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Co-Pyrolysis of Empty Fruit Bunch and High-Density Polyethylene Over HZSM-5: Thermogravimetric, Kinetic and Thermodynamic Analysis

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ABSTRACT

This study conducted non-catalytic and catalytic co-pyrolysis of empty fruit bunch (EFB) and high-density polyethylene (HDPE) with HDPE-to-EFB mass ratios of 1:0, 0:1, and 1:1 via thermogravimetric analyser (TGA) and the application of Coats-Redfern method for kinetic and thermodynamic analysis. Hydrogen-exchanged zeolite socony mobil-5 (HZSM-5) catalyst was used with a catalyst-to-feedstock mass ratio of 1:1 for all the catalytic samples. From TGA results, the highest amount of volatilized matter in Phase II was obtained from non-catalytic pyrolysis of HDPE (NCP: 98.6 wt%) while the lowest amount of volatilized matter in Phase II was obtained from non-catalytic pyrolysis of EFB (NCB: 67.3 wt%). The activation energy for the pyrolysis of HDPE was highest followed by the co-pyrolysis of EFB and HDPE and pyrolysis of EFB, for both non-catalytic and catalytic runs. The activation energy based on the HDPE-to-EFB mass ratio was obtained in the following order: NCP (353.6 kJ/mol) > CP (214.3 kJ/mol) > NCPB (109.6 kJ/mol) > CPB (64.7 kJ/mol) > NCB (25.8 kJ/mol) > CB (24.4 kJ/mol). For thermodynamic analysis, ΔH and ΔG were positive for all the runs while ΔS, was negative for the non-catalytic and catalytic pyrolysis of EFB and co-pyrolysis of HDPE and EFB (NCB, NCPB, CB and CPB) and positive for the non-catalytic and catalytic pyrolysis of HDPE (NCP and CP).

Keywords: pyrolysis kinetics, pyrolysis thermodynamics, co-pyrolysis, biomass, plastic, HZSM-5

NONMENCLATURE

Abbreviations	
CB	Catalytic pyrolysis of EFB over HZSM-5
CP	Catalytic pyrolysis of HDPE over HZSM-5
CPB	Catalytic co-pyrolysis of EFB and HDPE over HZSM-5
CR	Coats-Redfern
EFB	Empty fruit bunch
HDPE	High-density polyethylene
HZSM-5	Hydrogen-exchanged zeolite socony mobil-5
NCB	Non-catalytic pyrolysis of EFB
NCP	Non-catalytic pyrolysis of HDPE
NCPB	Non-catalytic co-pyrolysis of EFB and HDPE
TGA	Thermogravimetric analyser
Symbols	
E_A	Activation energy
K_B	Boltzmann constant
ΔH	Change of enthalpy
ΔS	Change of entropy
ΔG	Change of Gibbs free energy
α	Fractional conversion
β	Heating rate
h	Planck's constant
A	Pre-exponential factor
T	Temperature
R	Universal gas constant

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