PLASTIC POLLUTION: UNDERSTANDING THE CHEMISTRY OF DEGRADATION AND ITS ENVIRONMENTAL IMPACT

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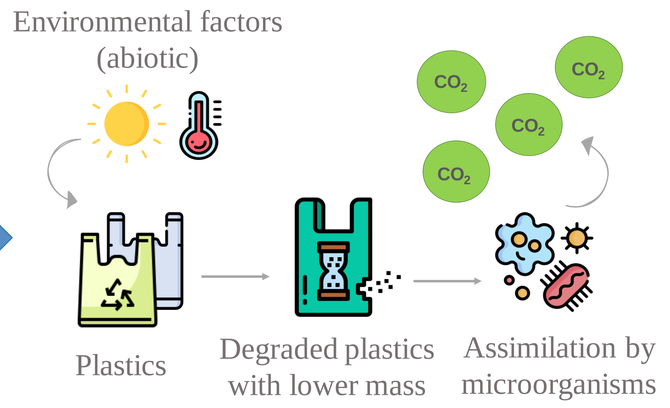
1. The Scientific Question

So much plastic everywhere

Biobased ≠ Biodegradable

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



How does plastics' chemistry and weathering influence their environmental impact?

2. Research objectives and methodology

Ob1: Artificial weathering of plastics using different protocols → **Ob2**: Characterisation of chemical degradation → **Ob3**: Correlation between weathering protocols and chemical structure

a. Plastics with different chemistry

LDPE
Fossil-based and non biodegradable

OXO LDPE
Fossil-based with pro-oxidant additive

PLA
Biobased and biodegradable

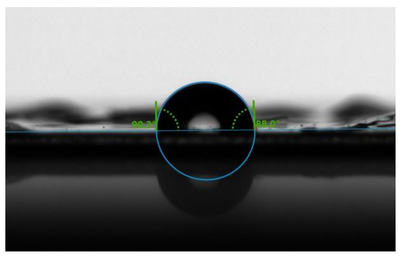
b. Accelerated artificial weathering

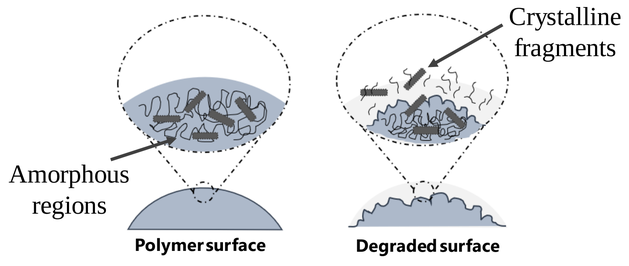
SUNLIGHT - PHOTO DEGRADATION
- Q-Lab QUV® Accelerated Weathering tester
- Main degradation in the environment
- **Degradation continues** if sunlight removed

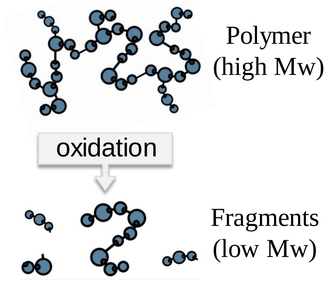
HEAT - THERMAL DEGRADATION
- Oven (50-70 °C)
- Influences secondary photochemical reactions
- Degradation rate **temperature-dependent**

c. Evaluation of polymer degradation

Preparation of unaged and aged **plastic samples** → **Spectra collected** by attenuated total reflection on **FT-IR** → Modifications **surface hydrophobicity** by **contact angle** → Changes in polymer **crystallinity** by **DSC** → Decrease of **molecular weight** by **HT-GPC**



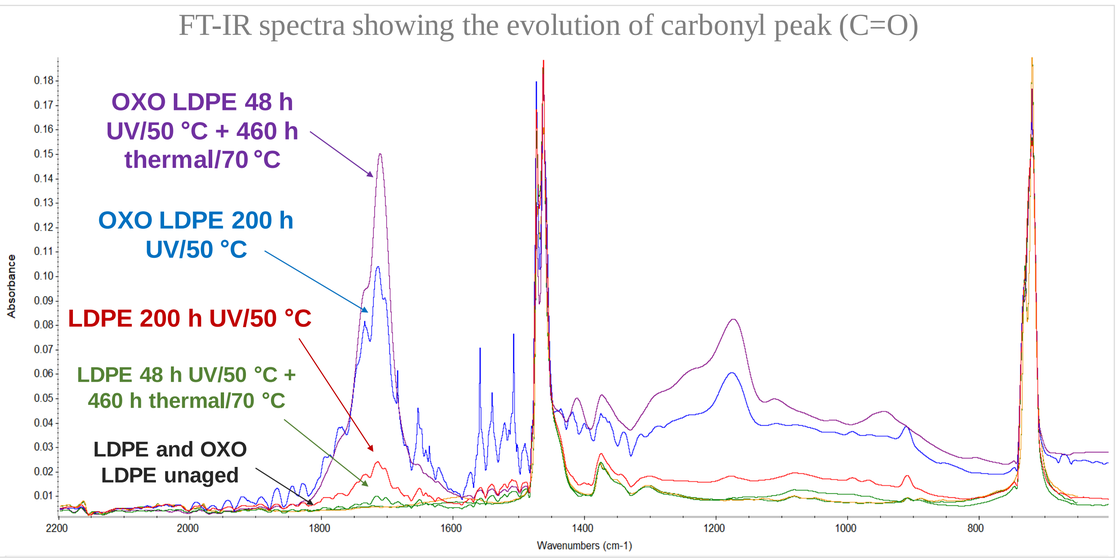




3. Artificial weathering: LDPE vs. OXO LDPE

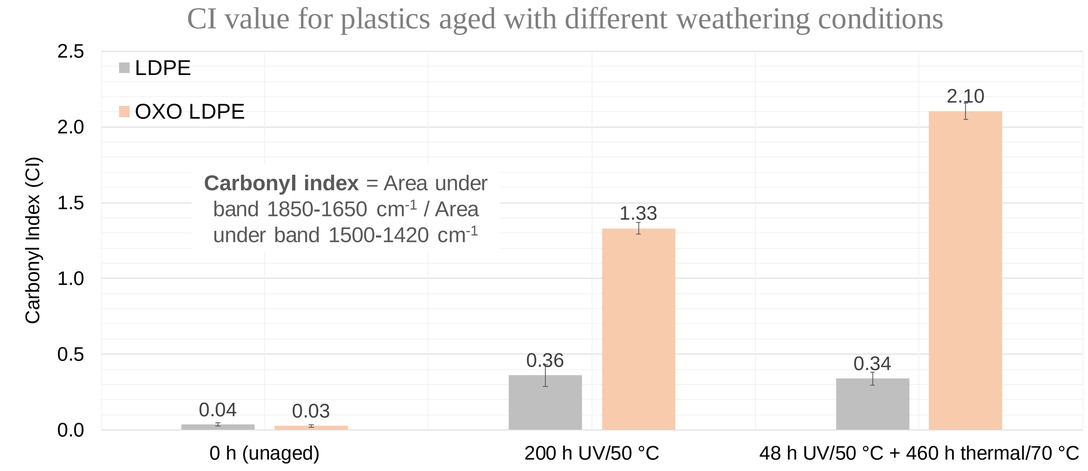
Method: Plastic samples subjected to different ageing conditions consisting of a combination of photo-oxidation (UV) and thermo-oxidation (heat) at different temperatures and different times.

FT-IR spectra showing the evolution of carbonyl peak (C=O)



The carbonyl peak (C=O) of OXO LDPE degraded with combination of UV and heat is more important than other samples.

CI value for plastics aged with different weathering conditions

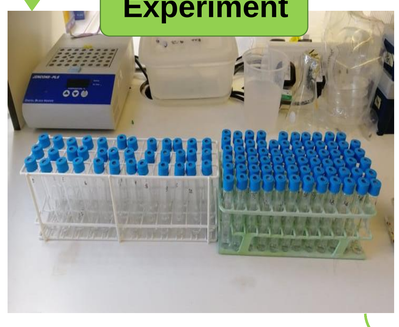


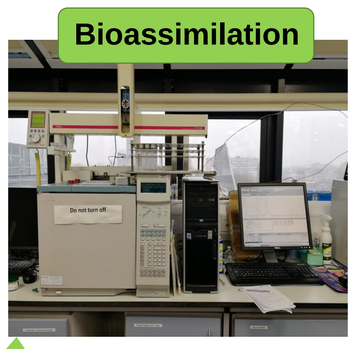
CI more important for OXO LDPE (48 h UV/50 °C + 460 h thermal/ 70 °C). Heat plays a role in the degree of oxidation for OXO LDPE because of the catalysed degradation mechanism.

4. Microbial degradation of plastics

Method: Plastic samples incubated with *Alcanivorax borkumensis*. 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 → **Experiment** → **Bioassimilation**



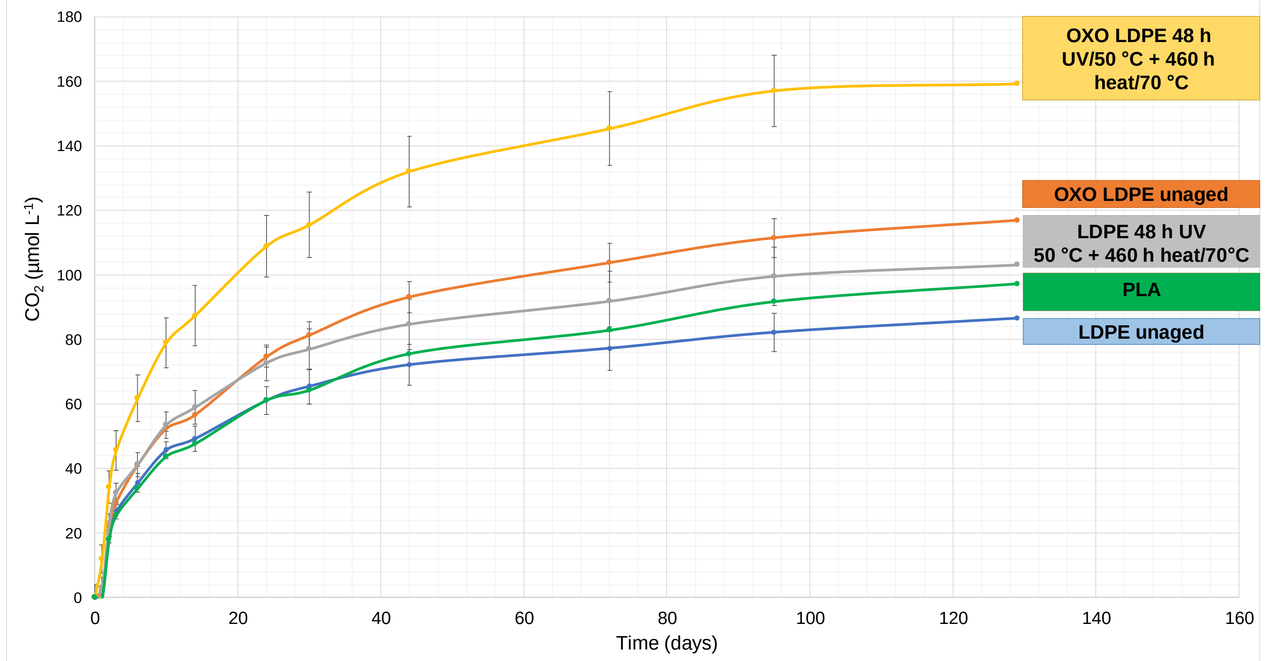


Bacteria: *Alcanivorax borkumensis*

Incubation with plastics

CO_2 monitoring by gas chromatography

Polymer degradation with *A. borkumensis* in µmol L^{-1}



OXO LDPE (48 h UV/50 °C + 460 h heat 70 °C) shows higher amount of CO_2 release. Unaged LDPE shows the least.

5. Conclusions

The combination of photodegradation (UV) and thermal degradation (heat) results in an excellent protocol for artificial weathering.

Measurement of carbonyl index (CI) provides evidences of formation carbonyl species.

***Alcanivorax borkumensis* differentiates plastic types according to weathering conditions.**

The interdependence of abiotic and biotic degradation mechanisms can be distinctively correlated with the modifications occurring in aged plastics.

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).