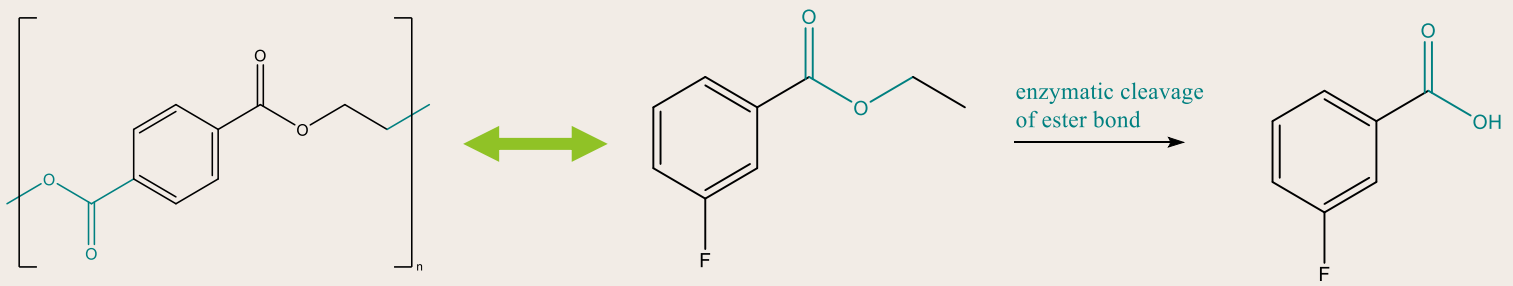
Enzymatic Biodegradation of Waste Plastics:

Degradation of Ethyl Benzoate from Lipase *Pseudomonas Cepacia*

Biodegradation of waste polymers offers a circular, biophilic solution to world waste plastic. Conducted here is a degradation of a PET ester mimetic dimer; the ester bond breakage by lipase represents mechanistically the enzymatic degradation of PET plastics, scaled to suit the short timescale of the project.



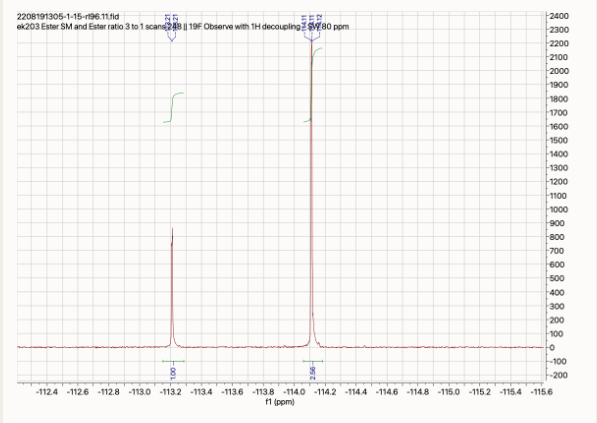
PET repeating unit

Enzymatic degradation of ester mimetic dimer

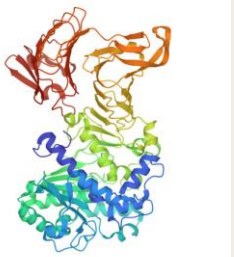
Results

Ethyl benzoate (0.200 g, 72.5%) was synthesised from phenyl carboxylic acid and ethanol, fluorine tagged (3-fluoro) for 19F NMR analysis.

Hydrolysis of the ester bond upon addition of the enzyme assay (lipase, *Pseudomonas sp.*) reached 66% after 72 hours of incubation (40 degrees with shaking). Positive controls (increased miscibility of olive oil with water after incubation with enzyme assay) and negative controls (no enzyme added resulting in zero conversion noted) confirm enzymatic degradative activity. Lipase thus confirmed to cleave polymeric mimetic ester bonds and successfully produce a degradation product.



19F NMR; 66% conversion to degradation product (right) vs starting ester bond (left)

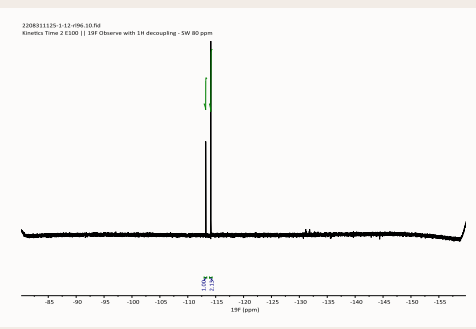


Lipase from *Pseudomonas Cepacia*, *rcsb.org/structure/1HQD*

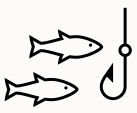
Kinetics

A kinetics study was commenced, utilizing pH8 buffer instead of pH7 as was used to confirm enzymatic activity. This resulted in a two-fold increase in rate, with 66% conversion being reached at the 23-hour mark as opposed to 72 hours. Further work includes plotting varying concentrations over time against absorbance to ascertain the rate of reaction for the assay.

19F NMR; 66% conversion to degradation product (right) vs starting ester bond (left)



Plastic Waste Contexts

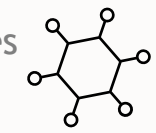


By 2050, there is projected to be more plastics than fish in the sea by mass.

Microplastic contamination has been record in reaching from human placenta of children born today, in the air we breathe and water we drink.

Recycling infrastructure is largely insufficient to process increasing production of the world's plastic wastes.

Enzymatic biodegradation is a catalytic, resource-efficient recycling mechanism. Enzymes can also transform plastics into biocompatible molecules, such as vanilla extract.



Advances in Enzymatic Polymer Degradation & State of PET-ases

PETase is a specifically-designed enzyme aiming to degrade the polymeric ester linkage in poly(ethylene terephthalate):

Enzyme complexes (multiple synergistic enzymes) can boost efficiency

AI-driven screening of potential enzymes aides searches for additional enzyme-polymer complexes

References

Lens-Pechakova, L., 2021. Recent studies on enzyme-catalysed recycling and biodegradation of synthetic polymers. *Advanced Industrial and Engineering Polymer Research*, 4(3), pp.151-158.

Tournier, V., Topham, C., Gilles, A., David, B., Folgoas, C., Moya-Leclair, E., Kamionka, E., Desrousseaux, M., Texier, H., Gavalda, S., Cot, M., Guémard, E., Dalibey, M., Nomme, J., Cioci, G., Barbe, S., Chateau, M., André, I., Duquesne, S. and Marty, A., 2020. An engineered PET depolymerase to break down and recycle plastic bottles. *Nature*, 580(7802), pp.216-219.