Fast pyrolysis in a fluidized bed reactor: the role of heterogeneous secondary reactions and char loading

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Biomass is a promising renewable source for the substitution of fossil feedstocks in the production of fuels and chemicals. Fast pyrolysis offers a direct route to the production of liquid fuels and chemicals with high feedstock flexibility. Furthermore, it fits well into extended-supply chain biomass valorization schemes, based on decentralized generation of intermediates at biomass harvesting/collection sites, and their feeding into centralized upgrading biorefineries. During fast pyrolysis, biomass decomposes to generate solid (biochar), liquid (bio-oil), and gases through a complex chemical network of series-parallel thermally activated reactions starting with depolymerization of lignocellulosic biopolymers, followed by fragmentation, repolymerization, aromatization and condensation reactions. Crude bio-oil is characterized by low heating value and by high viscosity, acidic pH and limited stability. These potential drawbacks are driving research toward improved reactor design and choice of process conditions to maximize yield and selectivity toward valuable compounds.

The present study focuses on fluidized bed fast pyrolysis, selected due to its versatility, robustness, and high thermal performance. However, particle heating and time-temperature history, biomass and volatile/gas residence times, gas-solids contacting, mixing, and flow pattern need careful control to drive conversion along the prescribed chemical pathway. Furthermore, the course of secondary reactions between depolymerization products and char, possibly enhanced by prolonged residence times and uncontrolled backmixing, may alter the quantity/quality of the produced bio-oil. This emphasizes the importance of proper control of char loading during operation. A careful assessment of fluidized bed fast pyrolysis of biomass is undertaken by means of a one-dimensional (1D) model based on the key features of the fluidized bed pyrolytic converter. The remarkable feature of the model is consideration of processes that control the char loading in the bed, namely, entrainment, elutriation, attrition, and bed drain/regeneration. Primary decomposition of biomass and secondary reactions are modeled using a semi-detailed reaction scheme. Model results are helpful to assess the role of heterogeneous secondary reactions and the proper management of char loading during fluidized bed fast pyrolysis, providing guidelines for the design and operation of a fluidized bed pyrolytic converter.

Keywords: *Biomass, pyrolysis, fluidized bed, secondary reactions*