Upcycling of Polyethylene Terephthalate into Biopolyol

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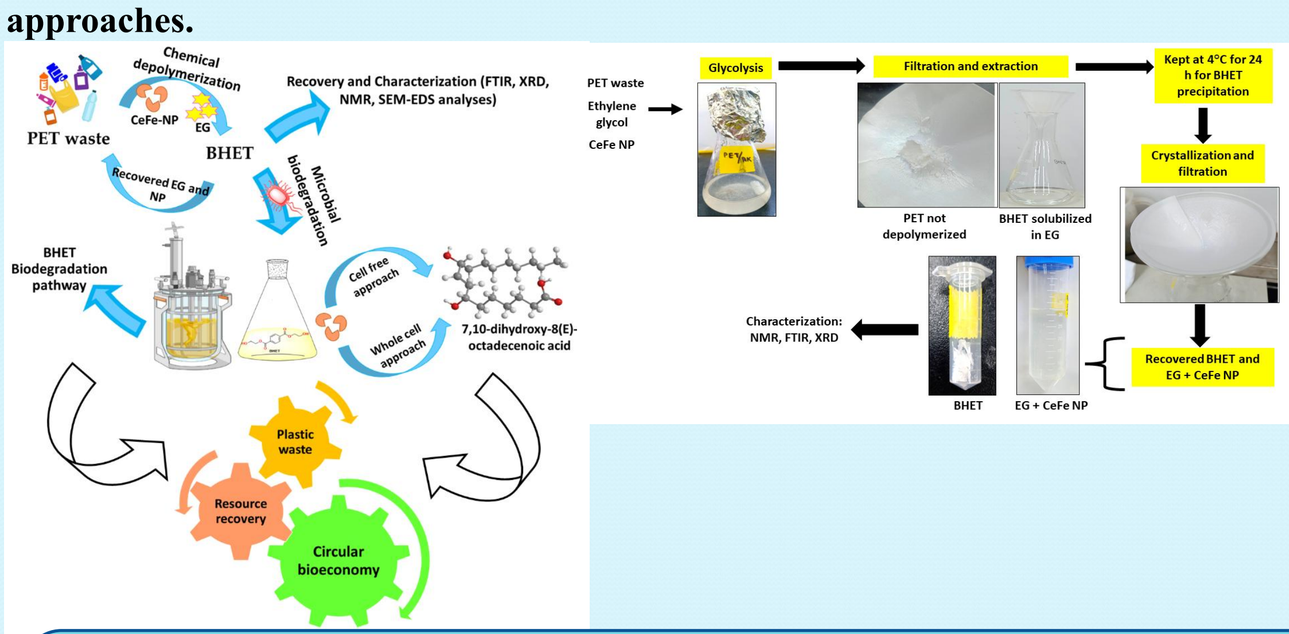
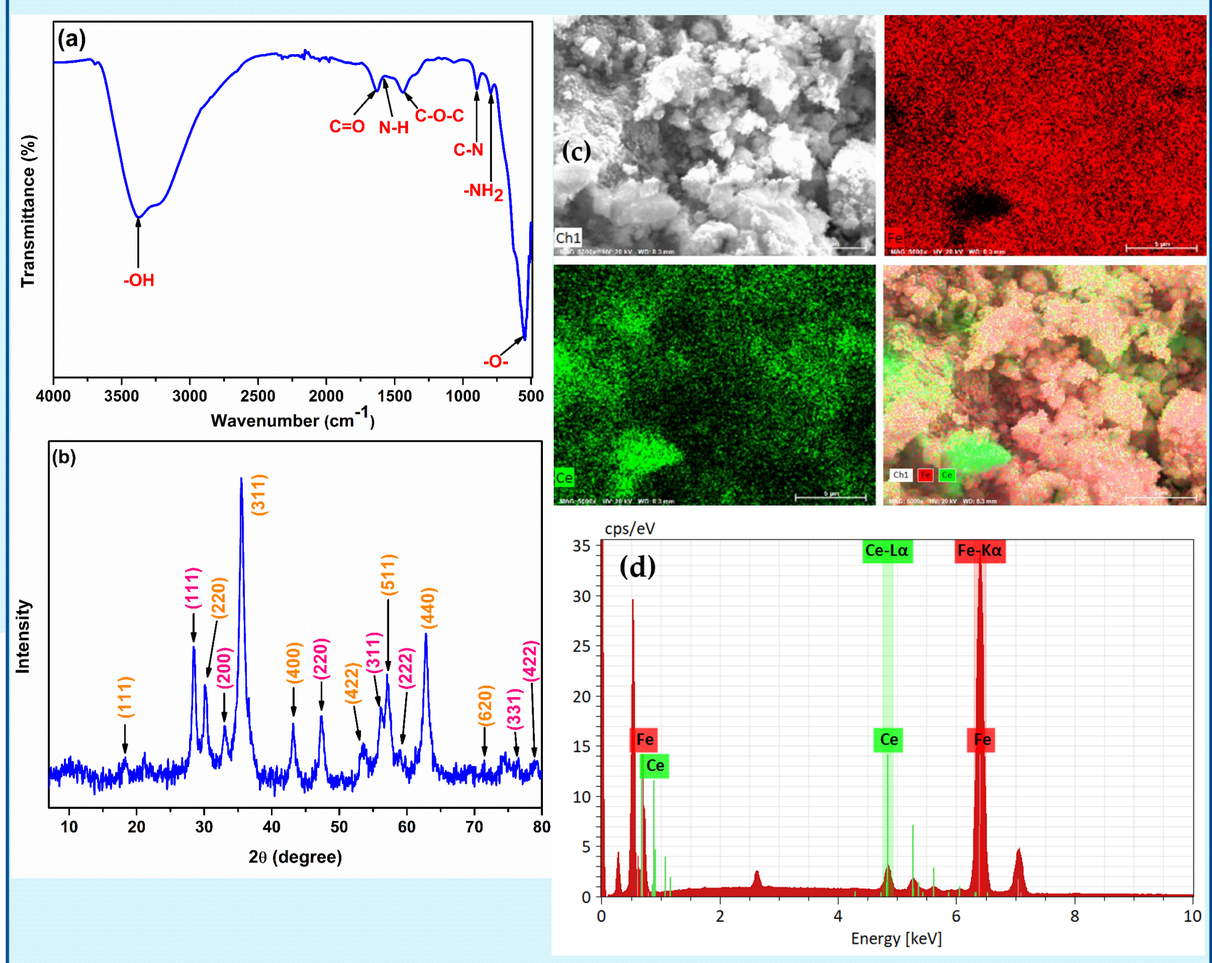
ABSTRACT

In this study, we established an integrated chemical/biological methodology for the complete poly(ethylene terephthalate) (PET) degradation and biopolyol production using cerium-iron oxide nanoparticles (CeFeNPs). Initially, three nanoparticles, i.e. CeNPs, FeNPs, and CeFeNPs were synthesized and evaluated for PET glycolysis. CeFeNPs demonstrated the best catalytic performance for PET depolymerization to bis(2-hydroxyethyl) terephthalate (BHET) and was further recovered from the PET depolymerized slurry to reutilize again. BHET was further biodegraded using hydrocarbonoclastic bacterium *Pseudomonas aeruginosa* PR3 under the batch modes using shake flask and stirred tank bioreactor. To elucidate the fate of BHET biodegradation under aerobic conditions, identification of various BHET degraded metabolites was carried out using liquid chromatography-mass spectrometry analysis. The strain could produce extracellular diol synthase enzyme which transforms oleic acid into the biopolyol, 7,10-dihydroxy-8(E)-octadecenoic acid (DOD). CeFeNPs were further supplemented to enhance DOD production via whole cell and cell-free approaches.

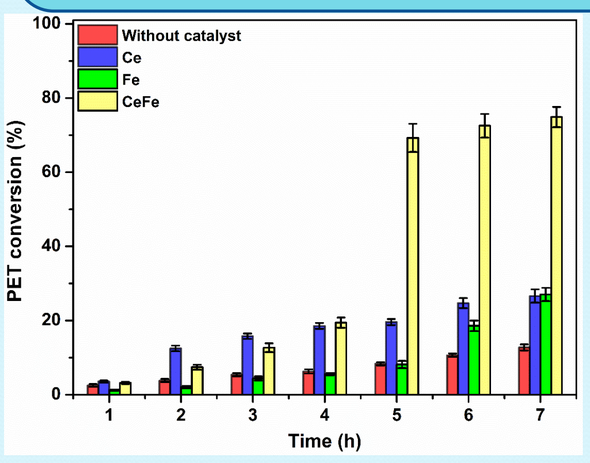


Cerium-doped Iron Oxide Nanoparticles

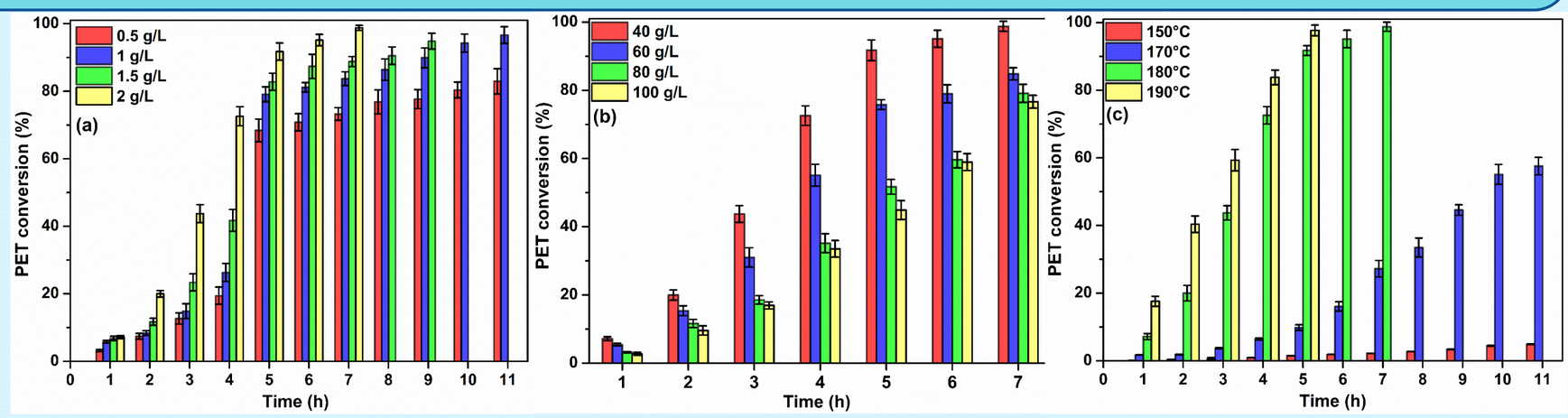


Various characterization of the prepared CeFeNPs. (a) FTIR, (b) XRD patterns, (c, d) SEM-EDS micrographs

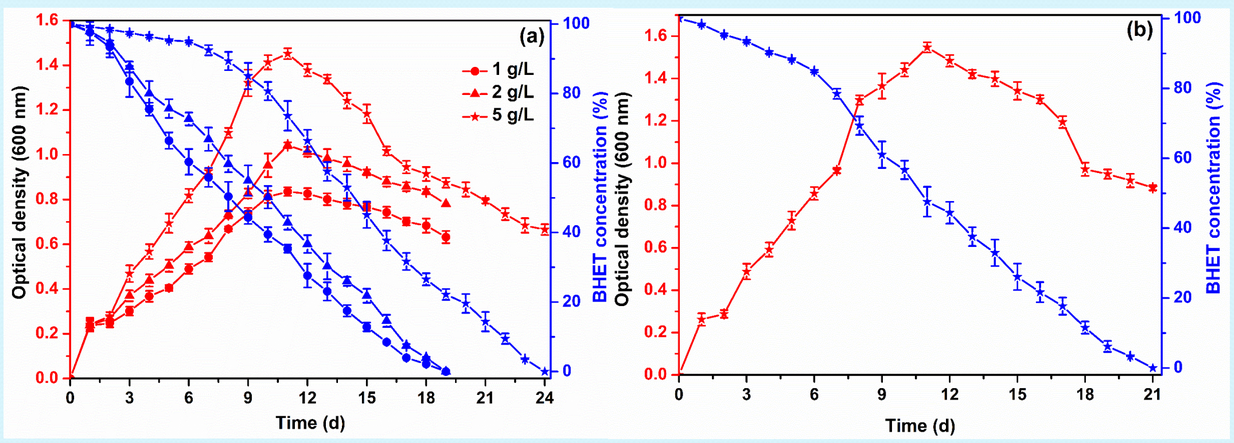
RESULTS



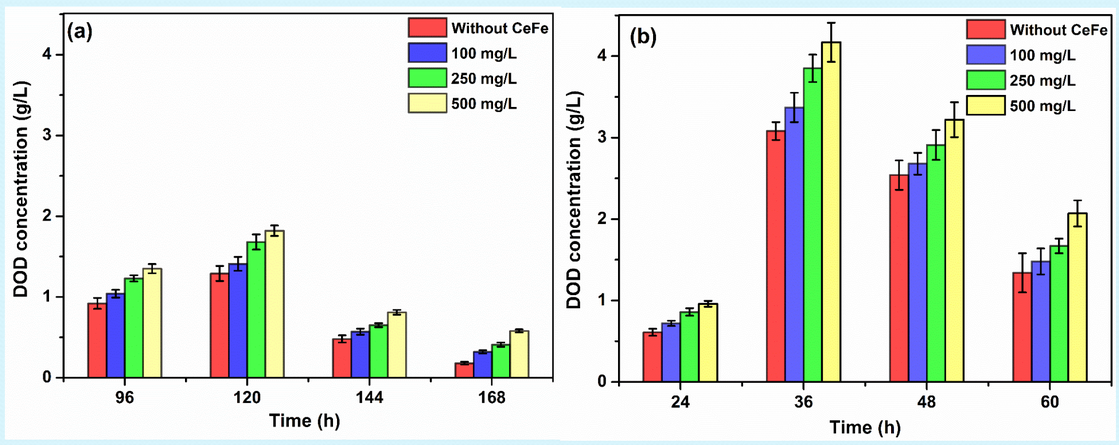
Catalytic performance of different catalysts for PET depolymerization at 180 °C.



Effects of (a) nanoparticle concentration, (b) PET concentration, and (c) temperature on PET conversion.



Time profiles of *P. aeruginosa* utilizing BHET as a sole carbon source under (a) batch shake flask and (b) batch stirred tank bioreactor system.



Utilization of CeFeNPs to enhance DOD production. (a) Whole cell approach and (b) cell-free approach.

CONCLUSIONS

- **In this study, the integrated chemical-biological approach was used for the complete PET degradation and simultaneous DOD production.**
- **CeFeNPs demonstrated the best catalytic performance for PET depolymerization to BHET and were further recovered from the PET glycolyzed slurry.**
- **BHET was further biodegraded using the strain PR3 under the batch modes using shake flask and stirred tank bioreactor and the biodegradation pathway was also elucidated using LC-MS analysis.**
- **The strain showed the ability to produce extracellular diol synthase enzyme, which bio-transforms oleic acid into DOD.**
- **In comparison to the conventional whole cell process, CeFeNP aided cell-free approach resulted in higher DOD production within 36 h.**

ACKNOWLEDGEMENTS

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