Bioresource Technology 255 (2018) 189–197

Contents lists available at ScienceDirect

Bioresource Technology

journal homepage: www.elsevier.com/locate/biortech

Thermogravimetric analysis and kinetic modeling of low-transition-temperature mixtures pretreated oil palm empty fruit bunch for possible maximum yield of pyrolysis oil

Chung Loong Yiin[a], Suzana Yusup[a,*], Armando T. Quitain[b,c], Yoshimitsu Uemura[a], Mitsuru Sasaki[d], Tetsuya Kida[b]

[a] Biomass Processing Cluster, Centre for Biofuel and Biochemical Research, Institute for Sustainable Living, Chemical Engineering Department, Universiti Teknologi PETRONAS, 32610 Seri Iskandar, Perak, Malaysia

[b] Department of Applied Chemistry and Biochemistry, Faculty of Advanced Science and Technology, Kumamoto University, 2-39-1 Kurokami, Chuo-ku, Kumamoto 860-8555, Japan

[c] International Research Organization for Advanced Science and Technology, Kumamoto University, 2-39-1 Kurokami, Chuo-ku, Kumamoto 860-8555, Japan

[d] Institute of Pulsed Power Science, Kumamoto University, 2-39-1 Kurokami, Chuo-ku, Kumamoto 860-8555, Japan

ARTICLE INFO

Keywords:
Thermogravimetric analysis
Empty fruit bunch
Kinetic modeling
Low transition temperature mixture
Pretreatment

ABSTRACT

The impacts of low-transition-temperature mixtures (LTTMs) pretreatment on thermal decomposition and kinetics of empty fruit bunch (EFB) were investigated by thermogravimetric analysis. EFB was pretreated with the LTTMs under different duration of pretreatment which enabled various degrees of alteration to their structure. The TG-DTG curves showed that LTTMs pretreatment on EFB shifted the temperature and rate of decomposition to higher values. The EFB pretreated with sucrose and choline chloride-based LTTMs had attained the highest mass loss of volatile matter (78.69% and 75.71%) after 18 h of pretreatment. For monosodium glutamate-based LTTMs, the 24 h pretreated EFB had achieved the maximum mass loss (76.1%). Based on the Coats-Redfern integral method, the LTTMs pretreatment led to an increase in activation energy of the thermal decomposition of EFB from 80.00 to 82.82–94.80 kJ/mol. The activation energy was mainly affected by the demineralization and alteration in cellulose crystallinity after LTTMs pretreatment.

1. Introduction

The depleting of fossil oil resources has become a major reason to develop sustainable sources of renewable energy and chemicals (Putro et al., 2016). Biomass from agricultural waste is one of the renewable energy and untapped source of raw feedstock with the highest capability to be converted into the energy (Balasundram et al., 2017). Malaysia has acclaimed intentions for generating alternative source of energy from the agricultural wastes (Abnisa and Daud, 2014). Malaysia is one of the top oil palm producers with a robust evolution in plantations and palm oil mills, whereby the waste by-product could reach 70–80 million tons per year (Roslan et al., 2014). Palm oil consists only 10% of the total biomass, whereas the remaining 90% biomass is abandoned as wastes (Awalludin et al., 2015). Hence, the utilization of biomass is crucial for the preservation of environment from disposal waste.

Some recent studies have been emphasized on the pyrolysis of empty fruit bunch (EFB) for bio-oil (Salema and Ani, 2012) and bio-ethanol (Chiesa and Gnansounou, 2014) production. Effective thermal conversion of cellulose is important for the development of an energy-saving pyrolysis process as cellulose is the most abundant biopolymer on earth (McNamara et al., 2015) and valuable component for chemical and fuel industries. Nevertheless, hemicellulose, cellulose and lignin components form a distinct structure which leads to burdensome in their utilization, separation and further refinery (He et al., 2016). The simultaneous conversion of these components in lignocellulosic biomass can produce various kinds of chemicals (Li et al., 2012). Thus, different pretreatment technologies have been introduced to destroy the lignocellulosic matrix in order to reduce the recalcitrance of biomass to the thermal conversion (Yu et al., 2015; Hao et al., 2017). Somehow, an effective conversion of lignocellulosic residues into cellulose-rich fiber through environmental friendly pretreatment methods remains challenging (Mahmood et al., 2017).

Thermochemical treatments have been used to alter properties of cellulose or modifying the crystallinity which could produce biomass with dramatically changed conversion performance (Mukarakate et al.,

* Corresponding author.
E-mail address: drsuzana_yusuf@utp.edu.my (S. Yusup).

https://doi.org/10.1016/j.biortech.2018.01.132
Received 15 December 2017; Received in revised form 25 January 2018; Accepted 27 January 2018
Available online 31 January 2018
0960-8524/