PLASTIC POLLUTION: CAN THE CHEMISTRY OF MICROPLASTICS INFLUENCE THEIR ENVIRONMENTAL IMPACT?

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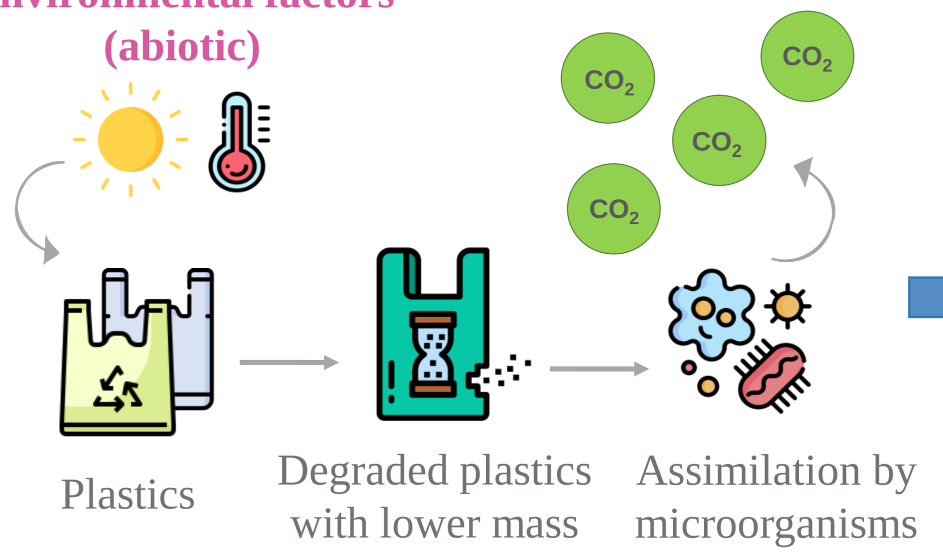
1. The Challenge

Plastic is everywhere

Biodegradable ≠ Biobased

	NON-BIODEGRADABLE	BIODEGRADABLE
BIO-BASED	BIOPLASTIC: Biobased polyethylene	BIOPLASTIC: Polylactic acid (PLA)
FOSSIL-BASED	CONVENTIONAL: Low density polyethylene (LDPE)	BIOPLASTIC: Polycaprolactone (PCL)



Can we mimic the formation of microplastics in the laboratory?

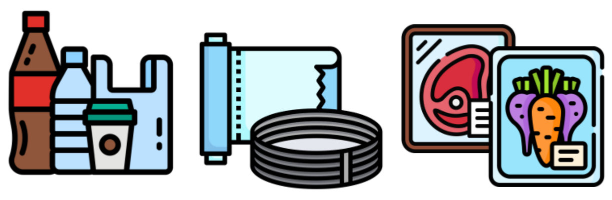
Artificial weathering!

2. Research objectives and methodology

Ob1: Artificial weathering of plastics and characterisation → **Ob2:** Link between weathering and chemical structure → **Ob3:** Environmental impact of artificial plastic fragments

a. Plastics with different chemistry

Polyethylene is the most ubiquitous type of plastics in the environment due to its use:



LDPE
Fossil-based and non biodegradable

OXO LDPE
Fossil-based with degradation catalyst

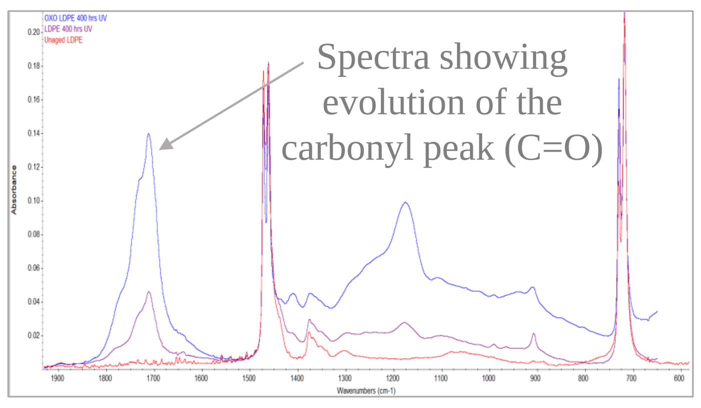
b. Accelerated artificial weathering

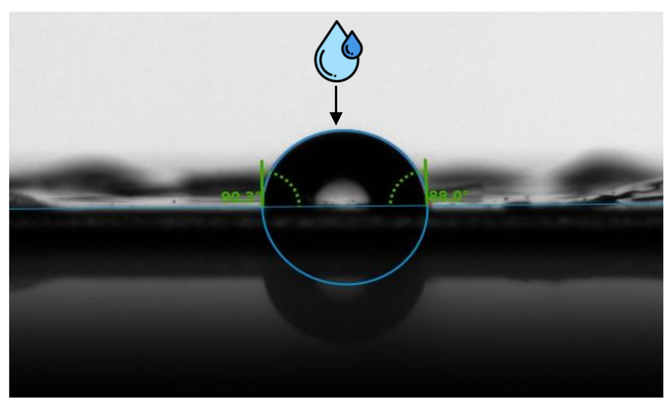
SUNLIGHT - PHOTO DEGRADATION
- Q-Lab QUV® Accelerated Weathering tester
- Main degradation factor in the environment
- **Degradation continues** if sunlight is removed

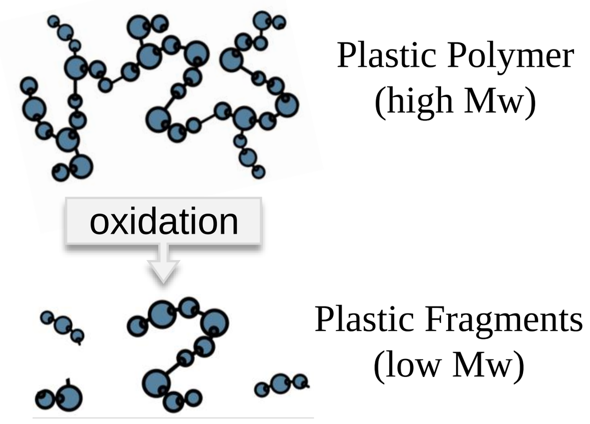
HEAT - THERMAL DEGRADATION
- Oven (50-70 °C)
- Influences secondary photochemical reactions
- Degradation rate is **temperature-dependent**

c. Characterisation of polymer degradation

Preparation of unaged and aged **plastic samples** → **Infrared spectroscopy** to **quantify oxidation** → Changes to **surface hydrophobicity** by **contact angle** → Decrease of **molecular weight** by **gel permeation chromatography**

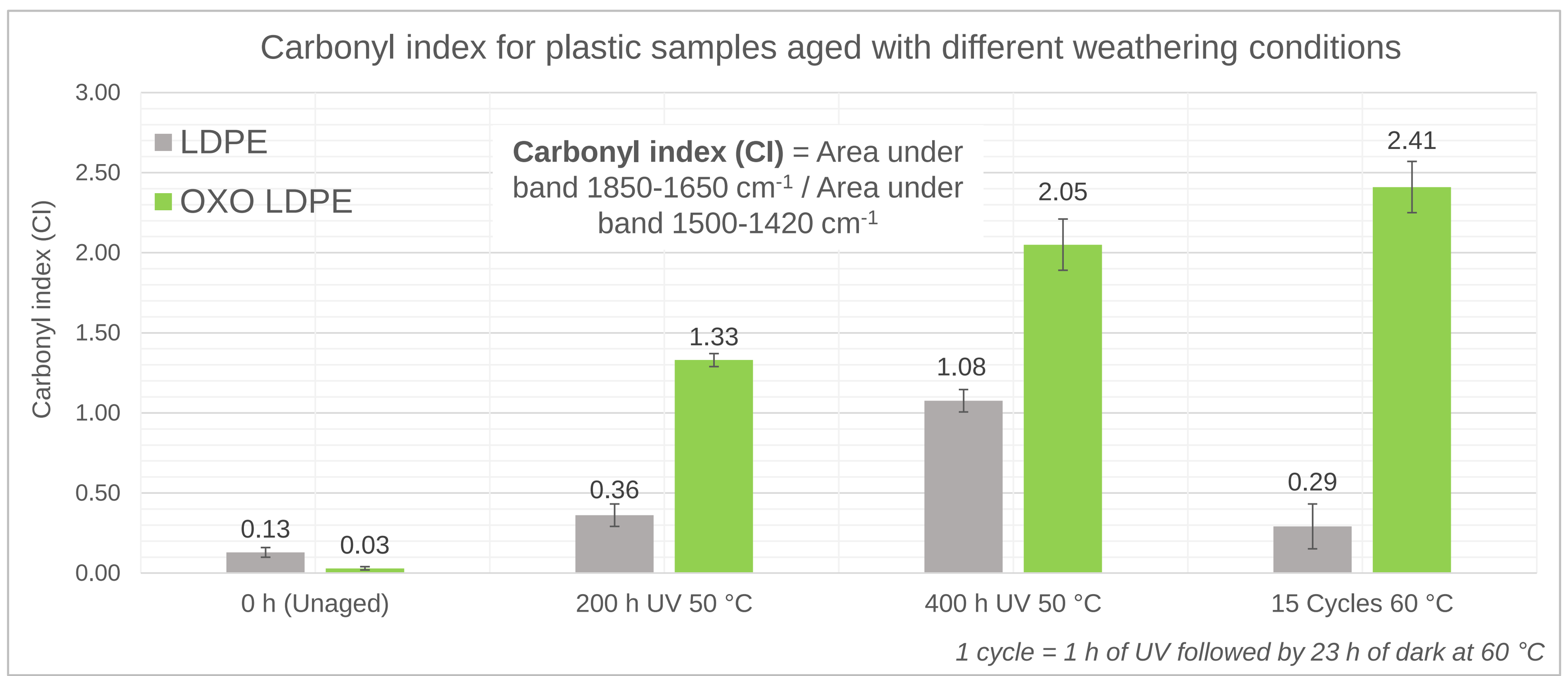






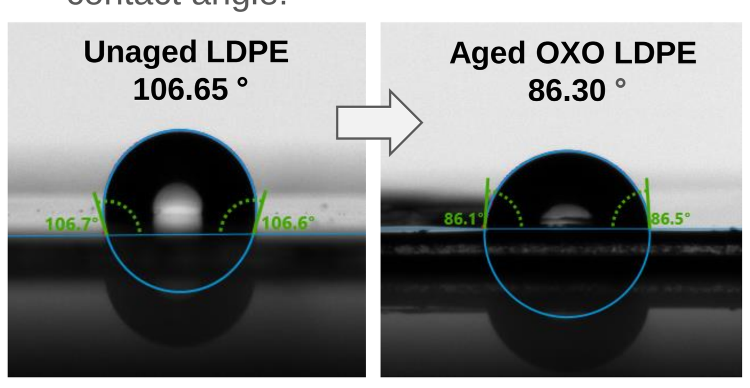
3. Artificial weathering: LDPE *vs.* OXO LDPE

Method: Plastic samples subjected to different ageing conditions, via a combination of photo-oxidation (UV) and thermo-oxidation (heat) at different temperatures and different times.



Carbonyl index data provide evidence that different ageing protocols have varying effects depending on the type of plastic and weathering.

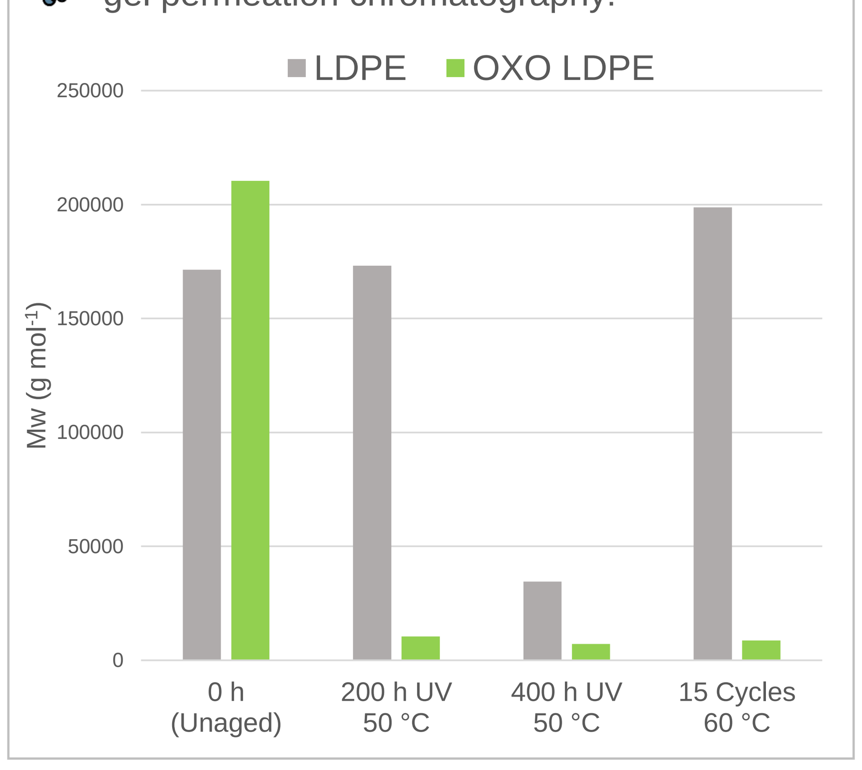
Changes in surface hydrophobicity by contact angle:



Formation of hydrophilic carbonyl groups on the surface decrease the contact angle

CA (°)	0 h Unaged	200 h UV 50 °C	400 h UV 50 °C	15 Cycles 60 °C
LDPE	106.65	104.50	97.90	106.52
OXO LDPE	104.64	95.19	74.95	78.75

Changes in molecular weight determined by gel permeation chromatography:



The presence of a degradation catalyst in OXO LDPE results in fragments with different chemical structure and morphology being formed with artificial weathering.

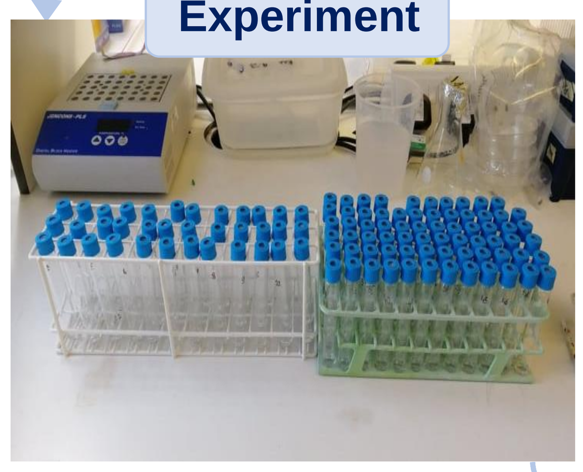
4. Environmental impact of plastic fragments

Method: Plastic samples incubated with *Rhodococcus rhodochrous*. Graph demonstrates the amount of CO_2 released by the bacteria depending on plastic type and ageing conditions as a result of microbial assimilation.

Cultivate media and bacteria

Bacteria: *Rhodococcus rhodochrous*

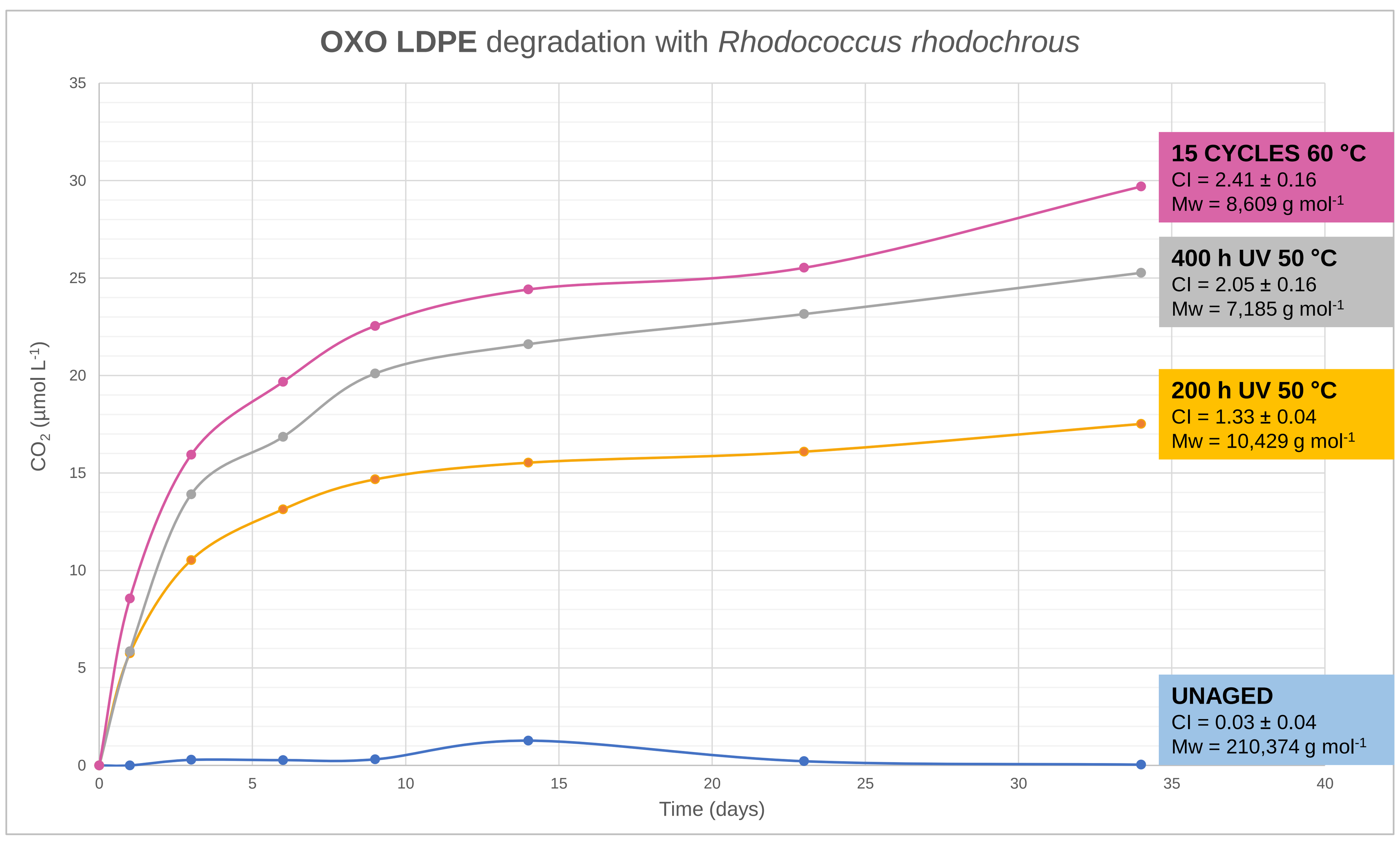
Experiment



Incubation with plastics

Bioassimilation

CO_2 monitoring by gas chromatography



OXO LDPE (15 Cycles 60 °C) shows higher amount of CO_2 release. Unaged OXO LDPE shows the least.

5. Conclusions

- **The combination of photodegradation (UV) and thermal degradation (heat) can be used successfully for artificial weathering.**
- **Different plastics respond differently to ageing protocols, leading to fragments with specific chemistry.**
- ***Rhodococcus* differentiates plastic types according to weathering conditions.**
- **The environmental impact of plastic fragments will be the result of close interdependence between abiotic and biotic degradation mechanisms.**

References

Jambeck, et al. (2015). Moore, et al. (2008). Thompson, et al. (2009). BSI PAS 9017:2020. Almond, et al. (2020). European Bioplastics (2019). Song, et al. (2009). Lucas, et al. (2008).

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