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Torrefaction of Empty Fruit Bunches in Inert Condition at Various Temperature and Time

Mohammad Hisham Sulaiman[a,*], Yoshimitsu Uemura[a], Mohammad Tazli Azizan[b]

[a]*Universiti Teknologi PETRONAS, Centre for Biofuel and Biochemical Research, 32610, Bandar Seri Iskandar, Perak, Malaysia*
[b]*Universiti Teknologi PETRONAS, Department of Chemical Engineering, 32610, Bandar Seri Iskandar, Perak, Malaysia*

Abstract

Malaysia is overdependence on fossil fuels as the primary source of energy. The issues related to environmental effects and energy security has driven the nation towards renewable energy, specifically biomass. The lignocellulosic biomass such as empty fruit bunches is potentially seen to replace fossil fuels because of its availability in Malaysia. In this study, torrefaction of empty fruit bunches was conducted in a tubular vertical reactor in inert atmosphere. The effect various torrefaction temperature (220, 260 and 300 ºC) and time (30, 60 and 90 min) on the mass yield, calorific value and CHN analysis of empty fruit bunches was investigated. The activation energy for torrefaction of empty fruit bunches was 30.81 kJ/mol.

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Keywords: torrefaction; empty fruit bunches; inert; mass yield; calorific value; kinetics

1. Introduction

The oil palm industry generates a huge amount of lignocellulosic biomass wastes such as empty fruit bunches. In fact, there are about 90 % biomass in the palm oil mill are disposed as wastes [1]. 351 of Malaysia's palm oil mills produced 30 million tonnes of empty fruit bunches (EFB) over 83 million dry tonnes of solid biomass in 2012 [2]. If the waste is not properly managed, it can create a disposal problem. In addition, Fossil fuel is our primary source of

* Corresponding author. Tel.:+6013-5304037.
E-mail address: hishamsulaiman22@gmail.com

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energy in the world with more than 80 % of energy consumption [3]. Overconsumption this non-renewable energy can contribute to global warming due to the massive emission of greenhouse gases. The problems related to fossil fuels and serious environmental concern motivates people towards sustainability and engaging in green technology. In addition, the variations in biomass feedstock properties exhibits certain drawbacks such as low heating value, low combustion efficiency and unstable operating condition in a combustor that must be overcome to utilise it as fuel. In order to address the limitation of biomass inputs, torrefaction process is required to tackle challenging biomass generation problems. Torrefaction, a biomass thermochemical pretreatment process at low temperature, was been found to be effective upgrading biomass combustible properties [4, 5, 6].

Torrefaction processes are usually conducted by following operating parameters; reaction temperature ranging from 200-300 °C, heating rate below than 50 °C, residence time within 30 minutes, ambient pressure and various feedstock [7]. In other words, torrefaction is also known as roasting slow, mild pyrolysis, wood cooking or high temperature drying. According to Bergmann *et al*[8], there are four major steps are involved in torrefaction process, namely, heating, drying, torrefaction and cooling. The main advantages of torrefied biomass over the conventional biomass are higher energy density, improved heating value, better homogeneous composition and grindability. In the present study, the effect of torrefaction temperature and time on the mass yield of empty fruit bunches has been studied and the characteristics of untreated and treated empty fruit bunches have also been studied.

2. Experimental

2.1. Samples

The empty fruit bunches sample used in this study was sourced from Felcra Nasaruddin oil palm mill that located in Bota, Perak. The samples were placed in the oven for drying process for 24 hours at 105 ºC. The dried EFB was chopped into smaller size that could be fit into a grinder. Then, the chopped feedstock was grinded and sieved into a particle size range of 250-500 µm.

2.2. Experimental procedure

The raw materials were treated using a vertical tubular reactor (length 0.56 m and diameter 0.0271 m) as shown in Fig. 1. The torrefaction reactor was connected to a condenser which was immersed in ice cubes in order to collect the condensable gas. The sample was placed in the centre of reactor and was flushed with nitrogen gas for 15 min. Then, it was heated up using electrical furnace at 10 ºC/min of heating rate in ambient pressure. Once the desired temperature was reached, the torrefaction temperature was maintained. The operating conditions were studied as follows; torrefaction temperature were 220, 260 and 300 ℃ and the reaction time were 30, 60 and 90 min. The torrefaction process produces solid, liquid and non-condensable products. The solid torrefied biomass was retrieved later from the reactor after the cooling down and weighed. The vapor phase condensed was collected in a condenser and weighed.