Biobased Fuel Gas and Syngas

BIOREFINING PROCESS SOURCE

Black liquor gasification, biomass gasification

DESCRIPTION

Black liquor gasification and biomass gasification are high-temperature processes (600 to 1000^{o}C)[1] to decompose the complex hydrocarbons of biomass into simpler gaseous molecules, primarily hydrogen, carbon monoxide, and carbon dioxide. Some char, mineral ash, and tars are also formed, along with methane, ethane, water, and other constituents. The product gas must be cleaned of solids, tars, and other contaminants sufficient for the intended use. The mixture of raw product gases vary according to the feedstock and gasification approach.

Steam-reformed, indirect, and oxygen-fired direct gasification systems produce **biobased syngas**, a medium-energy combustible and reactive mixture rich in hydrogen and carbon monoxide, with a heating value[1] in the range of 10 to 20 MJ/Nm^3. The addition of steam causes a steam reforming reaction that increases the amount of hydrogen in the product gases, raising the energy content of the product gas. Co-firing syngas in an auxiliary boiler for heating generally requires minimal cleanup.

A typical composition of a medium energy biobased syngas from biomass gasification is as follows[2]: hydrogen (H_2) 22.0 percent, carbon monoxide (CO) 44.4 percent, carbon dioxide (CO_2) 12.2 percent, methane (CH_4) 15.6 percent, ethylene (C_2H_4) 5.1 percent, and ethane (C_2H_6) 0.7 percent, with a heating value of 17.3 MJ/Nm^3 (about 465 Btu/scf). A typical composition of a biobased syngas from indirect black liquor gasification with steam reforming is as follows[3]: hydrogen 61.9 percent, carbon monoxide 23.7 percent, carbon dioxide 10.5 percent, methane 3.5 percent, with a heating value of 20.95 MJ/kg. A typical composition of a biobased syngas from direct oxygen blown black liquor gasification is as follows[3]: hydrogen 27.5 percent, carbon monoxide 26.1 percent, carbon dioxide 11.3 percent, methane 1.4 percent, and water 32.7 percent with a heating value of 9.3 MJ/kg.

When air is the oxidant to facilitate the gasification reaction, nitrogen accounts for about half the product gas.[4] This dilutes the concentration of hydrogen and carbon monoxide gases, resulting in a low-energy **biobased fuel gas**, "producer gas," or "wood gas," with a heating value[1] of 2.5 to 8.0 MJ/Nm^3. A typical composition of biobased fuel gas is as follows[5]: oxygen (0_2) 0 percent, hydrogen (H_2) 20 percent, carbon monoxide (CO) 20 percent, carbon dioxide (CO_2) 7 percent, methane (CH_4) 2 percent, the balance is nitrogen (N_2) 51 percent with a heating value of 5 MJ/Nm^3 (about 134 Btu/scf).

Systems producing either fuel gas or syngas must deal with the cleanup of five primary contaminants including: particulates (mineral ash and char), alkali compounds, tars, nitrogen-containing components, and sulfur.[1] Methane, ethane, and other hydrocarbons are acceptable if the products gases are to be combusted. For use in fuel synthesis or fuel cells, they must be reduced to conversion technology-specific acceptable levels.

REPRESENTATIVE BIOBASED PRODUCT OPPORTUNITIES

BIOBASED PRODUCT	CLASSIFICATIONS	MARKET OPPORTUNITY	MARKET SIZE
Low energy fuel gas	Gaseous fuel	The low energy fuel gas is generally suitable for combustion to produce thermal energy, although microturbines are being developed for low energy gas.[5,6]	Large
Medium energy syngas	Gaseous fuel	The cleaned syngas can be used as auxiliary fuel in boilers, or as a fuel for electricity and steam generation via gas turbine combined cycle plants or fuel cells. Some fuel cell designs have limited tolerance for carbon monoxide.	Large
Steam reformed syngas	Gaseous fuel	The high hydrogen content of steam reformed syngas allows use in gas turbine combined cycle plants, in fuel cells, and as a feedstock for catalytic chemical synthesis. These applications demand high levels of gas cleanliness. Some fuel cell designs have limited tolerance for carbon monoxide.	Large
Methanol, Dimethylether (DME), and other hydrocarbons	Liquid fuel	Synthesis of automotive fuels is conducted with a clean syngas having a hydrogen to carbon monoxide ratio of about 2.1 to 1.[1] Fischer-Tropsch (F-T) chemistry utilizes metal catalysts with high temperature and pressure to convert syngas to a wide range of hydrocarbons, however, the large scale of F-T plants and the availability of low cost petroleum and flared natural gas feedstocks put biobased syngas at an economic disadvantage.	Large, but not presently economically competitive with coal or petroleum[1]
Fuel gas and syngas fermentation byproducts	Liquid fuels, acetic acid, plastics	Microorganisms exist that can directly ferment hydrogen and carbon monoxide to byproducts such as methane, ethanol, acetic acid, polyhydroxyalkanoic acids (PHA's, a feedstock for biobased plastics), and wax ester oils.[7] Research is ongoing.	Large

REFERENCES

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[7] Brown, Robert C. 2003. Biorenewable Resources Engineering New Products from Agriculture. Iowa State Press, Ames IA.