Gasification of Southeastern Woody Biomass for the Production of Transportation Liquid Fuels

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With the rapid development in countries like India and China, the demand for energy and petroleum products will continue to grow. If this demand is not met in a responsible manner, it could result in irreversible climate change. This has sparked research and development of alternative energy and renewable sources to replace or substitute petroleum-based fuels and products. In theory, utilizing renewable resources creates a carbon cycle of emission and sequestration rather than the introduction of “locked carbon” associated with earthen bound fossil fuels. Gasification is a promising technology for this effort; it can convert carbon trapped in biomass by sequestration into fuels and chemicals. Gasification uses low levels of oxygen to partially combust biomass, converting about 70% mass into carbon monoxide, hydrogen, methane, and carbon dioxide. The production of these combined gases, known as syngas, can be burned directly as an energy source or processed further to produce gasoline and other petroleum products such as waxes and plastics. What challenges this process is finding a way to supply enough biomass to meet the growing demand, operate the reactor efficiently, and create clean syngas.

Using a bench-scale bubbling fluidized bed gasification unit, we compare syngas and contaminants (i.e., ammonia, sulfur dioxide, hydrogen sulfide, and tar) production of different, readily available woody biomasses from the southeastern United States such as pine, eucalyptus, and hybrid poplar. Each biomass is gasified under different parameters such as reaction temperature, feed rate, and oxygen to fuel ratio to improve our understanding of optimal reactor conditions for producing better quality syngas. Each run is analyzed using the collected steady state gas composition data. These data sets are then modeled as a continuous process enabling mass and energy balances to be performed showing that these three types of woody biomass (e.g., pine, hybrid poplar and eucalyptus) will produce very similar syngas.

A difficulty that was not foreseen with these experiments was the major difference in feed rate between different biomass types. The gasifier’s feeding system is comprised of a biomass holding hopper with bottom alternating screws rotating at a set speed of 200 RPMs (revolution per minute), feeding the biomass into a horizontal spinning auger that delivers the biomass into the reactor. It is believed that variation in feed rate is due to the fibrous nature of the material and high moisture content. Eucalyptus was particularly difficult, while pine, hammer-milled and sieved (through 1/32” screen size) to the same size as eucalyptus, flowed more easily providing the fastest feed rate. An investigation is on-going in another group in Biosystems Engineering Department, to understand the feeding behavior with different biomass.

In conclusion, pine and eucalyptus are viable feedstocks which can supplement the demand for renewable sources of carbon while hybrid poplar is being evaluated. Gasification operation has been improved by better understanding the specific nature of each type of biomass. A still precedent issue that is the focus of our future work is reducing the levels of contamination of “tar”.

Statement of Research Advisor:

Ryan’s research project focuses on understanding the quality of syngas from different biomass types and at different ages. Ryan has developed a protocol for measuring syngas and contaminants using a bench-scale gasifier. His project is funded by the National Institute of Food and Agriculture of U.S. Department of Agriculture (NIFA-USDA).

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