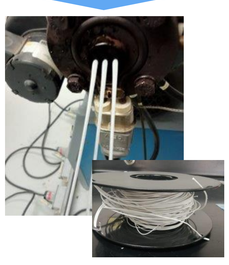


Mixing of ABS with GPPS-XPS and MB67 additives

Milling of ABS/GPPS-XPS and ABS/MB67 blends



Obtention of ABS/GPPS-XPS and ABS/MB67 filaments



Injection of specimens for tensile tests

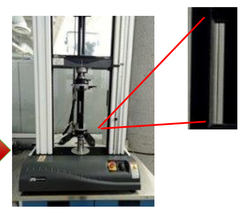
Ultrasonic Microinjection (UMIM)

Fused deposition modeling (FDM)

ABS Specimens

Characterization

- -TGA
- -FTIR
- -Mechanical tests
- -Biodegradation tests



RESULTS AND DISCUSSION

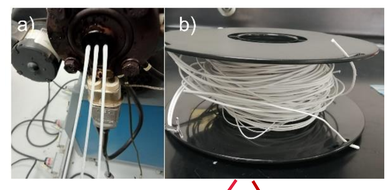


Figure 1. a) Extrusion of the ABS filament modified with the additive. b) Filament collected from the ABS polymer modified with the additive

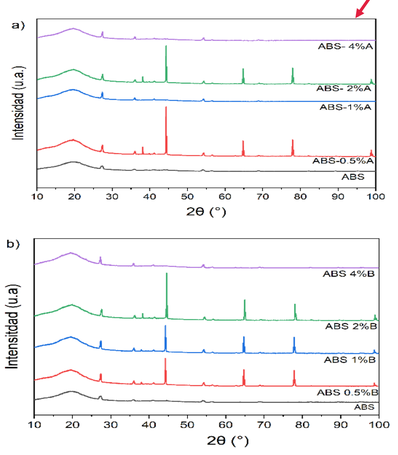


Figure 2. XRD patterns obtained from ABS filaments modified with additive a) A and b) B.

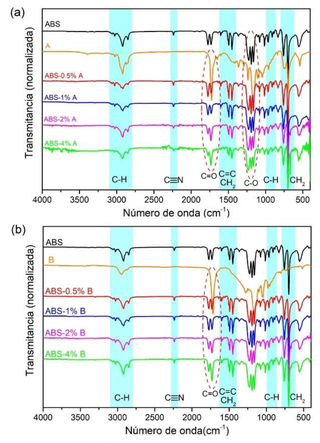


Figure 3. FTIR spectra of ABS and ABS modified with a) Additive A and b) Additive B.

- ✓ **The chemical structure of ABS is kept unchanged with the presence of additives at such contents.**
- ✓ **This suggests good compatibility of both additives with ABS.**

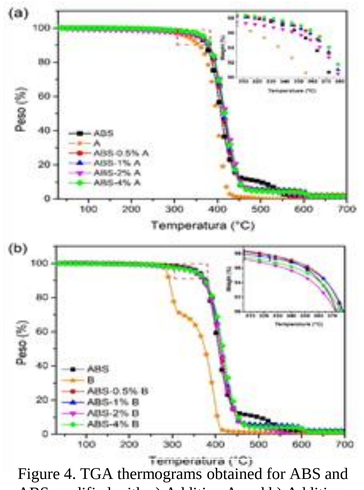


Figure 4. TGA thermograms obtained for ABS and ABS modified with a) Additive A and b) Additive B.

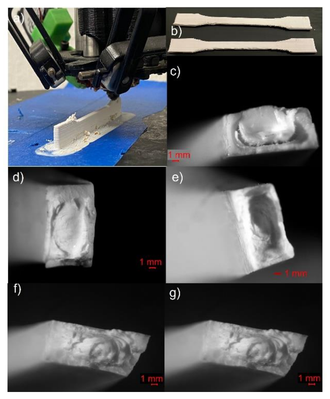


Figure 5. Images captured with conventional photography of a) FDM printing process using the developed filament, b) uniaxial tension specimens printed by FDM. Images taken with the optical microscope of c) pure ABS filament, d) 0.5% ABS filament, e) 1% ABS filament, f) 2% ABS filament, g) 4% ABS filament. The images presented correspond to the ABS filament obtained with additive A.

CONCLUSIONS

This research explores the feasibility of creating a filament optimized for FDM printing by modifying standard ABS polymer with organic additives designed to improve biodegradability.

The thermal stability remains mostly unchanged, with some cases indicating an increase of about 2.8% following the addition of these additives. XRD analysis shows the emergence of new diffraction planes in samples with additives A and B; however, no definitive relationship is observed between the intensity of these planes and the additives' concentration. The diameter of the produced filament closely matches that of the original commercial ABS filament.

As parallel study, a new organic additive is being developed to promote the biodegradation of some conventional thermoplastics, this initiative is named KCASs (Knowledge, Commitment, Action, Sustainable solution).

ACKNOWLEDGEMENTS

We extend our sincere gratitude to the Institute of Advanced Materials for Sustainable Manufacturing and the Challenge-Based Research Funding Program 2022 for their generous support of this project (IJXT070-23EG60001). Additionally, we appreciate the funding from Fundación Femsa for the Materials of the Future project, which has made this research possible.

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[1] M. Suzuki, C.A. Wilkie, ¨The thermal degradation of acrylonitrile-butadiene-styrene terpolymei as studied by TGA/FTIR¨ *Polymer Degradation and Stability* **47** 217(1995).
[2] V. Barskov, S.Besedin, V. Rassokhin, A. Smetankin, K. Besedina, N.Lavrov, D. Panfilov, Y. Smirnov, Y. Lypar and L. R. Mukhametova. The study of the