Gasification of contaminated biomass to synthesize renewable fuels

Julian Dutzi, Athanasios Vadarlis, Nikolaos Boukis, Jörg Sauer
Institute of Catalysis Research and Technology (IKFT), Karlsruhe Institute of Technology (KIT), Eggenstein-Leopoldshafen/Germany

Abstract

Polluted soils, especially those contaminated with heavy metals, pose a significant risk to humans, animals, and the environment. Phytoremediation offers a solution by using plants to free these soils of pollutants. To avoid secondary contamination, it is important to utilize the plants that grow on contaminated land. This is the goal of the H2020 EU-project CERESiS. In the process of supercritical water gasification (SCWG) contaminated biomass can be gasified in a single process step at $T \geq 650°C$ and $p > 221$ bar. This process enables the decomposition of organic contaminants and the separation of inorganic contaminants like heavy metals in concentrated form. The resulting combustible product gas, mainly consisting of H_2, CO_2 and CH_4, can be used for synthesis or further processed to produce pure hydrogen. In the past, long time operation was limited due to low gasification efficiencies and solid formation in the system.

In the present study a newly developed SCWG reaction system is described in which contaminated biomasses were gasified with high carbon gasification efficiencies (CE > 80 %) and without the formation of solid deposits, enabling long time operation. Optimal parameters (temperature, pressure, biomass concentration, catalyst addition) for economic operation while ensuring sufficient gasification / avoiding solid formation were determined.

Based on the obtained product gas of the SCWG process, two different pathways are proposed to gain valuable fuels:

1) Upgrading the gas to pure hydrogen
   This is done by reforming the hydrocarbons in the product gas via steam reforming and subsequently performing water-gas shift reaction and removing CO_2 via PSA.
2) Upgrading the gas to Fischer-Tropsch fuels *(route investigated in CERESiS)*
   This is done by first removing H_2S from the product gas via Membrane-Gas-Adsorption, followed by Dry Reforming of the product gas to adjust the H_2/CO-ratio. Lastly, Fischer-Tropsch synthesis with downstream product upgrading to obtain valuable fuels.

Supercritical Water Gasification thus is a technology that can help to utilize unconventional biomasses, like contaminated plants, to obtain valuable fuels. This technology however is not limited to plants but can also be applied to wet biomasses like sewage sludge and possibly also offers the opportunity to utilize organic residues of conventional refineries.