CHAPTER 4

Characteristics of Biochar from Microwave Pyrolysis of Oil Palm Shell

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4.1 INTRODUCTION

With the global issue of climate change, we are forced to come up with alternatives for clean energy to replace fossil fuels, which are heavily polluting the environment. Over a staggering 4 million premature deaths are caused by air pollution from the burning of fossil fuels such as coal, oil, and gas alone. The gasses produced from these fossil fuels such as methane, carbon dioxide, carbon monoxide, and sulphur oxide, which are toxic when inhaled in vast amounts. Clean energy is relatively more expensive and more sophisticated to handle which prompts energy companies to opt for these traditional methods of generating energy instead. If a cheaper and efficient method of generating clean energy were to be discovered, this global issue can surely be controlled. One potential method that meets the stated criteria for generating clean energy would be the conversion of biomass to products.

Biomass waste is massively abundant around the world. Globally, the annual generation of biomass waste is around 140 Gt (Tripathi et al., 2020; Chun & Brisson, 2015). Focusing on Malaysia, the country has numerous varieties of biomass such as Empty Fruit Bunch (EFB), oil palm trunk (OPF), Oil Palm

Kernel (OPK), and Oil Palm Shell (OPS), which are generated from palm oil mill and during re-planting (Al-Sabaeei et al., 2022; Mpob, 2019; Sukiran et al., 2018; Lim et al., 1997; Anis et al., 2011). Aside from the benefits of using renewable energy, there is a worrying problem since discarded biomass waste has negative impacts on the environment and an efficient method in optimizing the usage of these biomass waste must be devised.

Pyrolysis, a thermal conversion process, is one effective method to convert biomass into value-added products. The higher reactivity and short residence time for the reaction are the advantages of this method as compared to biochemical methods. This thermal conversion method can be applied to the oil palm wastes since this wastes are abundantly generated during re-plantation of tree and processing of fruit to produce desired products. It was estimated that about 5 million tons and 1.1 million tons of trunks and fronds, respectively were discharged as a waste (Mpob, 2019). Hence, oil palm waste, particularly OPS has enormous potential as a sustainable biomass resource for the productions of various valuable carbon and alternative fuels through pyrolysis method.

Pyrolysis work using the conventional reactor has been immensely reported in the literatures (Yang et al., 2021, Sarkar & Wang, 2020; Bakhtiar et al., 2019; Brickler et al., 2021; Fiore et al., 2018; Halim et al., 2022; Sahoo et al., 2021). The pyrolysis process is categorized into slow and fast pyrolysis modes depending on the pyrolysis temperature, time, and heating rate achieving a varied range percentage yield of by-products. Slows pyrolysis refers to conventional pyrolysis commonly employed to convert various types of biomass material into biochar products. Unfortunately, the heat transfer is not uniform, and the chemical reaction is quite long to complete the pyrolysis process compared to the fast pyrolysis method. The fast pyrolysis method is

proposed to assist the chemical reactions, this is, Microwave-assisted Pyrolysis (MWP) with a higher heating rate and shorter pyrolysis time producing nearly the equivalent yield of biochar produced from the conventional pyrolysis process.

One of the advantages of microwave heating is microwave energy will penetrate towards inside the biomass particle, transformed into thermal energy, and then transferred towards the outside of biomass particle (Halim et al., 2022; Miura et al., 2004). Thus, the heat transfer is more uniform, and the product formations are expected to be different than conventional heating due to uniform of heat transfer into biomass.

Biochar in general has a lot of unique characteristics. Other than having thermal and electrical properties which is yet to be explored, it is widely used as a soil amendment to restore soil fertility due to its highly porous physical structure that functions as a habitat for the growth of microorganisms (Haque et al., 2021). Biochar has in common applications, which is carbon sequestration, a process that removes carbon dioxide from the atmosphere into solid or liquid form (Woolf et al., 2010). The potential usage of biochar from OPS is worth investigating. Therefore, this research is mainly focused on the production of biochar from oil palm shell via microwave pyrolysis. The study also investigates the effects of carbonization temperature and time on the properties of biochar.

4.2 EXPERIMENTAL PROCEDURES

4.2.1 Materials

Oil palm shell was obtained from an oil palm mill located in Johor, Malaysia. The oil palm shells were cleaned with distilled water, dried under the sun for two days, and subsequently in an