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Thermo-catalytic co-pyrolysis of palm kernel shell and plastic waste mixtures using bifunctional HZSM-5/limestone catalyst: Kinetic and thermodynamic insights

April Ling Kwang Chee [a], Bridgid Lai Fui Chin [a,h,*], Sharon Meng Xuang Goh [a], Yee Ho Chai [b], Adrian Chun Minh Loy [c], Kin Wai Cheah [d], Chung Loong Yiin [e,g], Serene Sow Mun Lock [f]

[a] Department of Chemical and Energy Engineering, Faculty of Engineering and Science, Curtin University Malaysia, CDT 250, 98009, Miri, Sarawak, Malaysia
[b] HICoE-Centre for Biofuel and Biochemical Research, Institute of Self Sustainable Building, Chemical Engineering Department, Universiti Teknologi PETRONAS, 32610, Seri Iskandar, Perak, Malaysia
[c] Department of Chemical Engineering, Monash University, Clayton, VIC, 3800, Australia
[d] Chemical Engineering Department, School of Computing, Engineering and Digital Technologies, Teesside University, Middlesbrough, TS1 3BX, United Kingdom
[e] Department of Chemical Engineering and Energy Sustainability, Faculty of Engineering, Universiti Malaysia Sarawak (UNIMAS), 94300, Kota Samarahan, Sarawak, Malaysia
[f] CO_2 Research Center (CO2RES), Department of Chemical Engineering, Universiti Teknologi PETRONAS, 32610, Seri Iskandar, Malaysia
[g] Institute of Sustainable and Renewable Energy (ISuRE), Universiti Malaysia Sarawak (UNIMAS), 94300, Kota Samarahan, Sarawak, Malaysia
[h] Energy and Environment Research Cluster, Faculty of Engineering and Science, Curtin University Malaysia, CDT 250, 98009, Miri Sarawak, Malaysia

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ABSTRACT

Kinetic and thermodynamic parameters of catalytic co-pyrolysis of palm kernel shell (PKS) and high-density polyethylene (HDPE) with three different catalysts (zeolite HZSM-5, limestone (LS) and bifunctional HZSM-5/LS) using thermogravimetric analyser via nitrogen environment were studied. The experiments were carried out at different heating rates ranging from 10 to 100 K/min within temperature range of 50–900 °C. Flynn-Wall-Ozawa (FWO), Kissinger-Akahira-Sunose (KAS) and modified Distributed Activation Energy Model (DAEM) methods were employed in this current study. The average E_a for PKS, HDPE, PKS/HDPE (2:8) – HZSM-5, PKS/HDPE (2:8) – LS, PKS/HDPE (2:8) – HZSM-5/LS, PKS/HDPE (5:5) – HZSM-5/LS, PKS/HDPE (8:2) – HZSM-5/LS are 137.26–145.49, 247.73–250.45, 168.97–172.50, 149.74–152.79, 115.30–120.39, 124.36–129.41, 151.03–154.47 and 152.67–157.31 kJ mol^{-1}, respectively. Among the different catalysts used, LS demonstrated the lowest average E_a (151.30–120.39 kJ mol^{-1}) and ΔH (109.65–114.74 kJ mol^{-1}). Positive values for ΔH and ΔG were found for the catalytic co-pyrolysis of PKS/HDPE mixtures which indicates the process is in endothermic reaction and possess non-spontaneous nature. The kinetic and thermodynamic analyses revealed the potential of PKS and HDPE as a potential feedstock for clean bioenergy production.

1. Introduction

As the world population increases, the demand for resources surges exponentially over the years as a result of extensive human activities to accommodate for the growing population. This exerts a downward pressure on the resources available. Non-renewable resources, particularly the fossil fuels, which have been on the brink of extinction have ignited the exploration of energy resources with greater sustainability and are environmentally friendly. In fact, fossil fuels have been the major source towards primary energy consumption. This can be evidenced through the upsurge of consumption demand for fossil fuels by approximately 51% between 1995 and 2015 and the percentage was believed to be further increasing by at least 18% by 2035 [1]. The subsequent effect of huge dependence on fossil fuels is the intense

* Corresponding author. Department of Chemical and Energy Engineering, Faculty of Engineering and Science, Curtin University Malaysia, CDT 250, 98009, Miri, Sarawak, Malaysia.
E-mail addresses: aprilchee@postgrad.curtin.edu.my, 700029897@curtin.edu.my, aapril_chee09@hotmail.co.uk (A.L.K. Chee), bridgidchin@gmail.com, bridgidchin@curtin.edu.my (B.L.F. Chin), 700031739@student.curtin.edu.my (S.M.X. Goh), yeeho.chai@utp.edu.my (Y.H. Chai), adrian.loy@monash.edu (A.C.M. Loy), k.cheah@tees.ac.uk (K.W. Cheah), clyiin@unimas.my (C.L. Yiin), sowmun.lock@utp.edu.my (S.S.M. Lock).

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