INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

Name of the Student	:	Harrison Hihu Muigai
Roll Number	:	176151012
Programme of Study	:	Ph.D.

Thesis Title: Biochar production from pyrolysis and co–pyrolysis of biomass blends: analysis, characterization and applications

Name of Thesis Supervisor(s)	:	Dr. Pankaj Kalita and Prof. V. S. Moholkar
Thesis Submitted to the Department/ Center	:	10/08/2021
Date of completion of Thesis Viva-Voce Exam	:	06/08/2021
Key words for description of Thesis Work	:	Biomass, Kinetic analysis, pyrolysis, co–pyrolysis, characterization

SHORT ABSTRACT

Co–pyrolysis of biomass is a promising technology capable of producing compatible substitutes for petroleum derived fuels and chemicals. To manufacture the renewable fuel precursors and chemicals on a large scale, the process needs to be cost–competitive. However, co–pyrolysis has not gained significant commercial success because of complex feedstock chemistry. Computational models help in efficient design of reactor, and understanding complex processes involved during pyrolysis and co-pyrolysis. However, all integral isoconversional methods are based on the assumption that activation energy remains constant over the whole interval of integration. In practice, such behaviour is not observed. Especially, for the biomass, the error can be as large as 20–30% in the case of strong variations of activation energy with conversion. The International Confederation for Thermal Analysis and Calorimetry (ICTAC) has recommended the use of more accurate equations and performing an iterative correction procedure for the value of activation energy. To correct these errors, ICTAC has recommended to use advanced methods that work with small conversion intervals such as Vyazovkin_advanced isoconversional model (AIC) and Distributed Activation Energy Model (DAEM).

In this the present study various aspects of biomass pyrolysis and co–pyrolysis processes were analyzed. Physico–chemical characterization and kinetic analyses of three biomass, viz. invasive species of water hyacinth (WH), *Thevetia peruviana* (TP), and industrial by–product of sugar cane bagasse (SCB) to assess their potential as feedstock for pyrolysis were investigated. Four isoconversional methods, viz. Kissinger–Akahira–Sunose (KAS), Friedman, Ozawa–Flynn–Wall (OFW), and advanced Vyazovkin_AIC were used to determine the kinetics triplets of thermal conversion at three different heating rates 10, 30 and 40 °C min^{-1}. The activation energies for raw biomass viz. WH, TP and SCB determined using the four isoconversional methods were found to be in the range of 188–330, 182–389, and 193–293kJ mol^{-1}, respectively. In the case of biomass blends the activation energies for binary blends of WHSCB, WHTP, TPSCB were observed to be in the range of 123–238, 128–273, and 125–236kJ mol^{-1}, respectively. For ternary blends of

WH111, WH211 and WH311, activation energy varied in the range 120–194, 123–247, and 122–195kJ mol^{-1}, respectively. The characterization and kinetic analysis of all biomass essentially demonstrates their potential as feedstock for pyrolysis and co–pyrolysis.

Pyrolysis was carried out in a fixed batch reactor at 350°C and 550°C with a heating rate of 20°Cmin^{-1}. Biochars were characterized for proximate and ultimate (elemental) analysis, and also using standard techniques (SEM, EDX, TGA, BET, XRD, and FTIR). Biochars produced from three different biomass, viz. water hyacinth (whole plant and its components), yellow oleander and sugarcane bagasse, and their comparative assessment for potential application in agronomy and engineering were investigated. Biochar produced from sugarcane bagasse at 550ºC possessed best properties: fixed carbon (77.42 %), bulk density (0.13 kg/m^3), BET surface area (17.78 m^2/g), pore size (12.86 nm), total pore volume (0.025 cm^3/g), calorific value (30.18 $MJkg^{-1}$), ash content (1.16 %), and moisture content (2.03 %). Co–pyrolysis of ternary blend obtained from biomass viz. water hyacinth, *Thevetia peruviana* and sugarcane bagasse was carried out in a fixed bed reactor. The optimum process conditions were determined using response surface methodology (RSM). The optimum conditions for co–pyrolysis based on two responses viz. yield and higher heating value were obtained at the temperature of 368 C, heating rate of 16.33°C min^{-1} and residence time of 61min. The present study is useful for the understanding intensification of co–pyrolysis process and applications of biochar produced from noxious weeds and waste.