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TUS Research

We have a solution for plastic pollution!

SCAN ME! Get a closer look at my work

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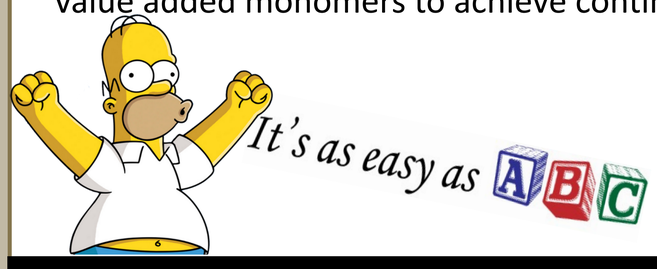
Introduction

Most plastics degradation methods are currently inefficient and are limited by processing difficulties, quality loss and diminished value. This research focuses on the development of novel ultra-green chemical recycling of PET plastic waste followed by enzymatic depolymerisation for the recovery of valued added monomers.

Aim

- Development of greener routes for Conversation of PET Plastic waste into value added monomers to achieve continuous circular economy of plastics.

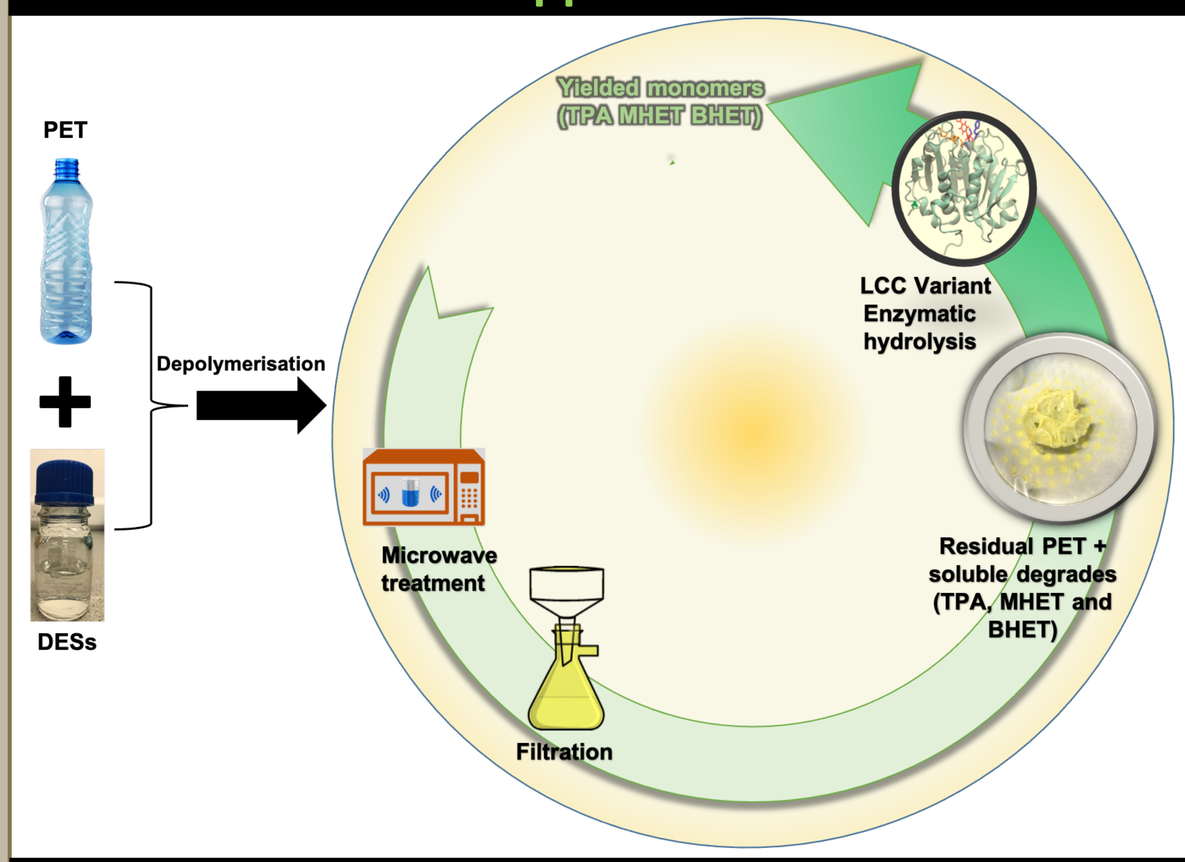


A (Ethylene glycol) + **B** (Terephthalic acid) = **C** (PET)

Objectives

- Utilization of environment friendly Deep eutectic solvents (DESs) based microwave technology (MW) in degradation of plastics (PET).
- To demonstrate enhanced biotransformation(using LCC variant) of PET plastics waste into monomers (TPA, MHET, BHET) by developing an optimized enzymatic hydrolysis technique.

New approach here!



Results and Discussions

1. FTIR:

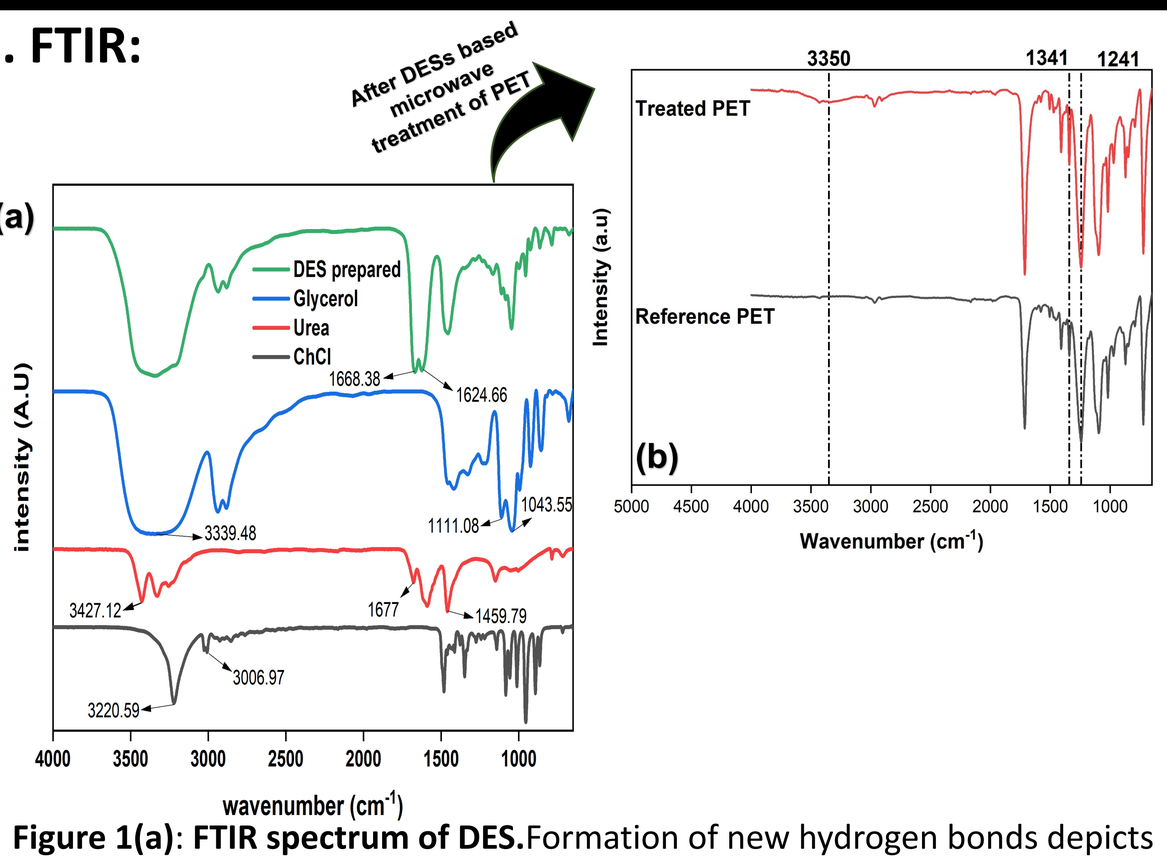


Figure 1(a): **FTIR spectrum of DES.**Formation of new hydrogen bonds depicts successful synthesis of DES. **Figure 1(b)**: **FTIR spectrum of pure PET and treated PET after treatment.** Formation of OH group in oligomers which is not present in the reference due to formation of chains containing OH,CH end groups. Furthermore, Reduction in peaks at 1341 and 1241 wavenumbers Depicts that amorphous part of PET is preferentially degraded.

2. TGA:

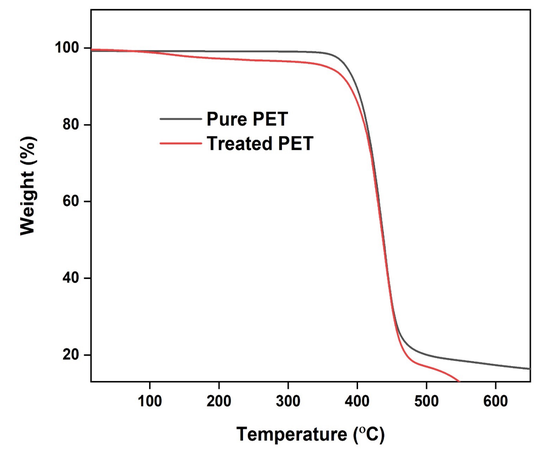


Figure 2: **TGA analysis of pure PET and treated PET.**The reference PET has main weight loss at 395^{0}C as a result of thermal decomposition but treated PET showed a lower weight loss temp around 130^{0}C.
It could be because of decrease in thermal stability depicting lower molecular weight product formation.

3. HPLC:

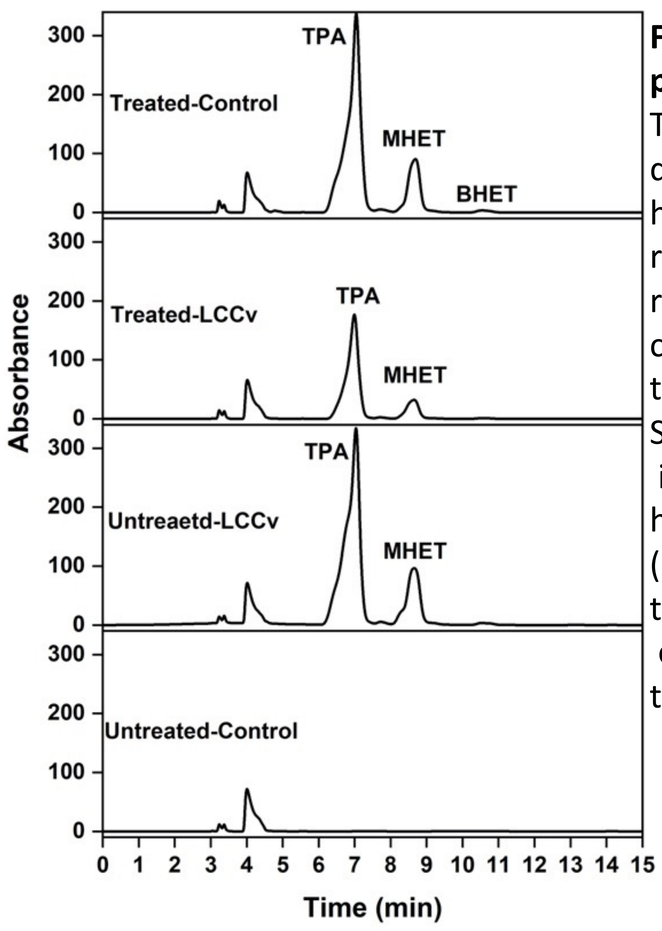
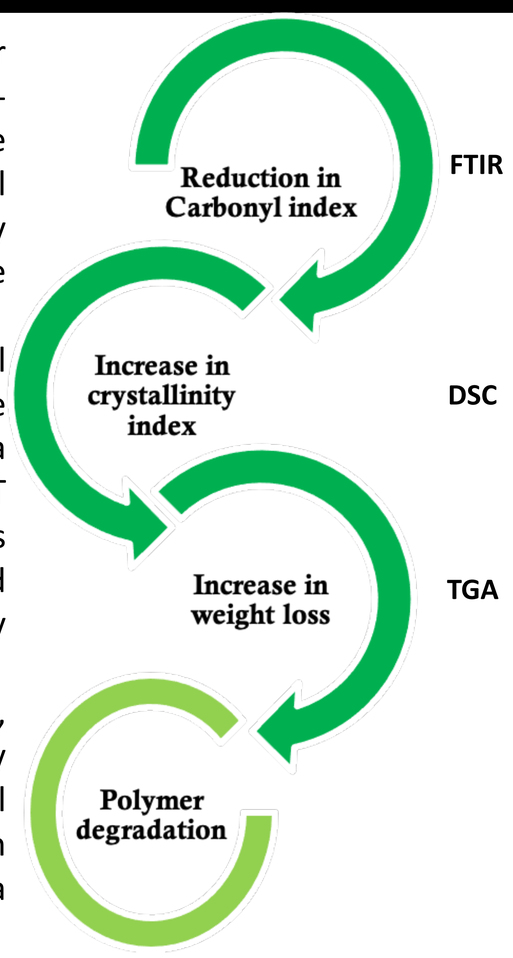


Figure 3: **HPLC chromatograms of post-enzymatic hydrolysis products.** The combined MW-assisted DES depolymerization and enzymatic hydrolysis of the treated PET residue using LCC variant ICCG resulted in a total monomer conversion of ≈16% (w/w) in the form of TPA, MHET and BHET. Such high monomer conversion in comparison to enzymatically hydrolysed virgin PET (1.56% (w/w)) could be attributed to the recognized depolymerization effect of the selected DES MW treatment process.

Conclusions

- A stepwise depolymerization process for PET comprising an all-green, fast, low-energy, MW-assisted DES technique without the use of additional depolymerizing agents followed by enzymatic hydrolysis using LCCv enzyme was demonstrated.
- FTIR, TGA, and DSC spectra of the residual PET obtained after treatment with the MW-assisted DES technique showed a significant increase in residual PET carbonyl index and percentage weight loss at onset temperature of degradation and maintenance of PET crystallinity percentage.
- The combination all-green treatments, which operated under mild, low-energy conditions without the use of additional depolymerization agents, produced an average PET weight loss of 22 ± 1.7% and a total monomer conversion of ≈16% (w/w).



Future Work

- The isolation of these produced monomers will be carried out.
- Effect of ultrasonication coupled with microwave will be evaluated to study combined effect of treatments on total monomer yield.

References

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2. T. Aarthi, M. S. Shaama, and G. Madras, "Degradation of water soluble polymers under combined ultrasonic and ultraviolet radiation," Ind. Eng. Chem. Res., vol. 46, no. 19, pp. 6204–6210, 2007, doi: 10.1021/ie070287+.

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Acknowledgements

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