Gamma Irradiation Effect on Ethyl Cellulose Foils:

Advancing Sterilizable and Sustainable Biopolymer Materials

Nano Innovation 2026 Rome, 14-18 September Conference & Exhibition

CNR IMM Istituto di Microelettronica e Microsistemi

ENEA AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE, L'ENERGIA E LO SVILUPPO ECONOMICO SOSTENIBILE

Elena Palmieri[1], Beatrice D'Orsi[2], Rocco Carcione[2], Alessia Cemmi[2], Luca Maiolo[1], Francesco Maita[1]

[1] Istituto di Microelettronica e Microsistemi (IMM), Consiglio Nazionale delle Ricerche (CNR), Rome, Italy
[2] Dipartimento Nucleare (NUC), ENEA, C.R. Casaccia, Rome, Italy

ABSTRACT

Ethyl cellulose (EC), a hydrophobic and film-forming cellulose derivative, is gaining attention as a sustainable material platform, particularly in applications demanding water resistance, mechanical durability, environmental resilience and processability.

However, its behavior under sterilization conditions, such as gamma irradiation, remains underexplored.
In this study, transparent EC foils were irradiated at 10 and 25 kGy, and their structural, chemical and mechanical stability was assessed using Raman, FTIR, EPR, DMA and TGA analyses.

The results revealed only minor molecular changes, with limited signs of crosslinking or oxidation, negligible radical formation, and a modest increase in thermal stability.

These findings confirm EC's robust resistance to gamma-induced degradation, supporting its use in sterilizable, bio-based materials for packaging and related technologies.

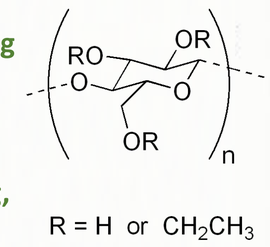
KEYWORDS: Ethyl cellulose, Flexible electronics, Flexible biomedical devices, Gamma irradiation, Sterilizable materials.

HIGHLIGHTS

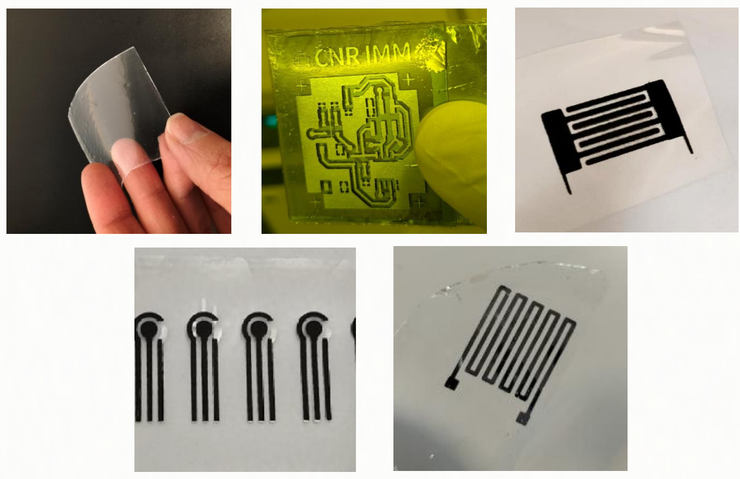
- **EC foils remain structurally and chemically stable up to 25 kGy.**
- **Minimal oxidation and limited radical formation after irradiation.**
- **Slight increase in thermal stability.**
- **EC is a promising sterilizable biopolymer for sustainable applications.**

ETHYL CELLULOSE (EC)

- **Hydrophobic, water-resistant and film-forming**
- **Excellent mechanical and environmental stability**
- **Biodegradable and biocompatible**
- **Suitable for advanced applications: packaging, sensors, medical devices, cultural heritage**



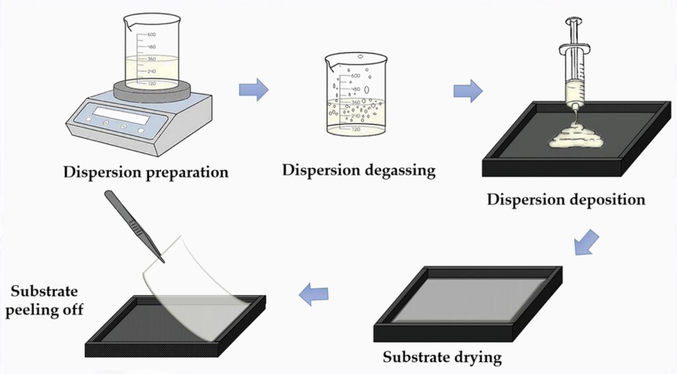
R = H or CH_2CH_3



EXPERIMENTAL

1. Sample preparation

Transparent EC foils were prepared by solvent casting of EC (10% w/v in ethanol).



2. Gamma Irradiation

- Samples were irradiated in air at room temperature at absorbed doses of 0 (control), 10 and 25 kGy using a ^{60}Co gamma source (dose rate ≈ 1.5 kGy h^{-1}).

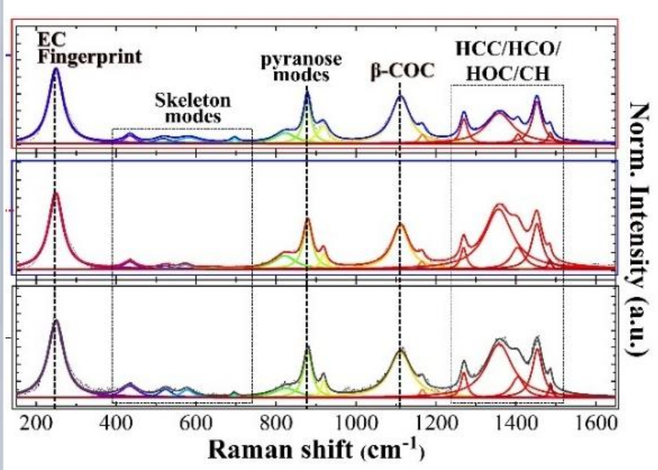
^{60}Co

3. Characterization techniques

- Raman spectroscopy (785 nm)
- FTIR spectroscopy (4000–500 cm^{-1})
- EPR spectroscopy (X-band)
- Dynamic Mechanical Analysis (DMA)
- Thermogravimetric Analysis (TGA-DTG)

RESULTS

1. RAMAN SPECTROSCOPY

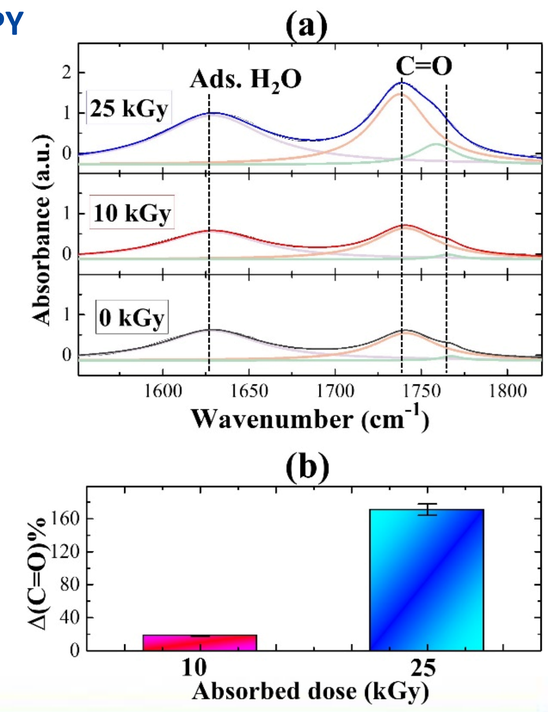


No significant changes in peak positions or intensities after irradiation.

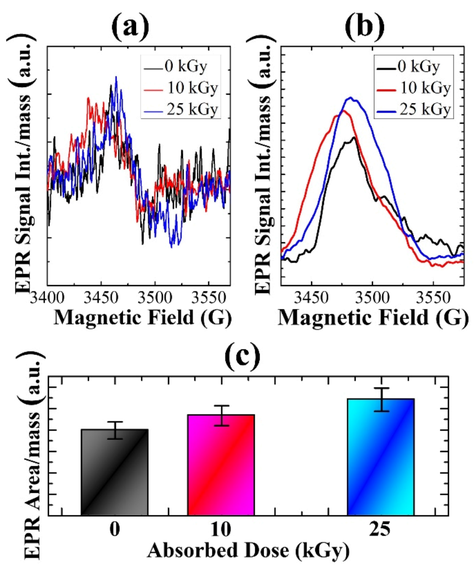
2. FTIR SPECTROSCOPY

a) Representative deconvolved FTIR spectra

b) ≈10 % increase at 10 kGy; ≈ 200% increase at 25 kGy in carbonyl content.

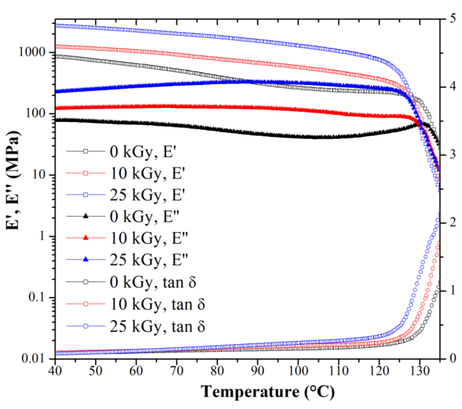


3. EPR SPECTROSCOPY



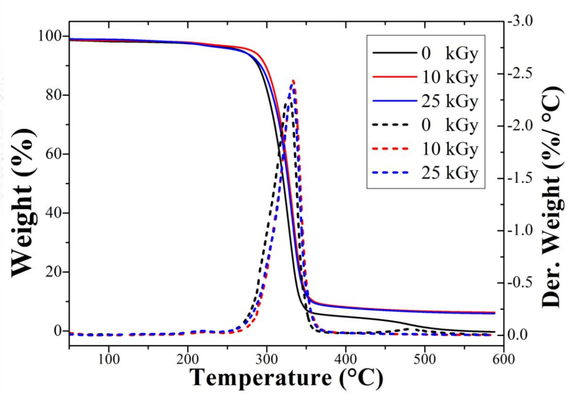
Low radical concentration in al samples with only a modest increase at 25 kGy.

4. DMA (TENSION MODE)



Slight shift to higher temperature and limited changes in storage modulus and tan δ.

5. TGA-DTG



- All samples show a single main degradation step (~270 °C).
- Slight increase in thermal stability at 10 and 25 kGy.
- Residual mass > 50% at 600 °C for all samples.

CONCLUSIONS

- Ethyl cellulose foils exhibit excellent resistance to gamma irradiation up to 25 kGy.
- Only minor chemical modifications were observed: limited oxidation and negligible radical formation.
- A slight increase in thermal stability was detected.
- EC maintains its structural integrity and mechanical behavior after sterilization doses.
- **These results support the use of EC as a sterilizable, sustainable biopolymer for packaging, medical and electronic applications, as well as cultural heritage preservation.**

Corresponding authors: rocco.carcione@enea.it; elena.palmieri@cnr.it

ACKNOWLEDGEMENTS

This work was supported by ENEA (Calliope gamma irradiation facility). The authors thank the technical staff for their support. This work has been partially supported by the project Microtech for Green, funded by the Italian Ministry of the Enterprises and of the Made in Italy (MIMIT) - Fondo IPCEI.