



Microwave co-pyrolysis of waste polyolefins and waste cooking oil: Influence of N₂ atmosphere versus vacuum environment



Wan Adibah Wan Mahari^a, Cheng Tung Chong^b, Wei Haur Lam^c,
Tuan Nurul Sabiqah Tuan Anuar^d, Nyuk Ling Ma^e, Mohd Danial Ibrahim^f, Su Shiung Lam^{a,*}

^a Pyrolysis Technology Research Group, Eastern Corridor Renewable Energy Group (ECRE), School of Ocean Engineering, Universiti Malaysia Terengganu, 21030 Kuala Nerus, Terengganu, Malaysia

^b Faculty of Mechanical Engineering, Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia

^c Department of Naval Architecture and Ocean Engineering, School of Ocean Engineering, Tianjin University, China

^d School of Marine and Environmental Sciences, Universiti Malaysia Terengganu, 21030 Kuala Nerus, Terengganu, Malaysia

^e School of Fundamental Sciences, Universiti Malaysia Terengganu, 21030 Kuala Nerus, Terengganu, Malaysia

^f Department of Mechanical & Manufacturing, Faculty of Engineering, Universiti Malaysia Sarawak, Jalan Dato Mohd Musa, 94300 Kota Samarahan, Sarawak, Malaysia

ARTICLE INFO

Keywords:

Pyrolysis
Co-pyrolysis
Vacuum
Microwave
Plastic
Waste

ABSTRACT

Microwave co-pyrolysis (MCP) of waste cooking oil (WCO) and waste polyolefins (WP) was examined for its potential to convert these wastes into liquid fuel. The influence of performing the pyrolysis process under N₂ atmosphere and vacuum environment was investigated with emphasis on the temperature profile, heating rate, and the yield and properties of the liquid oil obtained. Different ratios of WP to WCO (1:2, 1:1.5, 1:1, 1.5:1, and 2:1) were also investigated. MCP performed under vacuum environment recorded higher heating rates (20–24 °C/min) and higher yield of liquid oil (up to 62 wt.%) compared to that performed under N₂ atmosphere (18–22 °C/min of heating rate and 24–50 wt.% of liquid oil). The high heating rate resulted in shorter reaction time and lower power consumption, leading to lower energy consumption by the pyrolysis process. The liquid oil comprised C₁₃–C₂₄ hydrocarbons (aliphatics, aromatics) within the hydrocarbon range of diesel fuel. It also showed promising green properties comprising low nitrogen and oxygen content, and free of sulphur. Combined with the detection of high energy content (42–49 MJ/kg) and low moisture content (< 1 wt.%), the liquid oil shows great potential to be used as a fuel. Our results show that MCP performed under vacuum environment shows potential as a promising pyrolysis approach with improved heating performance and production of hydrocarbon fuel with desirable fuel properties.

1. Introduction

Increased demand and consumption of plastics in daily activities (e.g. packaging and storage application) has inevitably resulted in generation of waste polyolefins (e.g. high density polyethylene, low density polyethylene), particularly from household activities. In addition, the consumption of cooking oil in commercial activities, catering and household cooking has led to massive production of waste cooking oil each day throughout the world [1]. In the European Union, it has been reported that the generation of waste materials of these nature (e.g. waste cooking oil, waste polyolefins) are more than 200 million tons/year [2,3]. In Malaysia, the production of waste polyolefins and food waste has been increasing up to 38,000 tons per day [4]. Due to

increased generation of these waste materials and the scarcity of land adequate for landfills, the disposal of these wastes has become a substantial challenge faced by all communities globally. Therefore, the conversion of these waste materials into an energy source has been researched as a potential solution.

In recent years, researchers are concentrating on transforming waste materials into hydrocarbon fuel via thermochemical routes (e.g. pyrolysis, gasification, hydroprocessing) [5–9]. Microwave pyrolysis technology has been researched as a promising technique for efficient conversion of waste materials into a cleaner energy [10–15]. It is a thermal decomposition process that is operated under an inert environment using microwave heating as a heat source. The thermal decomposition of waste materials occurs at high temperature (e.g.

* Corresponding author at: Pyrolysis Technology Research Group, Eastern Corridor Renewable Energy Group (ECRE), School of Ocean Engineering, University Malaysia Terengganu, 21030 Kuala Terengganu, Terengganu, Malaysia.

E-mail addresses: adibah.mahari@gmail.com (W.A. Wan Mahari), ctchong@mail.fkm.utm.my (C.T. Chong), wlam@tju.edu.cn (W.H. Lam), sabiqahanuar@umt.edu.my (T.N.S.T. Anuar), nyukling@umt.edu.my (N.L. Ma), imdaniel@unimas.my (M.D. Ibrahim), lam@umt.edu.my (S.S. Lam).

<https://doi.org/10.1016/j.enconman.2018.06.073>

Received 26 April 2018; Received in revised form 10 June 2018; Accepted 20 June 2018
0196-8904/© 2018 Published by Elsevier Ltd.