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Physicochemical Property Changes and Volatile Analysis for Torrefaction of Oil Palm Frond

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Torrefaction is an upgrading technique for biomass properties which involves the heating of biomass to moderate temperatures typically between 200 and 300 °C in an inert condition. Torrefied biomass has darker colour, high energy density, high heating value and exhibits hydrophobic characteristic that makes it easier for grinding. Therefore, the aim of this work is to conduct an experimental work in order to study the torrefaction effects on the physicochemical properties of oil palm frond (OPF) as well as to identify the evolution of volatiles composition during the torrefaction. Torrefaction experiments were performed at four different temperatures (240 – 330 °C) and three different residence times (15, 30 and 60 min). The higher heating value of raw and torrefied biomass were measured to establish a relationship between energy loss and mass loss during torrefaction. Scanning electron microscope (for physical analysis) was used to study the structure of raw and torrefied OPF. Elemental analysis was carried out by using Carbon, Hydrogen. Nitrogen and Sulphur (CHNS) analyser and the proximate analysis were measured based on the method specified by American Society for Testing and Materials (ASTM). Condensable and non-condensable gases were analysed by using high performance liquid chromatography (HPLC) and gas chromatography thermal conductivity detection (GC-TCD) respectively. Higher torrefaction temperature and longer residence time leads to severe decomposition which reduces the mass yield of the torrefied oil palm frond but increases the heating value of torrefied OPF. The carbon content increases with the increasing of temperature and residence time, while hydrogen and oxygen contents are decreases. The values of fixed carbon and ash content increases, while volatile matter value decreases when the oil palm frond is torrefied for a longer time at high temperature. For volatile release, carbon monoxide and carbon dioxide are the major compounds presence in non-condensable gas and traces of methane was only identified when OPF was torrefied at 300 °C and 330 °C. Acetic acid and methanol are the major compounds of condensable gases with the presence of formic acid and lactic acid at 330 °C. It can be concluded that high temperature gives significant effect on the chemical reaction for formation of condensable and non-condensable gases.

1. Introduction

The role of sustainability in the heat and electricity production continues to increase worldwide. The use of biomass as renewable energy has become essential for alternatives to fossil fuel. In Malaysia, oil palm wastes are identified as the potential biomass sources. There are several wastes produced from the growing of oil palm and from the processing of palm oil. Example of these wastes are oil palm trunk (OPT), palm kernel shell (PKS), empty fruit bunch (EFB), palm mesocarp fibre (PMF) and oil palm frond (OPF). From the oil palm waste, the largest contributors come from OPF. This is the results from cutting the OPF regularly during harvesting and pruning of the oil palm trees. Mainly the OPF is left for rotten between the rows of palm trees for nutrient recycling purpose (Awalludin et al., 2015). One way to utilise OPF is using the OPF as alternative biofuel for palm oil mill. The OPF cannot be used directly as a fuel for palm oil mill due to low heating value and low bulk density. The high moisture content presents in biomass and their ability to absorb moisture from

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