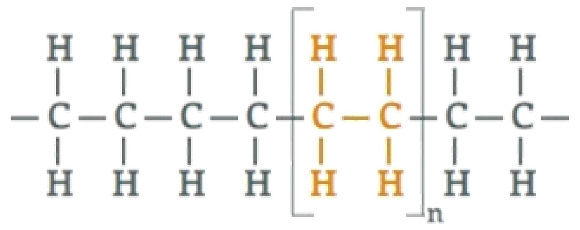
Up-cycling Process Feasibility for Coupled Radiolytic and Biochemical Conversion of Polyethylene



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Background

- There are currently no sustainable industrial scale processing routes for the recovery and conversion of 'low value' plastics such as polyethylene (PE).
- This research investigated the *proof-of-concept* of using gamma radiation to initiate the chemical functionalization and depolymerization of PE in aqueous solutions (water and saltwater) followed by biochemical conversion to yield useful synthetic feedstocks.

The Science

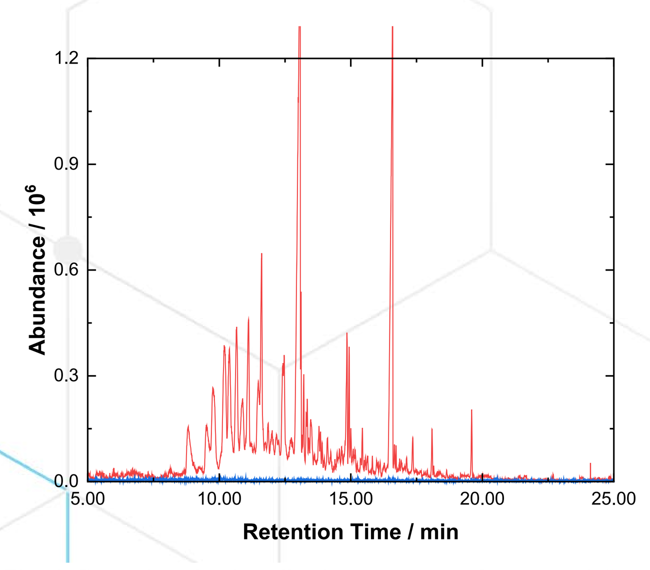


Fig. 1. Procedure for the effective treatment of commercially procured PE to remove residual contaminants. GCMS chromatogram of volatile organic compounds present in commercial PE (red) and the absence of these compounds after 50 h of heating at 70 °C (blue).

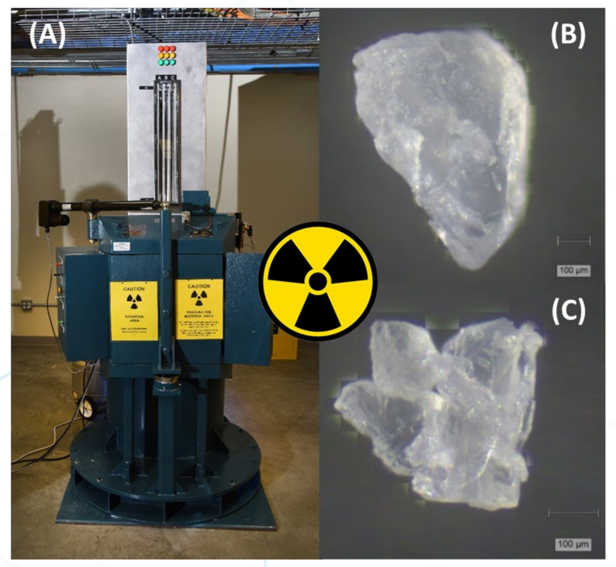


Fig. 2. The *INL Center for Radiation Chemistry Research* high dose gamma irradiator **(A)**, within which PE was irradiated in anaerobic aqueous solutions, and then analyzed by dark field microscopy: non-irradiated PE **(B)**, and an irradiated PE **(C)**.

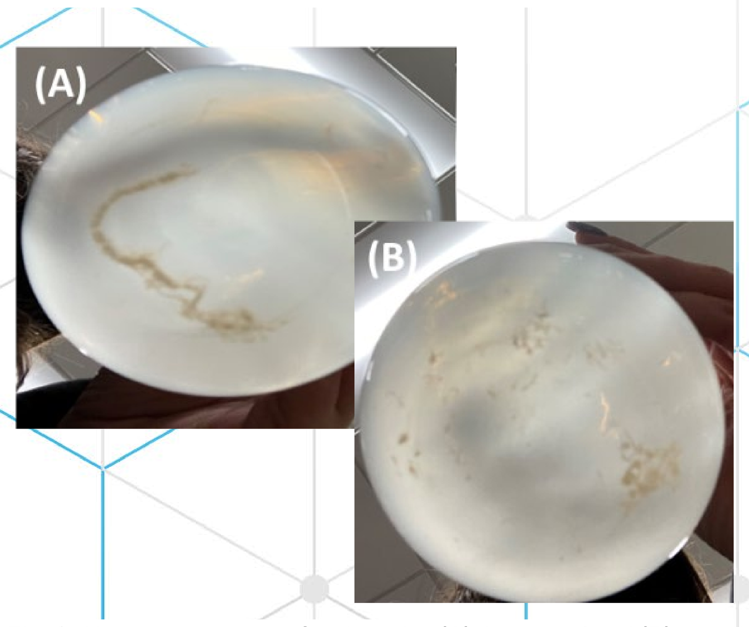


Fig. 3. *Neurospora crassa* after 4 weeks: **(A)** the control and **(B)** treated with irradiated PE, which was unable to survive.

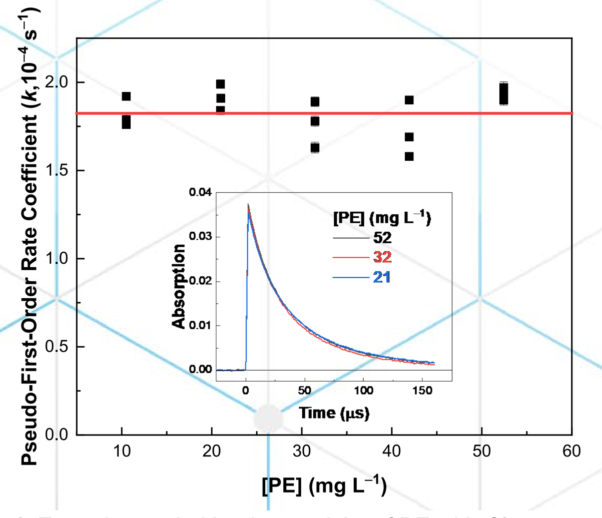
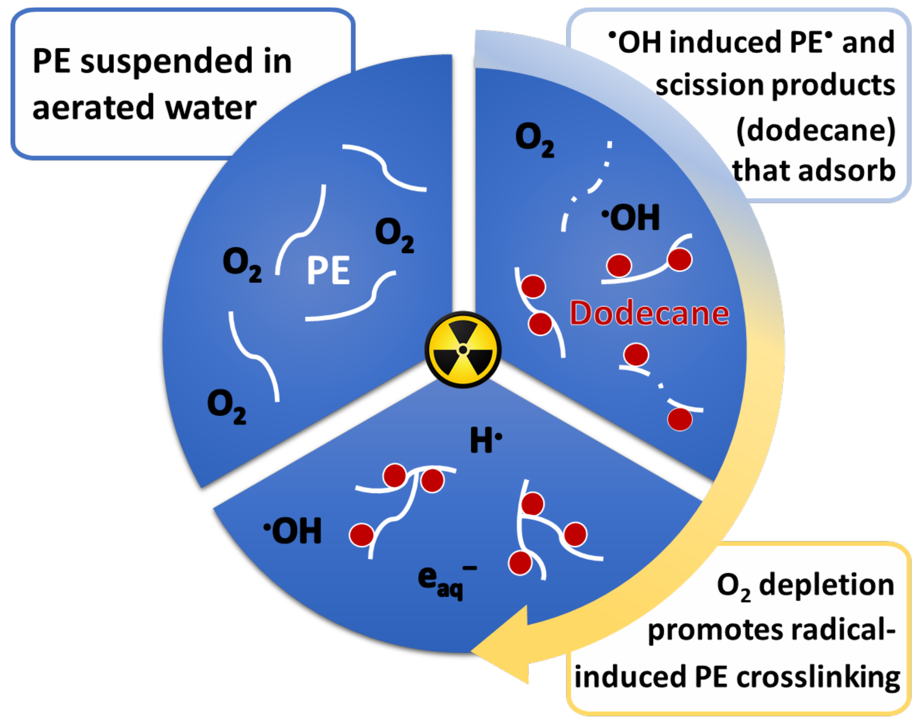


Fig. 4. Zero change in kinetic reactivity of PE with $Cl_2^{\bullet-}$ as a function of the concentration of PE in saltwater at ambient temperature. *Inset*: Decay traces for $Cl_2^{\bullet-}$ at 340 nm for 21, 32, and 52 mg L^{-1} of PE in saltwater solution.

Conclusions

- *Anaerobic* conditions and *saltwater* are not practical conditions for gamma radiation-induced chemical changes in PE for viable biochemical digestion by the fungus *Neurospora crassa*.



Research Outputs

Peer-Reviewed Publications

1. Peller, Mezyk, Shidler, Castleman, Kaiser, and Horne, The reactivity of polyethylene microplastics in water under low oxygen conditions using radiation chemistry. *MDPI Water* (Impact Factor = 2.544), **2021**, *13*, 3120. DOI: https://doi.org/10.3390/w13213120.
2. Peller, Mezyk, Shidler, Castleman, Kaiser, Faulkner, Pilgrim, Wilson, Martens, and Horne, Facile nanoplastics formation from macro and microplastics in aqueous media. *Environmental Pollution* (Impact Factor = 9.988), **2022**, *accepted*.

Conference Presentations

- *American Chemical Society Spring Meeting*, March **2021**; *Pacifichem*, December **2021**; *American Chemical Society Spring Meeting*, March **2022**; *International Conference on Ionizing Processes*, July **2022**; and *American Chemical Society Fall Meeting*, August **2022**.

Follow-on Funding

- ***National Science Foundation (NSF) – Environmental Chemical Science*** for $496,385 over 3 years in response to solicitation ***NSF 21-589, Division of Chemistry: Disciplinary Research Programs***, for a proposal entitled, "*Radical-induced weathering of micro- and nanoplastics in water: impacts on suspensions, agglomerations, and contaminant adsorptions.*"

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