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EB energy effect on mechanical properties of Ecovio® irradiated shopping bags

Yasko Kodama[1], Catharina Costa[1], Thamiris Marcondes da Silva[1], Gilmara de Luca[2], Wilson A. P. Calvo[3]
[1]IPEN-CNEN, [2]Sterigenics International, LLC, [3]DPDE-CNEN
e-mail: yasko.kodama@gmail.com

BACKGROUND

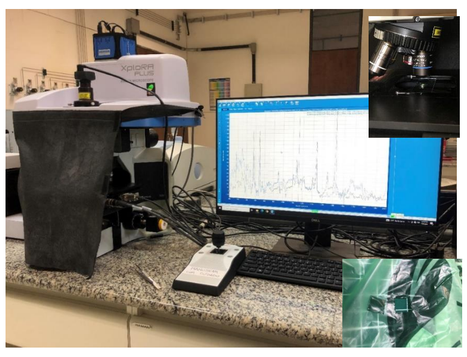
According to United Nations, “Plastic pollution poses major risks to the environment and human health” In this sense, alternative technologies have been developed to decrease degradation time and to produce polymers from renewable sources in order to reduce significantly the time of permanence in the environment. In this sense, Ecovio® composed of biodegradable aliphatic-aromatic Ecoflex® copolymer and polylactic acid (PLA) has increased applications of use. Besides that, for circular economy pursue nuclear technology can be beneficial by improving recycled post-consumer electron beam processed bags. Advanced research has shown that through irradiation in several different dose ranges, mechanical properties of these polymers and efficiency in the reuse in production process, or above certain radiation absorbed doses, degradability process can be improved. The changes induced by ionizing radiation alter Ecovio® chemical structure, thus modifying their degradation time while improving properties during needed time for farming.

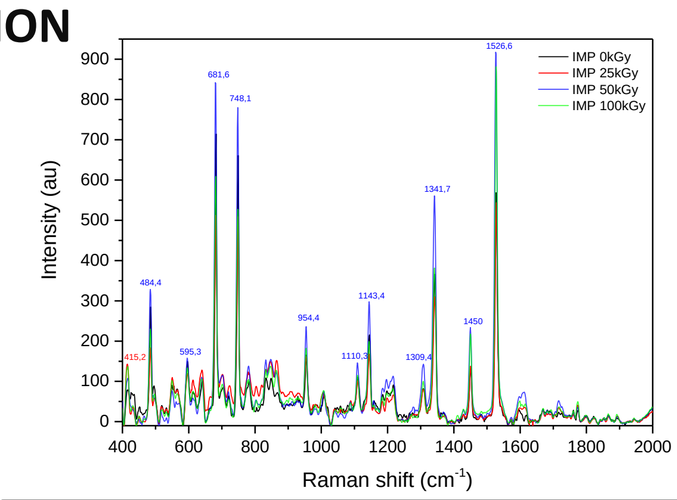
METHODOLOGY

Ecovio®, with 55% PBAT and 45% PLA bags supplied by Romapack, stacked in 10 bags radiation absorbed doses 25, 50 and 100 kGy in Dynamitron electron accelerator (1.5 MeV) and, another set of piled bags EB irradiated in Rodothon® TT200 (10 MeV). Mechanical properties were measured by using a universal test machine (Instron 5567 model) at RT with a load cell of 1 kN. Rectangular (1 × 4 cm^2) specimen. Raman spectra by Horiba JobinYvon, XploRA-PLUS, laser 785 nm, 85 mW, objective 50x, LabSpec6.

RESULTS AND DISCUSSION

Raman Spectroscopy





Raman spectrum of samples taken from a section with printed stamp of Ecovio® bags

Spectra from 800 to 2000 cm^{-1}peaks of PBAT and PLA of biodegradable Ecovio® bags composition. It is possible to observe the influence of radiation absorbed doses on Raman shift intensities compared to 0 kGy. Some scission occurred on carbonyl group at Raman associated to stretching shift on 1717 cm^{-1}, as well as observed on 1527 cm^{-1}. Raman shift at 1453 and1450 cm^{-1} can be attributed to CH_3 deformation.

Mechanical Properties

	Modulus (N)	STD	Instron Extension (mm)	STD
0kGy NO PRINTED	168,77	46,89	113,19	29,35
50kGy NO PRINTED	263,13	21,87	119,90	11,69
65kGy NO PRINTED	220,20	38,9	59,66	20,07
80kGy NO PRINTED	209,23	14,59	60,57	31,39
100kGy NO PRINTED	220,05	31,66	58,34	34,37

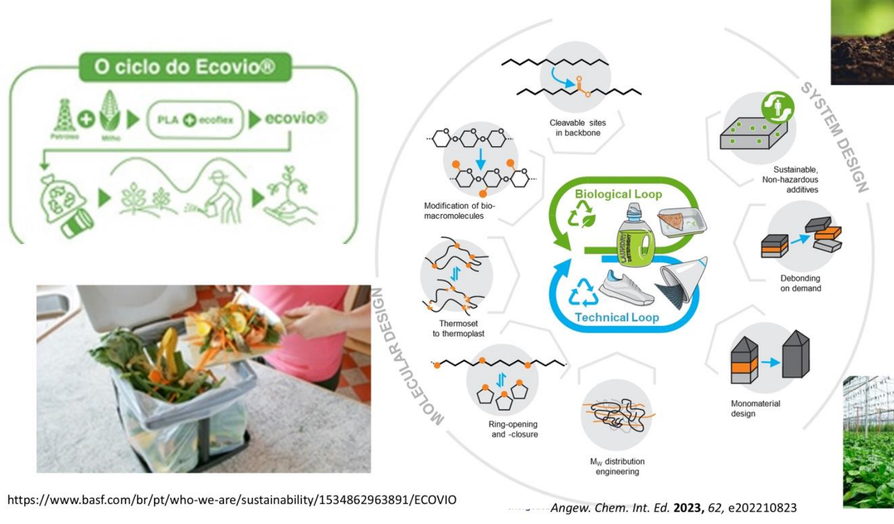
	Modulus (N)		Instron Extension (mm)	
0kGy PRINTED	190,68	63,61	62,39	17,75
50kGy PRINTED	197,85	29,37	34,75	16,50
65kGy PRINTED	219,59	28,32	32,85	12,18
80kGy PRINTED	239,64	35,92	34,55	15,37
100kGy PRINTED	233,10	22,60	24,67	8,31

CONCLUSION

It was possible to observe that higher energy of EB (10 MeV) improved mechanical properties of Ecovio® irradiated bags, up to 65-80kGy compared to lower energy (1.5 MeV). All tested samples irradiated with 100 kGy presented poor mechanical properties. This indicates that up to a certain dose of radiation Ecovio® recycled bags could be reused in the fabrication plant maybe of mulch films and, with higher doses, it will favor its biodegradation in soil.

https://www.knocksense.com/lucknow/international-plastic-bag-free-day-2023-taking-a-glimpse-into-indias-severe-plastic-waste-problem

Recycled shopping bags



https://www.basf.com/br/pt/who-we-are/sustainability/1534862963891/ECOVIO

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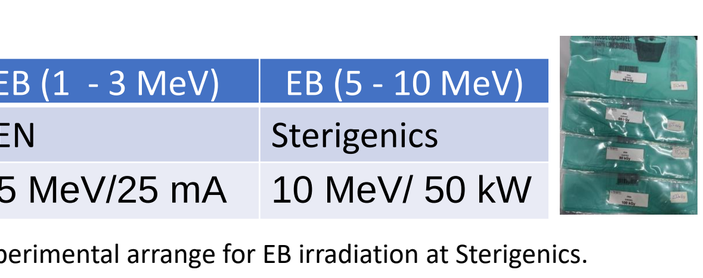
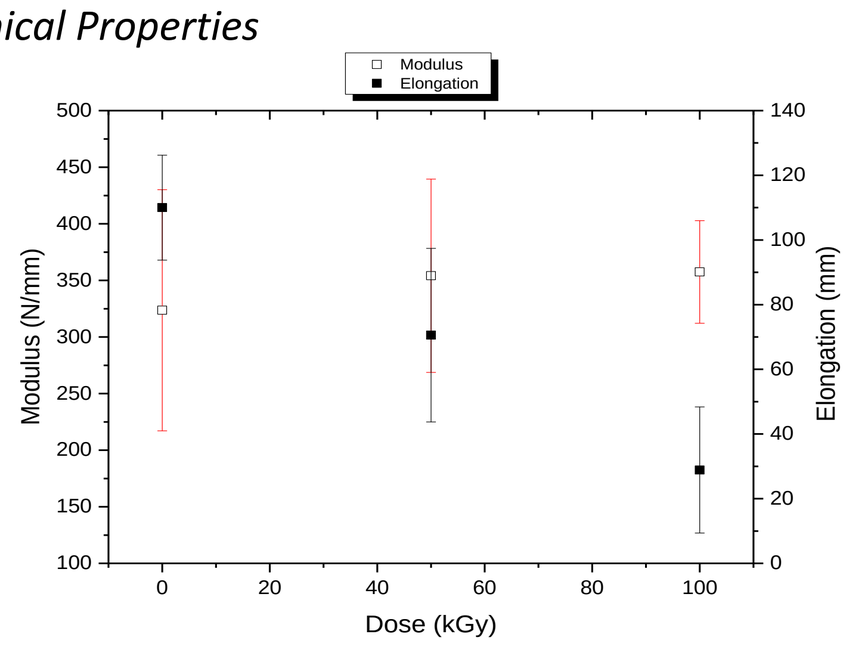


EB (1 - 3 MeV)	EB (5 - 10 MeV)
IPEN	Sterigenics
1.5 MeV/25 mA	10 MeV/ 50 kW

Experimental arrange for EB irradiation at Sterigenics.

Mechanical Properties



Young´s modulus seem not to be significantly affected by increasing EB radiation absorbed dose of IPEN irradiated bags, by the other side, elongation at break decreased significantly with increasing dose in the range studied. Higher energy EB radiation promoted less variation among tested specimen of the same dose compared to 1.5 MeV EB irradiation. Printed samples showed poorer resistance than without print region. It was possible to observe variation of PLA groups bands by Raman spectra, indicating some degradation must have occurred with increasing radiation absorbed dose

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REFERENCES

C. M. Finzi-Quintão, K. M. Novack, and A. C. Bernardes-Silva, “Identification of Biodegradable and Oxo-Biodegradable Plastic Bags Samples Composition,” *Macromol. Symp.*, vol. 367, no. 1, pp. 9–17, 2016, doi: 10.1002/masy.201500156.

S. M. M. Franchetti and J. C. Marconato, “Polímeros biodegradáveis - uma solução parcial paradiminuir a quantidade dos resíduos plásticos,” *Quim. Nova*, vol. 29, no. 4, pp. 811–816, 2006, doi: 10.1590/s0100-40422006000400031.

A. del Campo *et al.*, “Accelerated disintegration of compostable Ecovio polymer by using ZnOparticles as filler,” *Polym. Degrad. Stab.*, vol. 185, no. 2021, p. 109501, 2021, doi: 10.1016/j.polymdegradstab.2021.109501.

J. D. A. Jr *et al.*, “12 ° Congresso Brasileiro de Polímeros (12 ° CBPol) PBAT-PLA BLENDS USED IN SHOPPING BAGS : CHARACTERIZATION BY DIFFERENTIAL SCANNING CALORIMETRY , RAMAN SPECTROSCOPY AND WIDE ANGLE X-RAY DIFFRACTION,” pp. 23–26.

P. M. Munhoz, L. G. A. Silva, J. Harada, F. C. Nascimento, and W. A. P. Calvo, “Poly(Butylene Adipate Co-Terephthalate)/Poly (Lactic Acid) (Pbat/Pla) Blend Characterization Processed By Electron Beam,” Int. Nucl. Atl. Conf., no. 2005, pp. 2510–2524, 2019, [Online]. Available:http://repositorio.ipen.br/bitstream/handle/123456789/30637/26286.pdf?sequence=1

P. M. MUNHOZ, “Caracterização da blenda de PBAT/PLA – poli (butileno adipato co-tereftalato)/poli (ácido lático) irradiada por feixe de elétrons,” INSTITUTO DE PESQUISAS ENERGÉTICAS E NUCLEARES Autarquia Associada à Universidade de São Paulo, 2020.