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From Plastic Waste to Biopolymer Feedstocks: Hydrothermal Conversion of Polymers into Carbon- Rich Liquors

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ABSTRACT

Plastic waste accumulation remains a major environmental and resource management challenge, particularly for mixed or contaminated plastic streams that are difficult to recycle using conventional mechanical processes. Converting these materials into valuable chemical intermediates offers an opportunity to recover carbon from waste plastics and to support emerging circular-economy strategies. Hydrothermal processing technologies, particularly oxidative hydrothermal systems, provide a promising thermochemical pathway for depolymerising plastics into soluble organic compounds under aqueous conditions.

This study investigates the composition and resource recovery potential of carbon-rich liquors generated from the hydrothermal deconstruction of five widely used plastics: polypropylene (PP), low-density polyethylene (LDPE), polyethylene terephthalate (PET), polycarbonate (PC), and polystyrene (PS). The work focuses on evaluating the chemical characteristics of these liquors to assess their suitability as potential carbon substrates for microbial production of polyhydroxyalkanoate (PHA) biopolymers.

A comprehensive analytical framework was used to characterise the distribution of carbon

products formed during hydrothermal processing. Volatile fatty acids (VFAs), key intermediates for microbial PHA synthesis, were quantified using gas chromatography with flame ionisation detection (GC-FID). Chemical oxygen demand (COD) measurements were used to determine the total concentration of soluble organic carbon in the liquid phase, while gas composition analysis provided insight into carbon partitioning to gaseous products such as CO₂. In addition, gas chromatography–mass spectrometry (GC-MS) was applied to identify other dissolved organic compounds present in the hydrothermal liquors. Preliminary results indicate that polymer structure strongly influences the formation of VFAs and other soluble organics during hydrothermal conversion.

By linking thermochemical plastic deconstruction with biological resource recovery pathways, this work explores the potential to transform plastic waste streams into renewable carbon sources for sustainable materials production. This work demonstrates that thermochemical plastic conversion can generate carbon streams suitable for biological upgrading, providing a potential pathway to transform waste plastics into renewable biopolymer feedstocks.

KEY WORDS

Plastic depolymerisation, hydrothermal deconstruction, resource recovery, circular economy, thermochemical conversion.

BIOGRAPHY

Milica is a PhD candidate in the Department of Chemical and Materials Engineering at the University of Auckland. Her research investigates hydrothermal conversion processes for transforming plastic waste into carbon-rich intermediates and evaluating their potential as renewable substrates for polyhydroxyalkanoate (PHA) biopolymer production. This work contributes to the development of integrated thermochemical–biological pathways for the valorisation of plastic waste. Milica’s research interests include thermochemical processing, waste-to-resource technologies, and circular-economy approaches to sustainable materials production.

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