CHAPTER 4

The Utilization of Rice Husk Ash as Green Catalyst in Co-Pyrolysis of Empty Fruit Bunch and High-Density Polyethylene

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4.1 INTRODUCTION

Palm oil is widely produced in Malaysia, with 19.86 million tonnes produced in 2019, obtained from fresh fruit bunch (FFB) of oil palm trees, the second highest amount produced after Indonesia (Statista Research Department, 2021). Empty fruit bunch (EFB) makes up the majority of the waste produced from the plant, as 22 wt.% of FFB consists of EFB and is often discarded by simply burning, which contributes to air pollution (Garcia-Nunez et al., 2016). EFB is an attractive biomass resource as it contains valuable chemicals, such as benzene and phenols when converted to bio-oil (Chang, 2018). Some of these compounds are conventionally obtained from fossil fuels and since fossil fuels have been reported to have detrimental effects to the environment, EFB should be utilized to retrieve these chemicals to reduce our dependency on fossil fuels.

Pyrolysis can retrieve the valuable compounds by thermally degrading these materials at high temperatures, between 300 °C to 650 °C, without oxygen, into bio-oil, char, and non-condensable gas (Bhoi et al., 2020). Biomass pyrolysis alone produces bio-oil with low yield and high oxygen content, limiting its commercialization and thus, biomass can be paired with plastic, improving the decomposition of biomass which increases the bio-oil yield and quality. High-density polyethylene (HDPE) has previously been added to biomass pyrolysis because of its low degree of branching, making it easier to break down compared to other polyethylene (Charusiri et al., 2022). In addition, adding HDPE donates hydrogen to the biomass feedstock, which balances the carbon and oxygen, resulting in a reduced oxygen content in the bio-oil (Charusiri et al., 2022).

Moreover, catalysts can be added to pyrolysis to further increase the bio-oil quality. Hydrogen-exchanged zeolite socony mobil 5 (HZSM-5) can reduce oxygen content in the bio-oil by promoting aromatization reactions via its microporous structure and strong acidity and often used in pyrolysis (Ro et al., 2018). The synthesis of HZSM-5 uses certain chemicals that can be toxic, like such as tetraethylorthosilicate (TEOS). Thus, finding a safer and low-cost alternative can make catalyst synthesis greener.

Another common by-product of the agricultural industry in Malaysia are rice husks. In 2020, Malaysia produced around 2.3 million metric tonnes of paddy (Department of Agriculture [DOA], Malaysia, 2022). Rice husks, which makes up approximately 20% of the rice kernel, when pyrolyzed and calcined, forms rice husk ash (RHA) rich in silica (around 95%), making it a suitable silica source for catalyst synthesis (Singh, 2018).

Although previous studies have successfully synthesized catalysts with a HZSM-5 structure using RHA, its utilization, especially in pyrolysis, has not yet been explored (Zhang et al., 2019). The objective of this present work is to investigate the effect of the presence of catalyst sourced from RHA in the catalytic co-pyrolysis of empty fruit bunch (EFB) and high-density polyethylene (HDPE) via thermogravimetric analyzer. In addition to the catalyst presence, the effect of EFB-to-HDPE mass ratio will also be investigated.

4.2 METHODOLOGY

4.2.1 Feedstock Preparation

Empty fruit bunch (EFB) and high-density polyethylene (HDPE) were purchased from separate local companies in Selangor, Malaysia. Both materials were ground and sieved to uniform particle sizes of 0.5 mm.

4.2.2 Catalyst Preparation

Rice husks were obtained from a local company in Selangor, Malaysia. The rice husks were dried, ground and pyrolyzed at 750 °C for 1 hour in a tube reactor using nitrogen, obtaining black rice husk ash. To obtain white rice husk ash, the black rice husk ash was calcined in a muffle furnace at 750 °C for 3 hours.

The solvent-free method was used to synthesize catalysts with a HZSM-5 structure (Zhang et al., 2019). The detailed procedure and the physicochemical properties of the synthesized catalyst can be referred to our previous work (Shahdan et al., 2022).

4.2.3 Experimental Setup

The thermal degradation behaviour of HDPE, EFB and EFB+HDPE with and without catalysts were conducted using a