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Abiotic surface degradation induced by ozonation on poly (lactic acid) (PLA)/poly (butylene adipate-co-terephthalate) (PBAT) blends

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INTRODUCTION & AIM

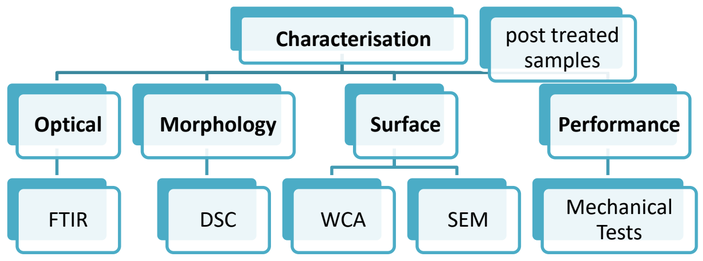
Biopolymers emerged as **sustainable alternatives** to conventional plastics due to their biocompatibility, biodegradability and non-toxicity, offering an environmentally friendly solution to reduce plastic pollution [1], [2]. However, **environmental factors**, particularly oxygen and ozone exposure, can promote **polymer degradation** and strongly influence **material performance**, affecting mechanical and structural stability.

This study **aims** to **evaluate** the **consequences** of **short-term** (0-2 h) and **long-term ozone aging** (24-96 h) of commercial poly(lactic acid)/poly(butylene adipate-co-terephthalate) (**PLA/PBAT**) blend films, commonly used in rigid and flexible packaging. By examining the structural modifications in aged materials, their resilience and changes in key properties could be assessed.

METHOD

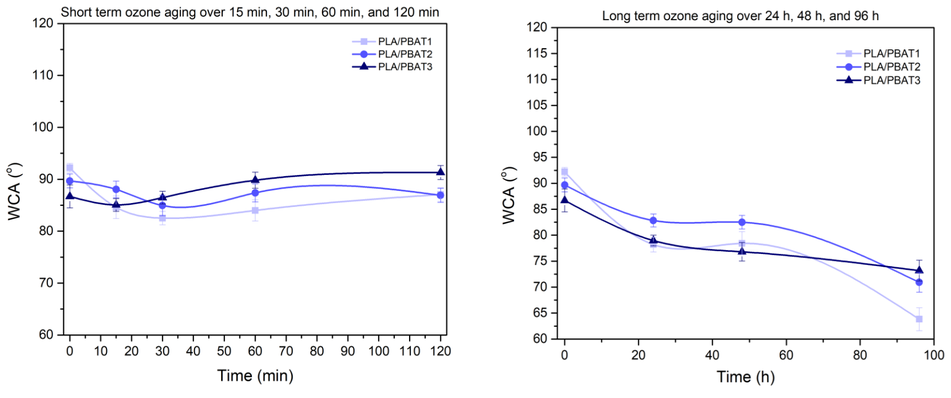
Oxidative O_3 simulated ageing:

- Films 100 µm thick.
- Anseros SIM 6050 T chamber.
- Temperature 40 °C.
- Ozone concentration 300 pphm.
- Short-term: 15, 30, 60 and 120 min.
- Long-term: 24, 48, 72 and 96 h.



RESULTS & DISCUSSION

Surface hydrophilicity



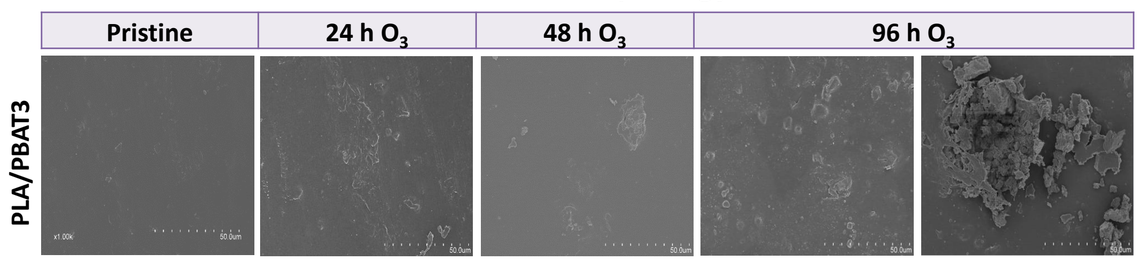
- **Short-term ozonation** (≤2 h) caused only **surface sterilization**, without altering surface characteristics.
- **Prolonged exposure** (≥24 h) **increased** surface **hydrophilicity**, as water contact angle decreased from 92.2° to 63.8° after 96 h.

Mechanical performance

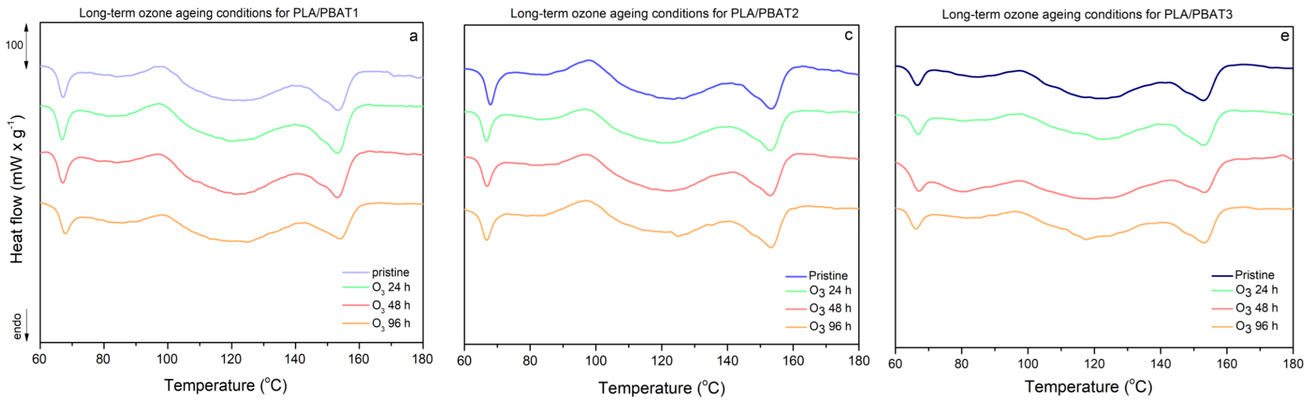
	Pristine	24 h O_3	48 h O_3	96 h O_3
TS (MPa)				
PLA/PBAT1	19.13 ± 0.55	13.77 ± 0.15	15.60 ± 0.60	20.83 ± 0.67
PLA/PBAT2	19.17 ± 0.06	15.13 ±1.00	16.43 ± 1.16	19.77 ± 0.51
PLA/PBAT3	25.30 ± 1.71	15.27 ± 0.25	22.80 ± 1.18	34.27 ± 1.42
ε (%)				
PLA/PBAT1	12.13 ± 1.06	15.07 ± 0.35	17.70 ± 070	14.40 ± 1.71
PLA/PBAT2	15.40 ± 1.31	15.67 ± 0.40	12.80 ± 0.46	16.97 ± 0.57
PLA/PBAT3	356.87 ± 41.11	273 ± 48.39	338.80 ± 6.87	336.20 ± 25.89
Ageing coefficient (S)				
PLA/PBAT1	-	0.89	1.19	1.29
PLA/PBAT2	-	0.80	0.71	1.14
PLA/PBAT3	-	0.46	0.86	1.28

- **Additive content** influenced the mechanical properties, as the PLA/PBAT3 sample showed the **highest tensile strength** and **elongation at break** due to higher plasticizer content and possible filler agglomeration.
- A **slight increase after prolonged oxidation** suggested partial surface reinforcement rather than degradation, confirming that the material retained its mechanical stability, whereas **additives buffered the effects of ozone**.

Surface morphology

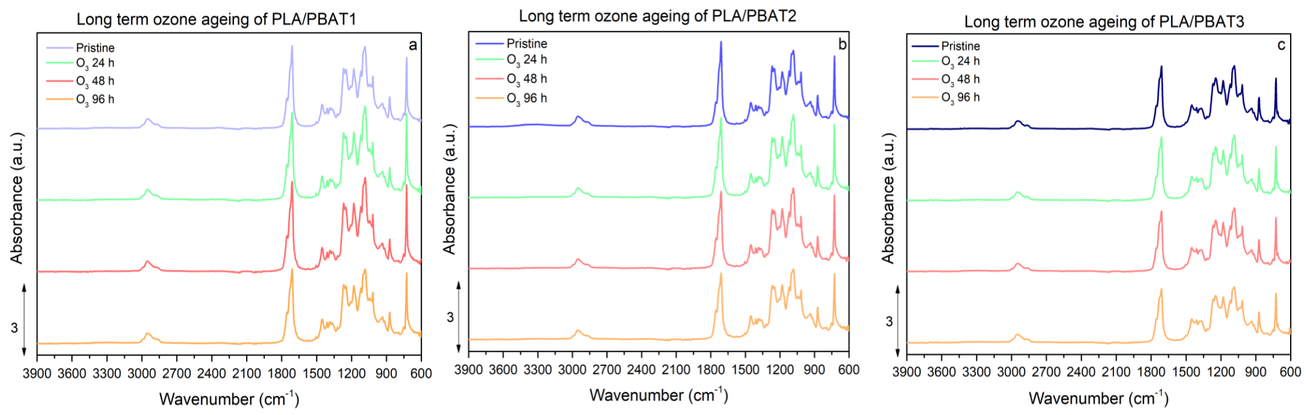


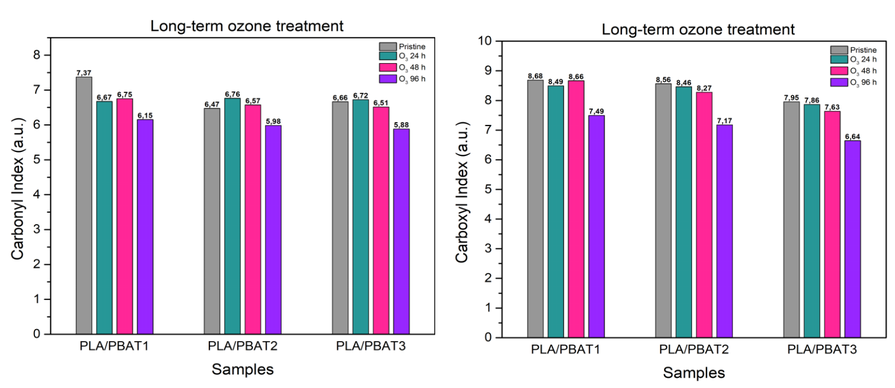
Thermal properties



- **No variations** in **thermal transition temperatures** was observed, indicating that the **bulk thermal stability** of PLA/PBAT films were maintained after ozonation.

Chemical structure





- **No formation** of **new functional groups** was confirmed.
- **Carbonyl** and **carboxyl indexes** slightly decreased (~17% and 16%) after 96 h of ozone treatment, suggesting mild surface oxidation and partial degradation of oxidized products.

- A **parabolic trend** in **surface evolution** was found, with **initial oxidation** after 24 h, temporary **reinforcement** at 48 h, and subsequent **re-degradation** after 96 h.
- The observed modifications were **limited** to the **surface**, without bulk penetration.

CONCLUSION

Long-term ozonation caused only surface modification without bulk degradation. The polymer matrix remained stable, demonstrating high chemical resistance due to the absence of reactive double bonds. The parabolic character of surface degradation suggests that ozonation time can either enhance or weaken the surface properties

FUTURE WORK / REFERENCES

Future work will evaluate the influence of **prolonged oxidation processes** (over 96 h) to verify whether **ozone treatment affects only the surface** or also causes **bulk modifications**. Furthermore, the **effect of ozone treatment** on the **biodegradation rate** and microbial activity of biodegradable polymer blends will be investigated.

[1] J.-G. Rosenboom, R. Langer, and G. Traverso, "Bioplastics for a circular economy," *Nat Rev Mater*, vol. 7, no. 2, pp. 117–137, Jan. 2022, doi: 10.1038/s41578-021-00407-8.
[2] G. I. Edo *et al.*, "Biopolymers: An inclusive review," *Hybrid Advances*, vol. 9, p. 100418, Jun. 2025, doi: 10.1016/j.hybadv.2025.100418.

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