Chemical reaction engineering of fluidized bed thermochemical conversion of biomass and waste

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ABSTRACT

This presentation explores the chemical reaction engineering of fluidized bed thermochemical conversion of biomass and waste, highlighting both the technological maturity and the persistent scientific complexity of fluidization. Fluidized beds have played a central role in chemical engineering for more than a century, from early coal gasification to petroleum refining, combustion, gasification, catalysis, and materials processing. Their application to biomass and waste conversion offers promising routes toward renewable energy production and sustainable chemical manufacturing.

The lecture focuses on the key physicochemical phenomena governing fluidized bed thermal conversion of biomass- and waste-derived feedstocks, including particle heating and drying, devolatilization, thermal depolymerization, heterogeneous and gas-phase reactions, hydrodynamic interactions, segregation of particles and volatiles, attrition, fragmentation, and fine particle generation. Particular attention is given to how these coupled processes influence reactor performance, especially solids and gas-phase mixing and segregation mechanisms.

By linking fundamental fluidized bed phenomena with reactor design principles, the presentation discusses how chemical reaction engineering can support the development of improved converters capable of reducing pollutant emissions, increasing yield and selectivity, and enhancing operational reliability. Selected examples from pyrolysis-based biorefinery pathways illustrate how advanced design criteria can be developed for premium biomass and waste conversion performance.