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Radiation Impacts on Raman spectra of PBAT/PLA (Ecovio) Bags Irradiated by Electron Beam

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1. Introduction

Biodegradable polymers are compounds derived from renewable sources such as biomass and organic components [1]. Therefore, they emerge as a promising alternative to reduce the environmental impact of traditional polymers derived from petroleum. Biodegradable polymers have physicochemical characteristics that allow a faster degradation compared to conventional polymers, significantly reducing the time of permanence in the environment and its negative impacts to the soil [2]. Ecovio®, being a sustainable and advantageous alternative, is composed of biodegradable aliphatic-aromatic Ecoflex® copolymer and polylactic acid (PLA). Its formulation includes anti-lock and sliding agents to facilitate film extrusion processing [3]. Its composition consists of 55% PBAT (Poly (butylene adipate co-terephthalate)) and 45% PLA (polylactic acid) [4].

Ionizing radiation is a type of radiation that has energy capable of ionizing atoms and molecules, displacing electrons from atoms. The use of electron accelerators to modify materials is a viable option that does not result in increased waste. These changes, induced by radiation doses, alter the structure of Ecovio® bags, thus modifying their degradation time [5,6].

The objective of this work was to analyze the microscopic and structural changes of the bags of Ecovio® through ionizing radiation focusing on increased biodegradability, amplitude in its versatility and applications.

2. Methodology

The plastic bags (Ecovio®, with 55% PBAT and 45% PLA) supplied by Romapack were stacked in sets of 10 bags for each type of dose and irradiated with absorbed dose of 25, 50 and 100 kGy in the Dynamitron electron accelerator. Fig. 1.

Figure 1: Experimental arrange for EB irradiation at IPEN.

Raman Spectroscopy

The Raman spectra were obtained using the Raman microscope (model: Xplora Plus) with 785 nm wavelength, 85 mW laser power, with the SyncerityTM CCD detector model, 1200 grid (750 nm) and 50X objective lens. The analyses were performed in the region of 2,000 cm^{-1} to 400 cm^{-1}.
The analyzes were performed from top to bottom, that is, the first bags began the research for having a higher radiation absorbed dose due to penetration of electron.

The samples analyzed were taken from two different locations, one with a printed design and the other without, with dimensions of 1x1 cm and thickness of 0.4mm.

3. Results and Discussion

For Raman interpretation it was based on findings from literature for PBAT and PLA [7,8]. Spectra were obtained from 800 to 2000 cm^{-1}, regions in which there are peaks of PBAT and PLA of biodegradable Ecovio® bags composition as presented in Table I.
It is possible to observe the influence of radiation absorbed doses on Raman shift intensities compared to 0 kGy. Indicated that some scission occurred on carbonyl group at Raman associated to stretching shift on 1717 cm^{-1} on figure 2 [6], as well as observed on Figure 3 on 1527 cm^{-1} [9].
Raman shift at 1453 and1450 cm^{-1} can be attributed to CH_3 deformation.

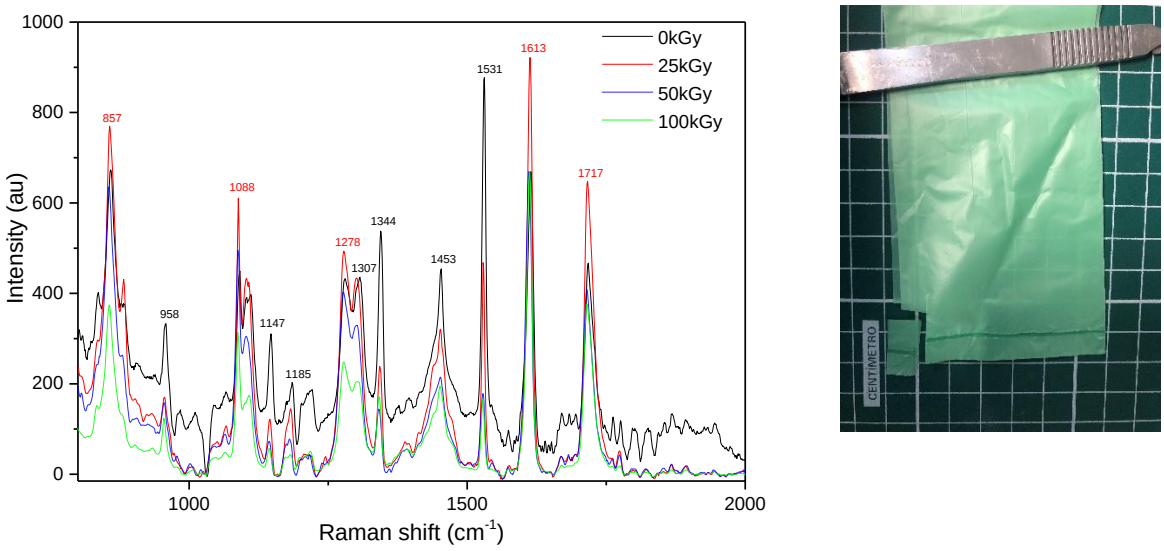

Figure 2: Raman spectrum of samples taken from a location that has no printed stamp of Ecovio® bags.

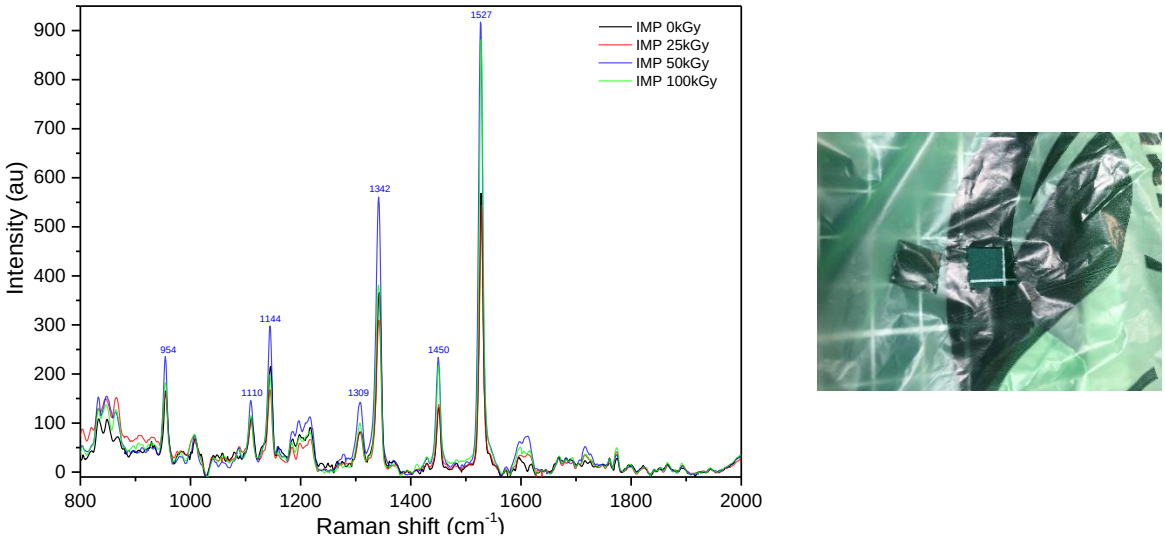

Figure 3: Raman spectrum of samples taken from a site that has printed stamp of Ecovio® bags.

Table I: Interpretation of vibrational modes found in Raman spectra for PBAT-PLA samples

Raman shift (cm^{-1})	Interpretation
802	vibrational states of the C–COO‴ PLA
958	stretching of C–CH3**PLA
1088	ν C-C PLA*
1111	ν C-O (PBAT+PLA)*
1147	C=O stretching**? PLA
1185	C=O stretching**PLA
1307	βC-H (PLA)*
1344	δ sim CH_3 PLA**
1453	δ assim CH_3 PLA**
1614	ν C=C (PBAT)*
1717	ν C=O (PBAT + PLA)

*1; **2

4. Conclusions

The application of ionizing radiation in Ecovio® bags allowed to modify its properties and expand its applications, contributing to the creation of more ecological and efficient products due to degradation that would favor biodegradability. From Raman results it suggests that PLA is more prone to degradation than PBAT. Future work will be on field composting tests.

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References

[1] S. M. M. Franchetti, J. C. Marconato, "Polímeros biodegradáveis - uma solução parcial para diminuir a quantidade dos resíduos plásticos" *Química Nova*, vol. 29, n. 4, pp. 811–816 (2006).
[2] S. Mara, M. Franchetti, &, J. C. Marconato, "Polímeros Biodegradáveis- Uma solução parcial para diminuir a quantidade dos resíduos plásticos", *Quimica Nova* ,Vol. 29, n 4 https://www.scielo.br/j/qn/a/QXT9wMDfVQ9PrhbVsp8b3Pc/ (2006).
[3] "ecovio ® F2332 Biodegradable compound for compostable film ® = ecovio and ecoflex are registered trademarks of BASF SE Biodegradable Polymers Product Information," https://download.basf.com/p1/8a8081c57fd4b609017fd63c8fb8061b/en/ecovio%3Csup%3E%C2%AE%3Csup%3E_F2332_Product_Data_Sheet_English.pdf?view (2023).
[4] P. M. Munhoz, L. G. A.Silva, J.Harada, F. C.Nascimento, & W. A. P. Calvo, "Poly(butylene adipate co-tereophalate)/Poly(lactic acid) (PBAT/PLA) blend characterization processed by electron beam", *Proceedings of 2019 International Nuclear Atlantic Conference - INAC 2019* Santos, SP, Brazil, October 21-25, pp. 2510-2524 (2019).
[5] A. Del Campo, E. de Lucas-Gil, F. Rubio-Marcos, M. P. Arrieta, M. Fernández-García, J. F Fernández, & A. Muñoz-Bonilla, "Accelerated disintegration of compostable Ecovio polymer by using ZnO particles as filler", *Polymer Degradation and Stability*, pp. *185*" https://doi.org/10.1016/j.polymdegradstab.2021.109501 (2021).
[6] J. Araújo Junior de et al. "PBAT-PLA blends used in shopping bags: characterization by differential scanning calorimetry, raman spectroscopy and wide angle x-ray diffraction," São Carlos: Associação Brasileira de Polímeros (ABPol), https://repositorio.usp.br/directbitstream/96b53e10-fa15-46ff-acee-2fc492eb1731/WIEBECK-2013-PBATPLAblends.pdf (2013).
[7] C. Bonacossa de Almeida , S. Pestana, "*Radiações Ionizantes e a vida*," Apostila educativa Por Yannick Nouailhetas Colaboradores. https://pointer.esalq.usp.br/departamentos/leb/aulas/lce1302/rad_ion.pdf>(2004).
[8] J. Harada "Extrusão de filme soprado de PBAT/PLA contendo negro de fumo, composto orgânico e cinza de cascas de arroz para aplicações na área agrícola", Tese, UNIVERSIDADE FEDERAL DO ABC (2018).
[9] E.Bolkis, E. Adomaviciut, E. Griškonis,"Formation and Investigation of Mechanical, Thermal, Optical and Wetting Properties of Melt-Spun Multifilament Poly(lactic acid) Yarns with Added Rosins", *Polymers*, v. 14, n. 379, https://doi.org/10.3390/polym14030379 (2022).