

Aspen Plus Simulation of Bio-char Production from a Biomass-based Slow Pyrolysis Process

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Abstract. Biomass-based pyrolysis is a thermo-chemical conversion of biomass feedstock with low oxygen supplied level to produce bio-char, bio-oil and bio-syngas products via slow, intermediate and fast pyrolysis, respectively. The specific yields from pyrolysis process depend on operating conditions to maximize outputs. Bio-char can be used as soil improvement, animal feed supplements, filter material, carbon storage, and energy source. This study has focused on the development a simulation model for slow pyrolysis process utilizing biomass from oil palm empty fruit bunches (EFB) in Aspen Plus software. The facts that EFBs are abundant in Malaysia and have huge feedstock potentials could be realized, among them, through process design dan analysis in the Aspen Plus. Simulation model was developed based on EFB proximate and ultimate analyses and aimed for optimal product fraction yields and for the elemental composition of the pyrolysis products, considering several factors or effects such as pyrolysis temperature, pressure and inert gas flowrate. Simulation results showed the optimal value of bio-char yield was 68.6 wt. % at 9 bars, 300 °C, and 0.1 kg/min of inert gas flow rate. Eventhough the developed simulation model was an equilibrium-based one, it is useful especially in determining the optimal values of the key effects for the slow pyrolysis process.

Introduction. Bio-char is a charcoal-like material that is being used mainly to re-store carbon quantities in soil. This will amend the quality of soil which may result in higher crops productivities. This material is produced from thermochemical processing of biomass via slow pyrolysis. According to [1], there are five synergistic targets for bio-char applications; i) ecological administration; ii) soil improvement; iii) waste management; iv) climate change mitigation; v) energy production. For the case of soil quality improvement, it is not an extravagance but rather a need in numerous districts of the world. In fact, the soil ammendment has been happened naturally for thousands of years before. Areas that is larger than the Great Britain, *Terra Preta* with pitch black soils were discovered in the Amazon [2]. This area is enriched with carbon, and has thus become much more fertile than the surrounding native soil.

Among motivations of this study was the fact that lignocellulosic biomass is one of the most abundant and renewable resources worldwide. Particularly, Malaysia is well known for its tremendous hectares of oil palm plantations, where lignocellosic biomass residues from the plantations and oil palm-based industries are huge and underutilized. One of those promising biomass residues is an empty fruit bunch (EFB) [3]. Pyrolysis of the EFB could produce three types of products depending the operating conditions, and they are bio-char, bio-oil and bio-syngas. Currently, conceptual design and analysis of the pyrolysis process are required before entering to the

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