UNIVERSITI TEKNOLOGI MARA

THERMAL DISTILLATION OF BIO OIL FROM FAST PYROLYSIS OF EMPTY FRUIT BUNCH (EFB) AND PALM KERNEL SHELL (PKS)

DEANA QARIZADA

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ABSTRACT

The palm oil industry generates abundance of oil palm biomass, such as empty fruit bunch (EFB) and palm kernel shell (PKS). Annually, around 30 million tonnes of biomass are produced in Malaysia. The objectives of this study are to characterize the raw material EFB, PKS and bio-oil, investigate the effect of temperature of distilled bio-oil, and compression of distilled bio-oil and bio-oil from PKS and EFB with liquid petroleum fuel. In this study, the pyrolysis of empty fruit bunch and palm kernel shell was investigated using a fixed bed reactor at 500 °C, and the thermal distillation of pyrolysis bio-oil were considered using a column reactor at three temperatures. Pyrolysis has received a lot of interest as it can convert biomass into liquid (bio-oil), gas, and solid products. Bio-oil can be used as a feedstock for various chemical well as fuel production, and heat and power generation. In this research, thermal distillation was performed to obtained ten distilled bio-oil (liquid fuel) at three temperatures 100 °C, 120 °C and 140 °C from fast pyrolysis bio-oil of the empty fruit bunch and palm kernel shell to elucidate the detailed characteristics of bio-oil and bio-oil fractions. The maximum bio-oil yield for EFB and PKS bio-oil were 54.50 wt % at 500 °C. Nitrogen flow rate of 200 mL/min and mass feeding was 6 kg/h. The maximum distilled bio-oil yield was 60–65 wt % at temperatures 100°C, 120 °C and 140 °C. The highest heating value obtained for PKS and EFB distilled bio-oil at 100°C, 120°C and 140 °C was 31.5 MJ/kg from PKS at 140 °C under sample number 10, and 28.5 MJ/kg from EFB at 140°C, also under sample number 10, which is about two times higher than pyrolysis bio-oil of PKS at 22 MJ/kg and EFB at 21 MJ/kg. The moisture content for both distilled bio-oils were arranged between 13–23.82 wt %, which is lower than the moisture content of the bio-oil. GC-MS and FTIR spectra indicated that phenol is a major component in both EFB and PKS distilled bio-oils, and most of the compounds were fused to the organic phase at high temperatures.

Keyword: Biomass pyrolysis, Thermal distillation, Bio-oil, Oil palm, Empty fruit bunch, Palm kernel shell, Renewable energy

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CHAPTER ONE
INTRODUCTION

1.1 Background of Study

The development of agriculture sector in Malaysia has been rapidly growing over the year, which led to a vast amount of agricultural waste (Ghani et al.,2010). Around 85% of palm oil in Southeast Asia is used as palm oil feedstock in the production of biodiesel and various products in Malaysia and Indonesia (Samiran et al., 2015). The most important product in Malaysia is palm oil and it is a source that has helped to change the context of its agriculture and economy sector. In 1990, the world's palm oil production had doubled from 5.0 million tons to 11.0 million tons in 1980, and in the year 2000, the production again doubled to 21.8 million tons. Around half of the world's palm oil production (10.8 million tons) comes from the palm oil produced in Malaysia (Ghani et al., 2010). In 2010, it was approximately 48.537 km^2 (4,853.7 ha) or 14.72% of the land was used for palm oil plantation, having an approximately 135-145 trees planted, per hectare (Abnisa et al., 2013).

Biomass can be converted into bio fuel by physical, thermo chemical and biochemical processes. Densification, crushing, heat, and pressure are the physical usage techniques to convert the biomass into bio fuel. The biochemical process converts biomass into clean energy by using enzymes and microorganisms to produce energy. In the thermo chemical process, a high amount of heat energy and catalyst are used for the decomposition of biomass (Saringat et al., 2015).

Pyrolysis is a thermo chemical decomposition process, which in the absence of oxygen, organic material or biomass is converted into a carbon-rich solid and a volatile matter of heating. Bio char or char is the solid product, and the volatile fraction of this process is partially condensed to a liquid fraction. Pyrolysis is a method to convert the biomass, in absence of oxygen, to bio-oil. The temperature is 500°C while the nitrogen flow rate is 200 ml/min and the process was performed in a fixed-bed reactor (Abnisa et al., 2013). For bio-oil, the light fractions are separated using KDL-5 molecular distillation equipment. The bio-oil and its fractions' physical properties were determined and the thermal pyrolysis behaviour was measured using FTIR and chemical composition was obtained via GC-MS (Guo et al., 2010). The