

Determination of the UV-protecting effect of natural antioxidants in HDPE samples



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Purpose

The aim of this study was to determine the potential UV stabilizing effect of different types of natural stabilizers in Phillips-type polyethylene. Particularly for bio-based high-density polyethylene (HDPE), the effect of gallic acid (GA) as a UV stabilizer was studied by Quiles-Carrillo et al [1]. In this study, we aimed to verify the UV-stabilizing properties of gallic acid in polyethylene and investigate the potential stabilizing properties of other natural antioxidants we have already used as a processing stabilizer [2]. The UV stabilizing effect of these natural antioxidants has not been investigated.

Why natural stabilizers?

Conventional synthetic antioxidants might cause environmental and health concerns [3] that could be avoided with the application of natural antioxidants.



Materials

- Phillips type polyethylene (PE)
- Applied in 1000 ppm:
- Trans-resveratrol (RESV)
- ellagic acid (EA)
- gallic acid (GA)
- Irganox1010 (I1010)
- Songnox PEPQ (PEPQ)

Processing

- Extrusion (260 °C) and compression (190 °C)

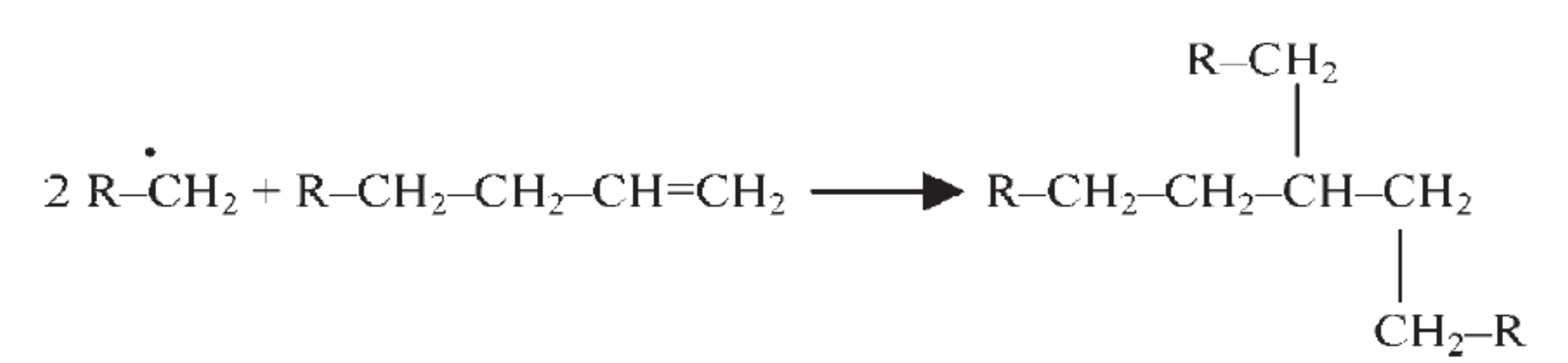
Aging

- UV chamber (60 °C, 100% UV irradiation)

Measurements

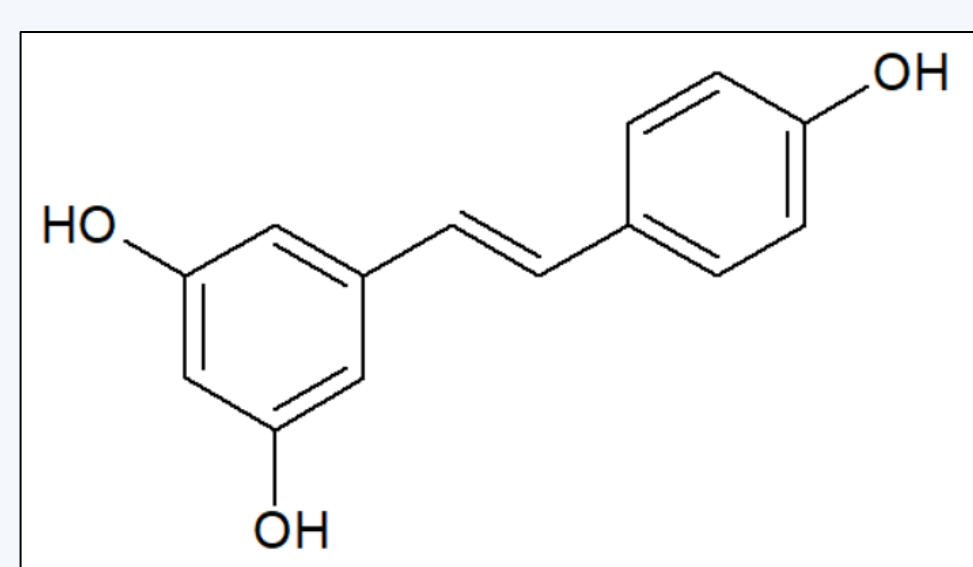
- Fourier Transform Infrared Spectroscopy (FTIR)
- Melt Flow Index (MFI)
- Oxidation Induction Time (OIT)
- Color measurements

Phillips type PE

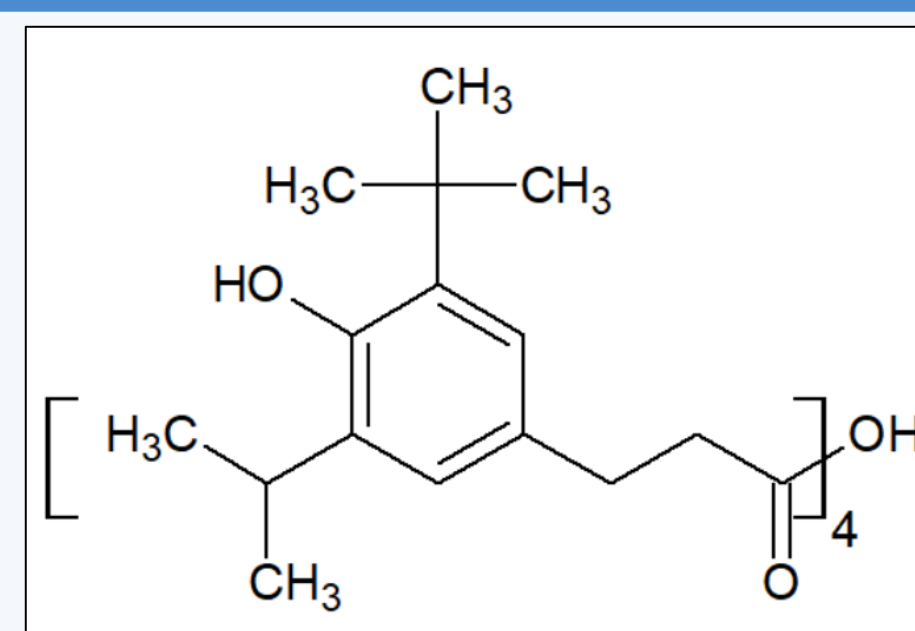


- High concentration of terminated unsaturated groups (1 vinyl/1000C).
- Formation of long chain branching.
- Vinyl groups decrease in number, flowability also decreases.

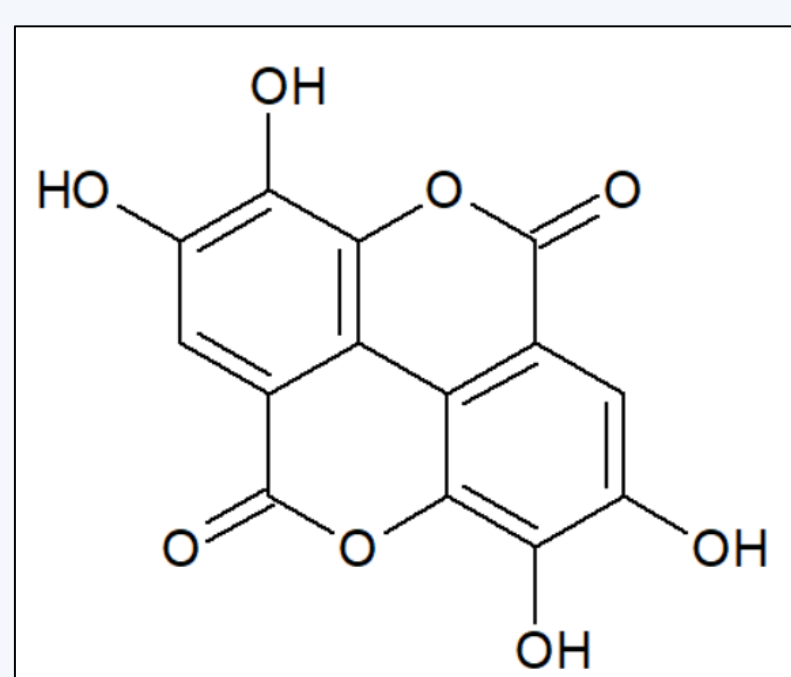
Chemical structures of primary antioxidants



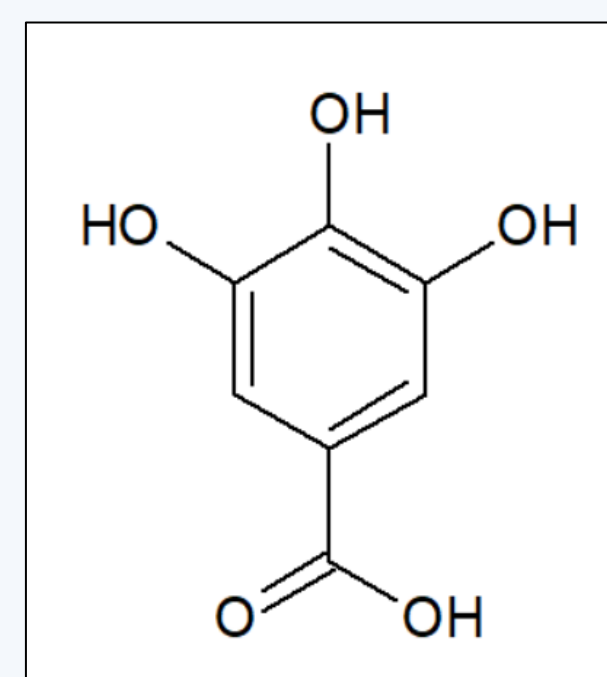
Trans-resveratrol



Irganox 1010



Ellagic acid

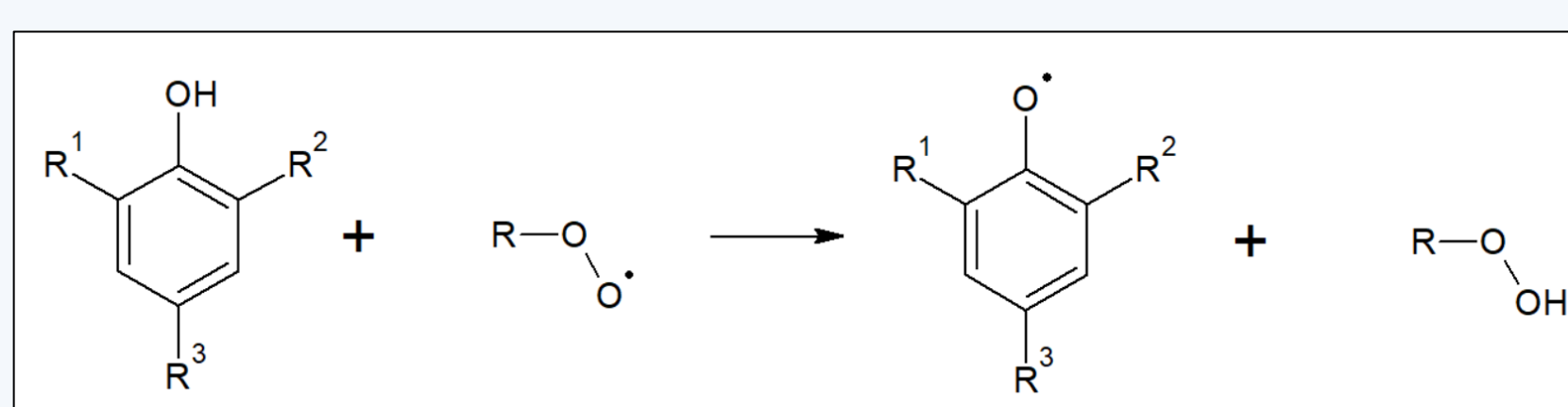


Gallic acid

Stabilization

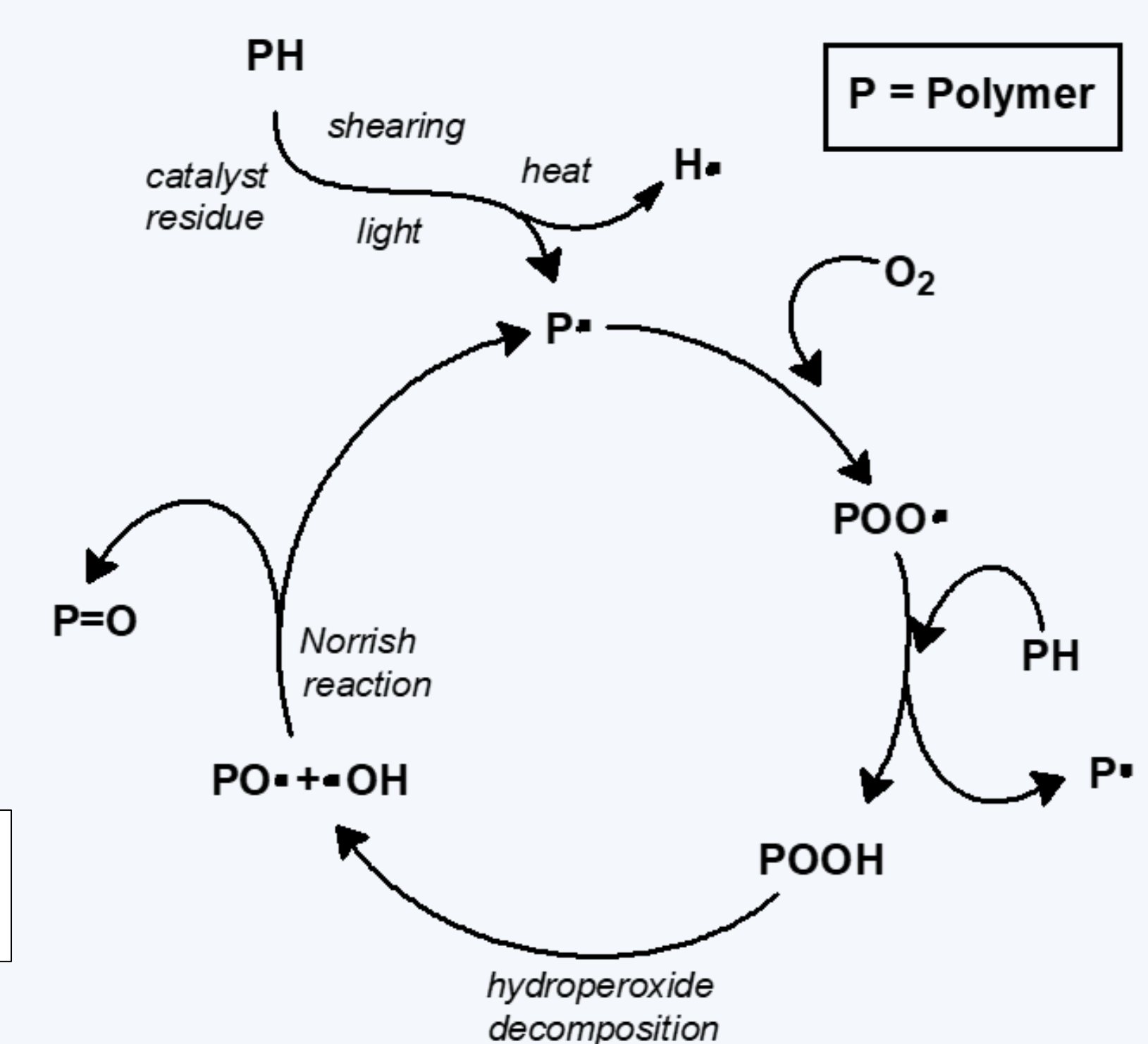
Primary antioxidants

- Hydrogen radical donor



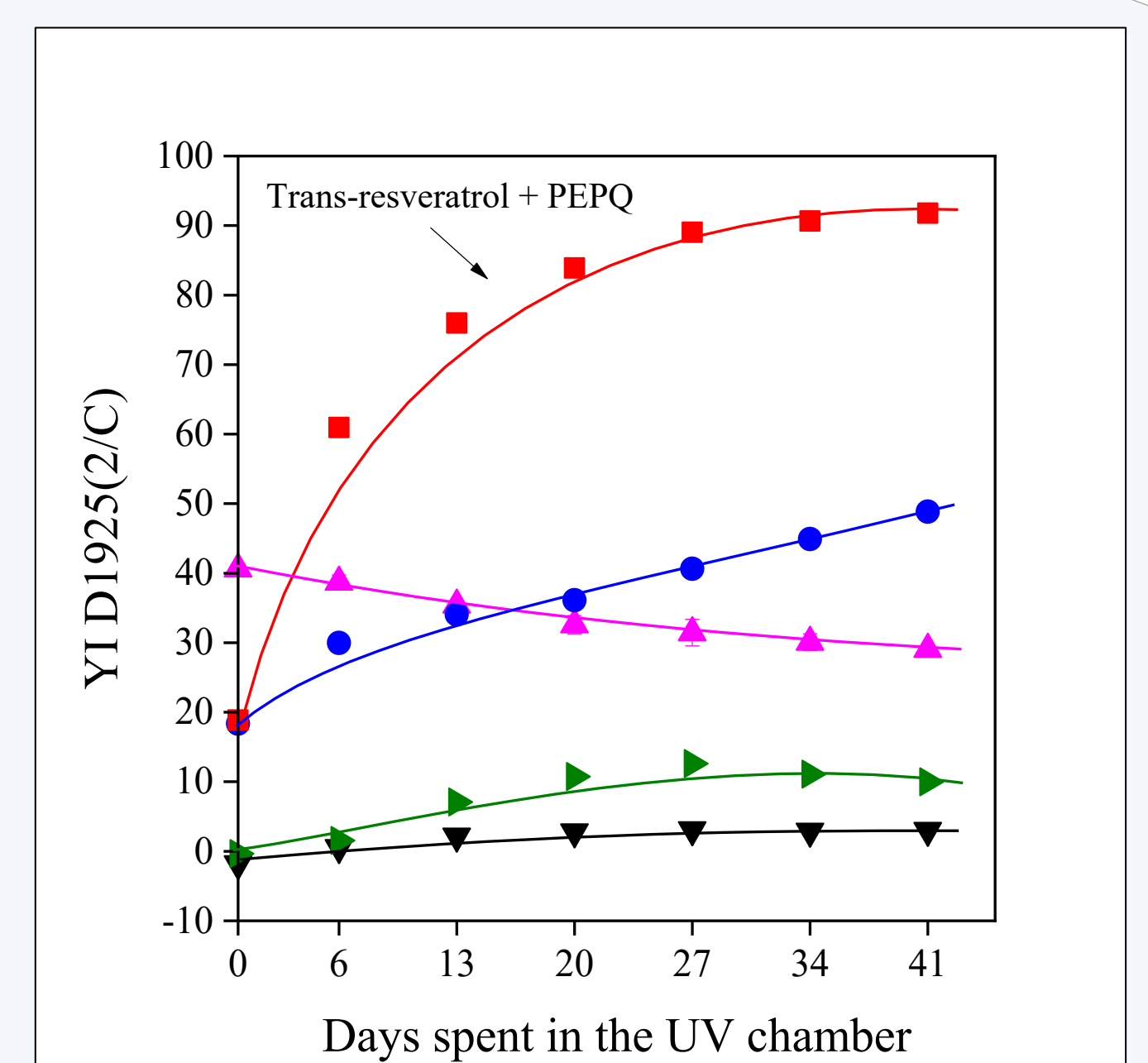
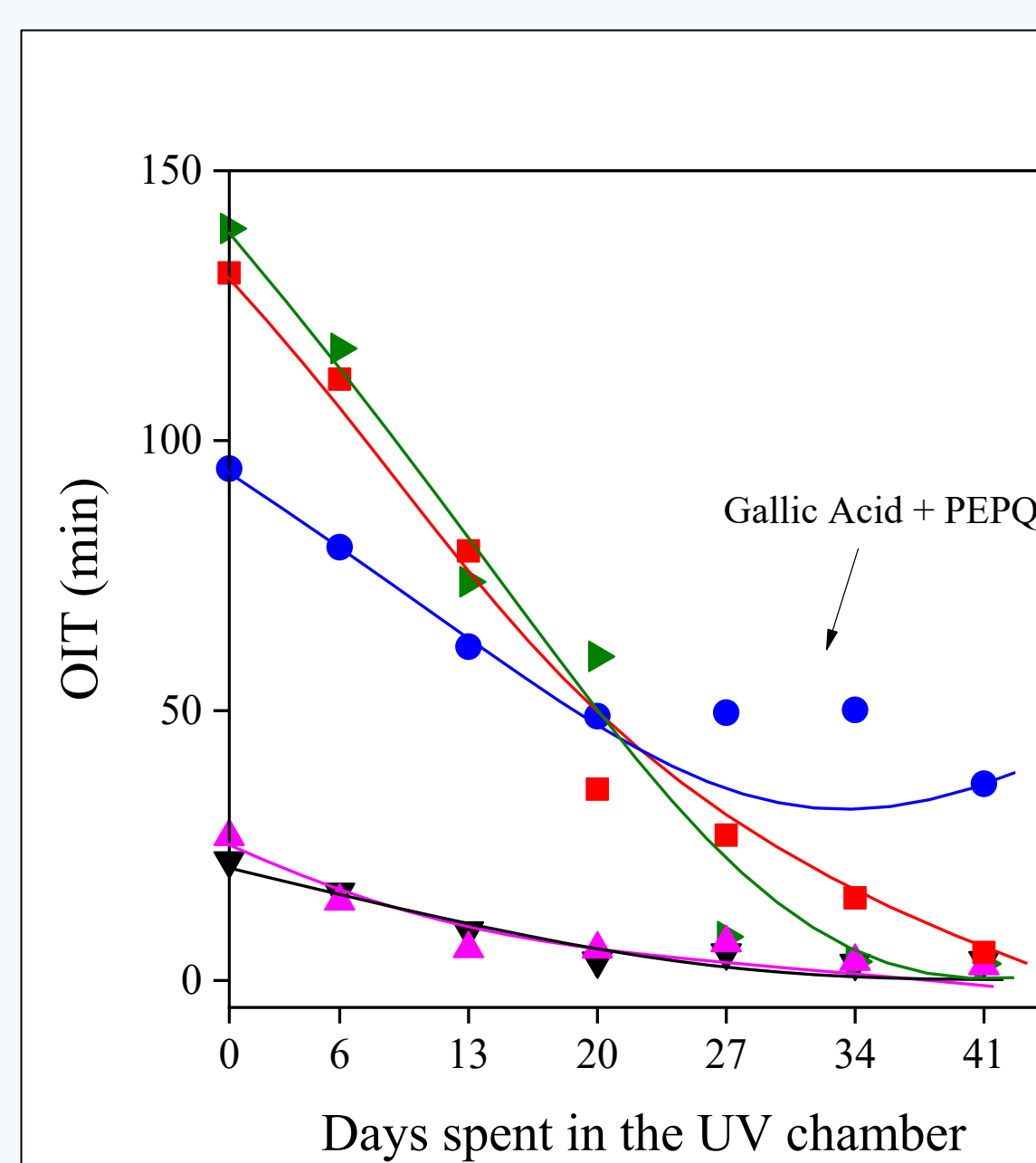
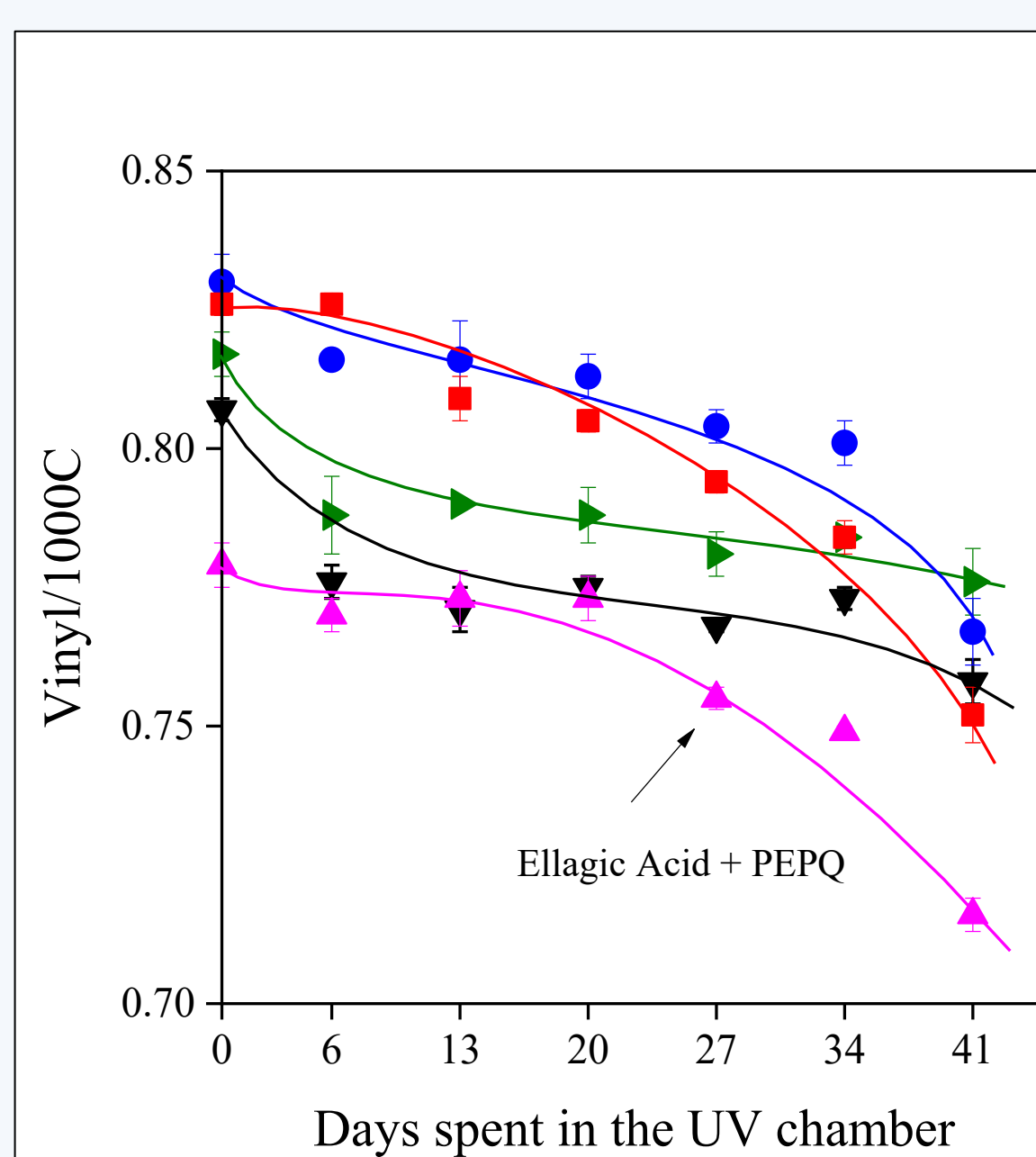
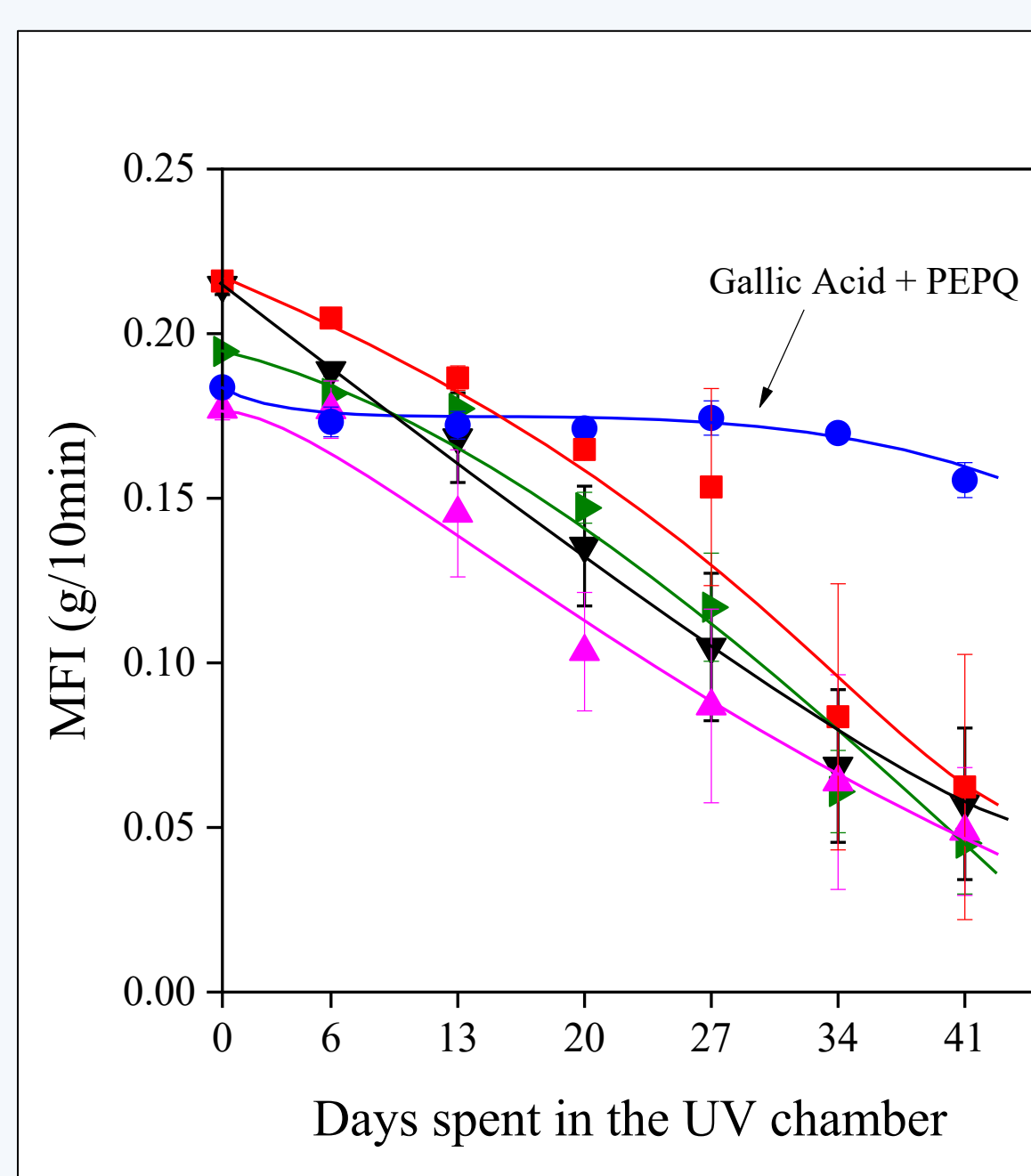
Secondary antioxidants

- Hydroperoxide decomposer



Results

- PEPQ
- I1010+PEPQ
- EA+PEPQ
- GA+PEPQ
- RESV+PEPQ



Overall, the findings indicate that gallic acid is the most effective natural antioxidant for UV stabilization among the tested samples. The GA+PEPQ combination significantly enhanced the polymer's resistance to degradation, maintaining its viscosity, flow properties, and color stability better than other antioxidants. This study highlights the importance of selecting effective antioxidant combinations, such as GA+PEPQ, to improve the longevity and functionality of polymers exposed to UV radiation.

Conclusions

Results showed that gallic acid can be used as a UV stabilizer, but the investigated other natural antioxidants and industrial ones cannot be applied.

Acknowledgement

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References

1. L. Quiles-C et al. *Polymers*, 12(1):31 (2020)
2. K. Takács et al. *Molecules* 28(3):1011 (2023)
3. D. Brocca et al. *Water Research* 36(15): 3675-3680 (2002)

