DEPOLYMERIZATION OF POST-CONSUMER POLY(ETHYLENE TEREPHTHALATE) (PET) BOTTLES AND POLYESTER BASED TEXTILES WASTE USING IRON-BASED CATALYSTS FOR EFFICIENT MONOMERS RECOVERY

MUHAMMAD AIDEL BIN RATNO HADIYONO

Final Year Project Submitted in
Partial Fulfilment of the Requirements for the
Degree of Bachelor of Science (Hons.) Chemistry with Management
in the Faculty of Applied Sciences
Universiti Teknologi MARA

JULY 2024

ACKNOWLEDGEMENTS

All praises to my *Lord*, Almighty Allah who bestowed me with intellectual power and understanding, and gave me spiritual insight, enabling me to discover Him through His wonders. Foremost, I'd like to express my deepest gratitude to my supervisor, ChM. Dr. Nor Wahida Binti Awang for her excellent guidance and expertise in Chemistry. Her mentorship played a crucial role in shaping the direction of my research and enhancing the quality of this thesis. Thank you very much for this great and amazing rollercoaster ride in completing my thesis.

I would also like to thank Prof. Dr. Kotohiro Nomura and Assoc. Prof. Dr. Mohamed Abdel-Latif from Tokyo Metropolitan University for their valuable guidance that really helped me to achieve such result while using their lab facilities.

I extended my heartfelt gratitude to my parents, Mr Ratno Hadiyono and Madam Misiani for their unwavering support and encouragement throughout this academic journey. Their love, understanding, and sacrifices have been the driving force behind my pursuit of knowledge and personal growth.

I am also grateful to my friends who stood by me during the highs and lows of this academic endeavor especially Nurhana Binti Lee Hai Liang@Kasman, Nazidah Binti Ramji, Zizie Izzati Binti Musa, Nur Ellydia Binti Gusties Norambia and Shally anak Pillet. Your encouragement, camaraderie, and shared laughter provided the much-needed balance to the rigorous demands of research.

This thesis would not have been possible without the support and contributions of those mentioned above and all individuals who helped me directly or indirectly. I am truly fortunate to have such a remarkable network of individuals in my life.

Muhammad Aidel Bin Ratno Hadiyono

TABLE OF CONTENT

ABSTRACT

DEPOLYMERIZATION OF POST-CONSUMER POLY(ETHYLENE TEREPHTHALATE) (PET) BOTTLES AND POLYESTER BASED TEXTILES CLOTHES WASTE USING IRON-BASED CATALYSTS FOR EFFICIENT MONOMERS

Polyethylene terephthalate (PET) is a widely used polyester in our daily life and extensively used for beverages, personal care products and other liquid goods. This ubiquity comes at a significant environmental level where it has been contributing to the escalating plastic waste crisis. One of the most promising strategies to address this growing challenge is chemical recycling such as depolymerization, a process that breaks down PET into its constituent monomers align with circular economy approach. The environmental impacts of traditional depolymerization methods have issues related to the toxicity and non-renewable catalysts. Existing depolymerization techniques suffer with challenges such as inconsistent product quality, cost, increasing energy consumption, and complications in catalyst residue and monomers recovery management. This study demonstrates the acid- and base-free depolymerization of poly(ethylene terephthalate) (PET) with ethanol by $FeCl_3$, $FeBr_3$ (1.0-5.0 mol%) and the results showed that both catalysts gave diethyl terephthalate (DET) and ethylene glycol (EG) exclusively (98->99 %, 160-180 ºC), while $FeCl_3$ showed better catalyst performance in terms of the activity. The utilization of the $FeCl_3$ catalyst facilitated the exclusive and selective depolymerization of PET derived from textile waste, resulting in the production of DET along with the recovery of cotton waste. It strongly suggested the possibility of chemical recycling of cloth waste by the transesterification in this catalysis.

CHAPTER 1

RESEARCH BACKGROUND

1.1 Introduction

Since the inception of synthetic plastic production in the 1900s, plastics have emerged as a vital category of materials in diverse industrial sectors such as packaging, construction, transportation, and electronics. This is primarily due to their distinctive properties and extensive range of uses. The global production of plastics has experienced a substantial increase in recent decades, surpassing 368 million tonnes annually by 2020 (Lee et al., 2023; Zhang et al., 2020a.). From this massive amount of manufactured plastics, 79% are disposed of in landfills, resulting in an annual influx of 2.41 million tonnes of durable waste materials into our ecosystem (Geyer et al., 2017). Statistics indicate that an estimated 150-200 million tonnes of plastic waste accumulate in the natural environment annually, resulting in significant harm to terrestrial and marine ecosystems (Chu et al., 2021; Jambeck et al., 2015; Tournier et al., 2020). Among various plastics, polyethylene terephthalate (PET) is commonly used polyester in industries due to its advantageous physical and chemical characteristics. These include high transparency, crystallization rate, thermal stability, mechanical properties, and oxygen barrier (Nisticò, 2020;