Development of a kinetic model for pressurized biomass torrefaction

Destination A. Mangenge[1], Lanrewaju I. Fajimi[1], and Bilainu O. Oboirien[1,*]

[1]*Department of Chemical Engineering, Doornfontein Campus, University of Johannesburg, Johannesburg, 2094, South Africa*

*Corresponding author: +27 115596003, +27 731740431, boboirien@uj.ac.za

Abstract

The process of wet torrefaction uses water as a raw material in order to enhance the efficiency of the process. It is essential to develop a kinetic model for this process as it helps to create an understanding of the mechanism that occurs during biomass torrefaction. The objective of this study is to estimate the kinetic parameters for wet biomass torrefaction using kinetic models such as Friedman Model (FM), Distributed Activation Energy Model (DAEM), and Flynn-Wall-Ozawa (FWO) Model. To achieve the objective, the weight loss kinetics of torrefaction of five different biomass samples were studied by non-isothermal thermogravimetric analysis and were carried out at different temperatures (20-300°C) and heating rates (5-20°C/min). The five different biomasses studied were Gum Tree (GT), Sugarcane Bagasse (SCB), Corn Cob (CC), Pine Tree (PT), and Wood Dust (WD). From the result obtained, the FM activation energy (E_a) ranged from 28.7-68.3kJ/mol with PT having the lowest and CC having the highest. The pre-exponential factors (k_0) from this model ranged from $5.40e^{-14}$-$1.46e^{-2}$. From the FWO kinetic result, SCB has the lowest E_a with 55.94kJ/mol while WD has the highest with 110.07kJ/mol and the k_0 from this model ranged from $3.79e^{-22}$-$9.37e^{-12}$. From the DAEM kinetic result, CC has the lowest E_a with 64.85kJ/mol while WD has the highest with 386.8kJ/mol and the k_0 from this model ranged from $4.53e^{-60}$-$2.02e^{-12}$. In addition, from the coefficient of determination (R^2) from the three kinetic models, the FWO and DAEM models have the best prediction accuracy with an average R^2 of 0.99 for the biomass samples.

Keywords: Biomass, Torrefaction, Kinetic Parameters, Biomass Reactivity, Kinetic Models