Degradation of PET Microplastics by Controlled Microbial & Photocatalytic, MoO_3, Exposure

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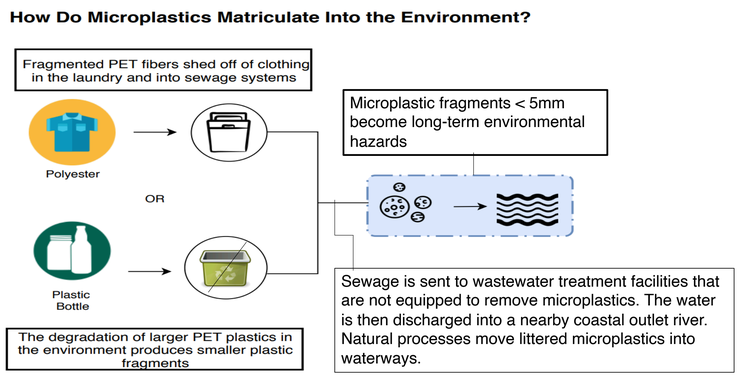
Background

- Polyethylene Terephthalate (PET) is a high-strength synthetic fiber used to manufacture common household items like clothing and water bottles.
- Annually, ~150-250 million tons of PET accumulates in landfills or the environment as microplastics[1].



- PET waste is especially concerning because the nature of its polymer makes it extremely difficult to hydrolyze and creates a potential for chemical toxicity in seafood. This toxicity has unknown implications on human health.
- This research project will compare the degradation of PET microplastics in water by two different means:
  - Soil microbial degradation of the PET
  - Photocatalytic MoO_3 Visible Light Exposure
    - The MoO_3, Molybdenum Trioxide, nanoparticle was selected for its photocatalytic ability in visible light

Synthesis of the nanoparticles:

Hydrothermal Reactor

$(NH_4)_6Mo_7O_{24}{\cdot}4H_2O + HNO_3$ → 90°C for 3 hours

MoO_3 Nanoparticles

Fig.1 Aka 2018.[2]

Objectives

The main goal of this project is to investigate the biological and chemical processes of microbial and photocatalytic exposure in the degradation of PET.

Acknowledgements

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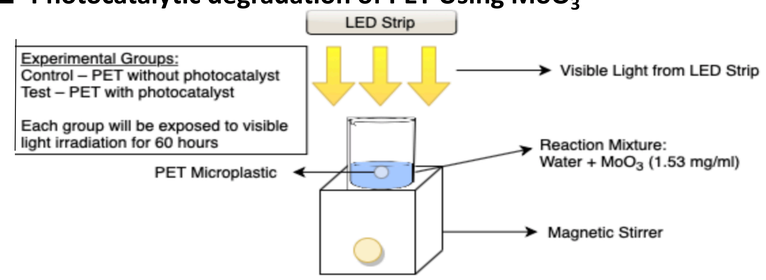
- Thank you to Zachary Holt and Hoang Nguyen for guiding me for these 12 weeks. You both have taught me so much.

Methodology

❑ Photocatalytic degradation of PET Using MoO_3

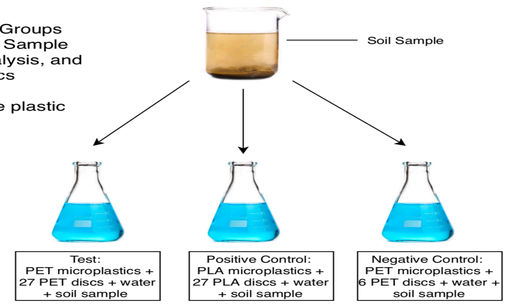


Experimental Design for Photocatalytic Degradation

❑ Biodegradation of PET

Setting:
- 16 Soil Samples
- Incubation of Experimental Groups
- 3 Experimental Groups Per Sample
- FTIR/Raman, Confocal Analysis, and Community Analysis on discs every 8 weeks

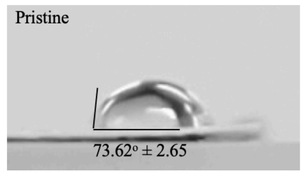
*PLA is known biodegradable plastic



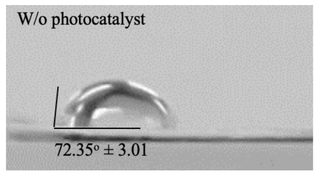
Results

❑PET Photocatalytic degradation

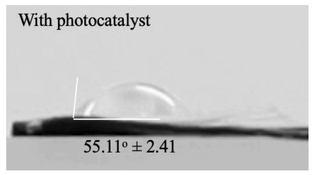
Contact Angle Analysis



Water Droplet on Pristine PET

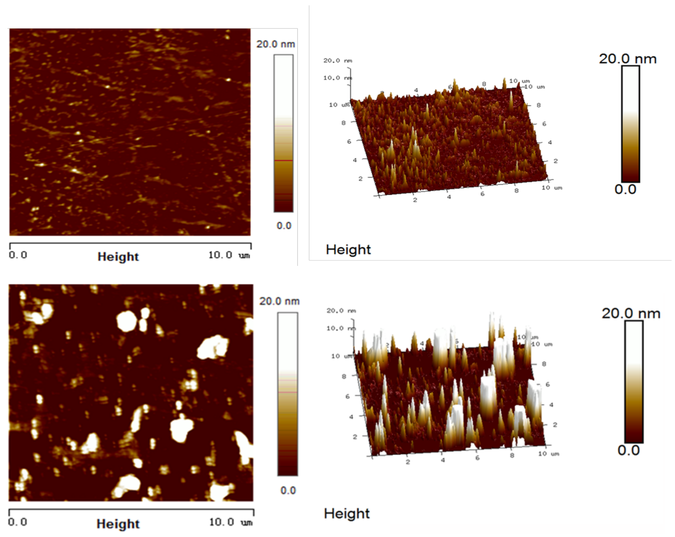


Water Droplet on PET exposed without photocatalyst



Water Droplet on PET exposed with photocatalyst

Atomic Force Microscopy



PET Exposed to Light without Photocatalyst
Image R_q: 2.22 ± 0.44 nm
Image R_a: 1.59 ± 0.26 nm

PET exposed to light with photocatalyst
Image R_q: 17.34 ± 7.32 nm
Image R_a : 10.38 ± 4.90 nm

❑Biodegradation

Experiment is still ongoing but we expect:

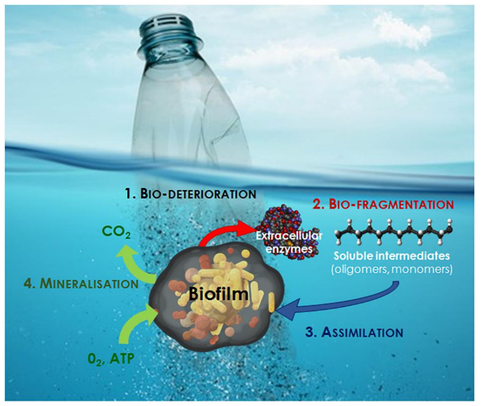


Image Source: Front. Microbiol., 25 April 2019 | https://doi.org/10.3389/fmicb.2019.00865

- **PLA to biodegrade quicker than PET**
- **PET to present some biofilm growth and changes to the plastic surface.**
- **Most likely, the functional groups broken by biological processes will be different than the groups broken by photocatalytic degradation**

Conclusions

- In this research, photocatalytic degradation of PET with MoO_3 under visible light irradiation for 60 hours was found to be effective in cleaving the bonds of the PET polymer and making visible changes to the plastic surface.
- Controlled biodegradation on PET is a comparatively longer, multi-step process that has not yet proven to be useful in this study.
- Furthermore, there are limitations to photocatalytic degradation of PET in wastewater treatment and more research needs to be done to establish proper parameters for exposure time when using MoO_3 as a photocatalyst in water.

References

1. Geyer, R., Jambeck, J. R. & Law, K. L. Production, use, and fate of all plastics ever made. *Sci. Adv.* **3**, e1700782 (2017).
2. Aka, Marie, et al. "Removal of Pharmaceutical Contaminants in Water Using Photocatalytic Nanomaterials, MoO_3." Undergraduate Research Day. The University of Houston. Houston, Tx. April 2018. Poster Presentation.