Karlsruhe Institute of Technology

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The Karlsruhe bioliq® Process

Research into and Development of 2nd-Generation Biofuels from Dry Residual Biomass

2nd-Generation Biofuels as a Contribution to the Energy Mix

Fuels from biomass have a great potential: In the short run, they will replace part of our fossil energy sources and will contribute to an efficient mix of renewable energies. Covering a wide range of different fuels, such as kerosene, diesel, and gasoline, BTL (biomass-to-liquid) fuels of the second generation have various advantages over bioethanol or biodiesel. Almost any kind of vegetable biomass material, whose origin and needs do not collide with those of plants grown for the food industry, can be used for biofuel production. Dry, cellulose-rich residual biomass (straw, residual wood) from agricultural waste, forestry production, and landscaping is particularly suited.

Fuel Legislation, Sustainability, and Certification

Fossil fuels are the basis of today's energy supply, but are becoming scarce over the long term. Their scarcity is creating new political and economic impulses to find solutions for a sustainable renewable energy supply. The EU biofuel regulations, for instance, have demanded an increase of renewable energy and of biofuels in overall consumption from 10 percent by 2020. In addition, it is stipulated that greehouse gas emissions in the industrial countries be reduced by at least 20 percent by 2020. Biofuels of the second generation are capable of reducing carbon dioxide emissions. EU subsidies will be granted in the future only for biofuels produced on the basis of sustainable biomass cultiva-tion. This applies to electric power from biomass (reimbursement in accordance with the Renewable Energy Act) and to biofuels which in Germany are credited against the biofuel ratio or are eligible for relief. Proofs of sustainability must be provided by acknowledged certification authorities.

The Karlsruhe bioliq® Process

The bioliq® pilot plant covers the process chain required for producing customized fuels from residual biomass. Being mainly synthesized from dry straw or wood, the BTL fuels offer environmental and climatic benefits through clean combustion. The integrative process chain, moreover, enables production of synthesis gas and chemicals. bioliq® intends to mainly convert large local quantities of residual biomass by densifying energy. To save carbon dioxide and reduce the transportation expenditure to refineries, the Karlsruhe BTL concept combines decentralized production of energy-rich biosyncrude by means of fast pyrolysis and central processing with final industrial-scale refinement. Since the energy density of biosyncrude is higher than that of the dry straw volume by more, it is evident that the method's efficiency is enhanced by decentralized energy densification and that such densification ensures that biomass can be fully exploited and put to use in substance and in energy.

BTL fuel production and refinement consist of five major process steps:

1. Fast Pyrolysis

The dry, comminuted biomass is mixed with hot sand at ambient pressure in the absence of air in a twin-screw mixing reactor. Pyrolytic conversion of the biomass particles at approximately

500 °C and condensation of the pyrolysis vapors take a few seconds only. Depending on the operating conditions and on the biomass selected, 40 –70 percent of liquid pyrolysis oil and 15 – 40 percent of pyrolysis char result as well as a fraction of non-condensable pyrolysis gas whose combustion heat can be used for heating or drying. In the pilot plant, 500 kg/h (2 megawatts) of biomass are converted into biosyncrude by fast pyrolysis.

2. Energy Densification: Production of biosyncrude

Pyrolysis char and pyrolysis oil are mixed to obtain a slurry (biosyncrude). The fast and efficient conversion of the mixture during gasification essentially depends on the size distribution of the char particles. Fast pyrolysis produces a pyrolysis condensates / pyrolysis char mixing ratio that is ideal for the slurry and contributes to optimizing product yields.

3. Entrained-flow Gasification

The biosyncrude is atomized with hot oxygen in an entrained-flow gasifier and is converted at above 1200 °C into a tar-free, low-methane raw synthesis gas. The gasifier used is particularly suited for the high amounts of biomass ashes that are produced during gasification. The process is performed at pressures that are determined by the subsequent synthesis. There is no need for complex gas compression procedures. While Fischer-Tropsch syntheses require process pressures of up to 30 bar, methanol or dimethyl ether (DME) syntheses are carried out at up to 80 bar. The bioliq® pilot gasifier is designed for 5 MW (1t/h) and two pressure stages of 40 and 80 bar.

4. Gas Cleaning and Gas Conditioning

Cleaning of raw synthesis gases: Particles, alkaline salts, H_2S, COS, CS_2, HCl, NH_3, and HCN are removed to prevent catalyst poisoning during fuel synthesis. The pilot plant is equipped with an innovative hot-gas cleaning system for particle filtration, pollutant decomposition, and adsorption at 500 °C.

5. Fuel Synthesis

Synthesized fuels are state of the art: Fischer-Tropsch, methanol, and dimethyl ether syntheses are well-established methods, by means of which several million tons of fuel are produced annually from black coal. Novel catalytic methods are available enabling production of large quantities of different kinds of environmentally compatible biofuels. Innovative approaches, for example single-stage DME synthesis prior to fuel synthesis, are implemented in the bioliq® pilot plant to reduce the duration of processes and achieve a continuous increase in economic efficiency.

Advantages of BTL Fuels over Conventional Fuels

- Reduction of carbon dioxide emissions.
- Saving of fossil fuels.
- Independence of energy imports to some extent.
- Strengthening of regional agriculture.
- Wide range of raw materials.
- No competition for land with food production.
- Infrastructures: Filling stations and routes of distribution can be further used.
- Fuels ("designer fuels") can be tailored to the needs of different types of engines.
- Covering of a large variety of fuel types.

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