Degradation of plasma pre-treated LDPE films by a fungal consortium

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Introduction

Plastic production reached 400Mt in 2022 and the management of plastic waste is one of the biggest challenge today. Many research try to develop a biological way to treat plastic wastes, but **biodegradation takes time and the rate is often low**.

Low-density polyethylene (LDPE) is one of the most produced plastic, but it is recalcitrant to biodegradation due to its inert backbone (C and H only).

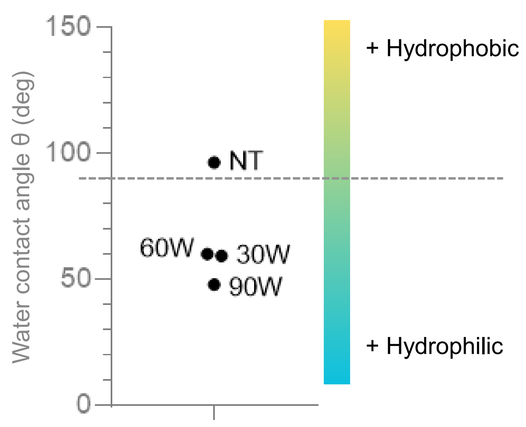
Objectives: to treat LDPE films with plasma to **enhance the action of a fungal consortium and improve biodegradation.** The obtained fungal biomass will finally be transformed into a mycelium-based material.

Here, we studied the **chemical and physical modifications of LDPE surfaces due to plasma treatment,** at different powers, and its **impact on fungal growth on LDPE films.**

Results

Hydrophobicity

Plasma-treated LDPE films are less hydrophobic than non treated ones (water contact angle is lower).



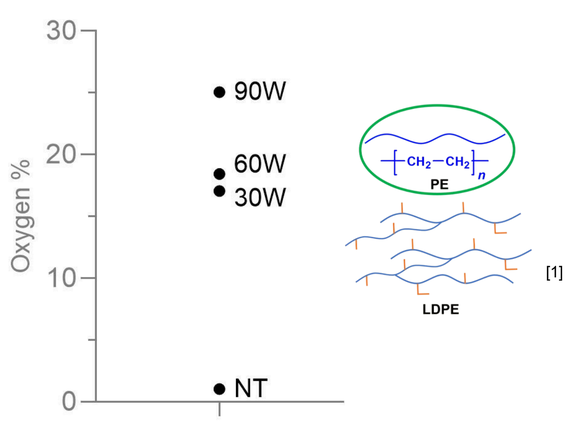
The more the power of plasma treatment, the more hydrophilic the surface because the more the WCA decreases (θ<90°).

Non-treated (NT) LDPE films are hydrophobic (θ>90°).

30W, 60W and 90W are the plasma powers applied to treat LDPE films.

Chemical groups on the surface

The more the plasma power, the more oxygen groups on the surface of LDPE films.



X-ray photoelectron spectroscopy (XPS) results.

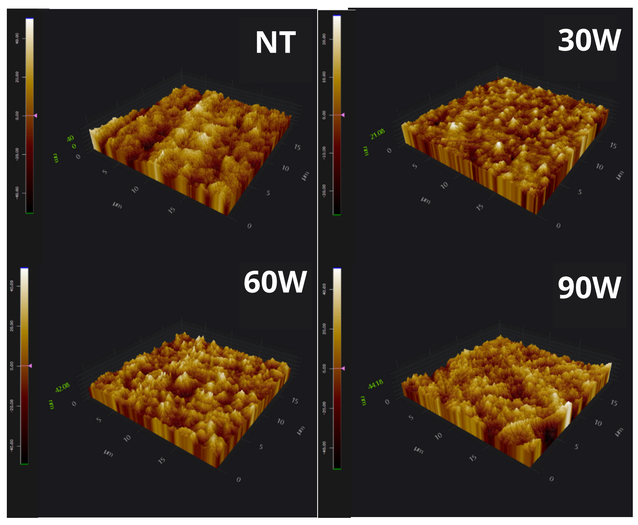
Oxygen groups are mainly hydroxyl, then ether, carbonyl and ester.

Non-treated (NT) films surface: 1.03±0.32% of oxygen.

[1] Burelo, M., Hernández-Varela, J. D., Medina, D. I. & Treviño-Quintanilla, C. D. Recent developments in bio-based polyethylene: Degradation studies, waste management and recycling. Heliyon 9, e21374 (2023).

Roughness

Plasma treatment modifies surface roughness and patern of LDPE films.



Atomic force microscopy (AFM) 3D views of LDPE films.

NT: non-treated

30W, 60W and 90W are the plasma powers applied to treat LDPE films.

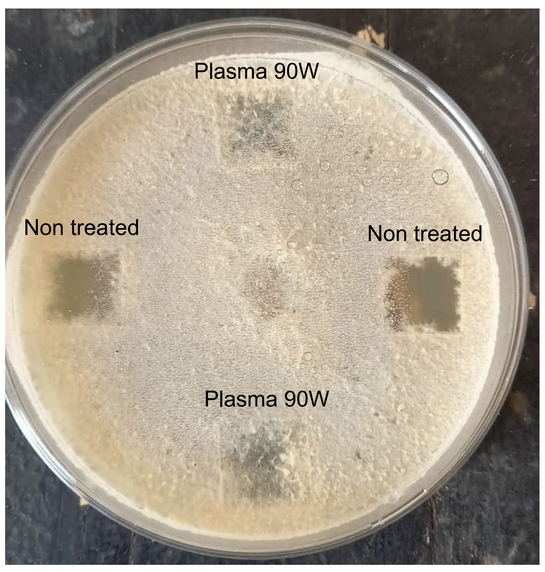
Fungal growth on LDPE films

Three fungi are studied:

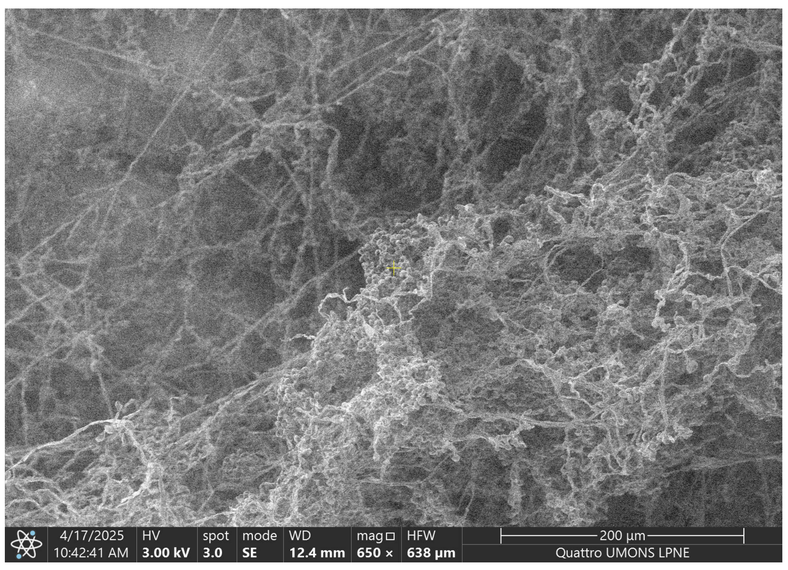
-*Phanerochaete chrysosporium* colonise more plasma-treated films than non treated ones.

-*Pleurotus ostreatus* colonise all films, wether treated or not (image not shown).

-*Trametes versicolor* do not form a dense biofilm on LDPE films, treated or not (image not shown).

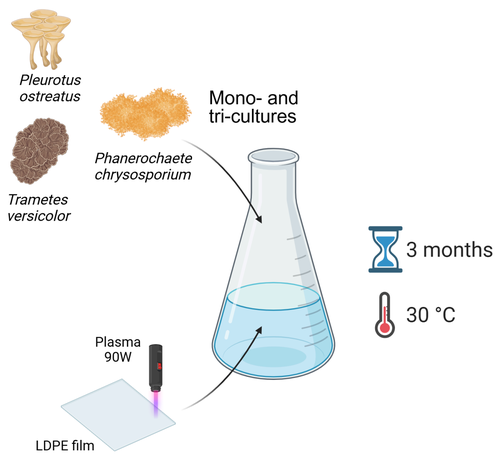


P. chrysosporium growth on malt extract agar plate, after 31 days at 30°C.



Mycelium network of *P. chrysosporium* on plasma-treated films, after 31 days (Environmental scanning electron microscopy - ESEM).

Ongoing experiments



Analysis every month:

-plastic weight loss
-enzymatic activity (laccase, lignin peroxidase, manganese peroxidase, esterase)
-proteomic on extracellular and intracellular proteins
-plastic surface: Environmental scanning electron microscopy (ESEM) and Infrared (IR)
-fungi proportion for tri-cultures

Conclusion

Plasma treatment modifies rugosity and chemical groups of LDPE films surface, thus decreasing hydrophobicity.

Those parameters can improve adhesion of microorganisms on the surface, as we observed for *P. chrysosporium.*

Easier adhesion may help to increase biodegradation: this will be analyzed in the coming months.

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