NABC National Advanced Biofuels Consortium
Biofuels for Advancing America
Developing cost-competitive, sustainable biofuels for today's transportation infrastructure.

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Hydrothermal Liquefaction: A Route to Improved Bio-Oils

A major research goal of the National Advanced Biofuels Consortium (NABC) is to develop improved methods for producing high value intermediates that can be transformed into hydrocarbon fuels. Hydrothermal liquefaction (HTL) is one of six process strategies being employed within the NABC to address this goal. To date NABC researchers, led by Andy Schmidt and Doug Elliott at Pacific Northwest National Laboratory (PNNL), have produced more than 5 liters (about 1.5 gallons) of HTL oil in multi-day continuous runs.

Thermal treatments provide a method to transform complex biomass from forest and agricultural residues into liquid oils. In the HTL process (Figure 1) the conversion is done with wet biomass at elevated temperatures (300°–350°C or 570°–660°F). Steam generated by heating the wet biomass results in high pressures (15–20 MPa or 2,200–3,000 psi). The conversion is done in a matter of minutes (5–20 minutes).

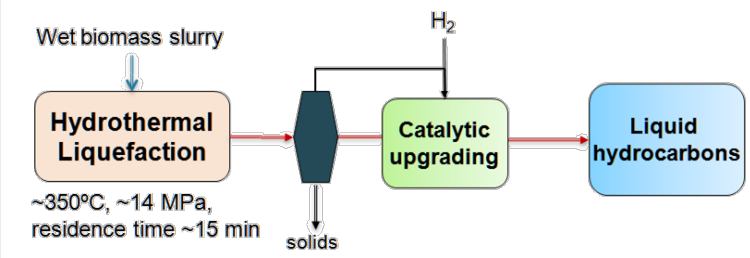

Figure 1. HTL process strategy

Researchers are using a 1-liter continuous stirred tank reactor (CSTR) to better understand the reaction. One challenge they face is continuous pumping of wet biomass slurries into the pressurized reactor. For bench scale testing (Figure 2), they outfitted a high pressure dual syringe pump to perform this step. Feed rates in multi-day continuous flow tests are 1.5 liters per hour. Oil and water are collected in liquid collectors, and gases that are formed are measured and analyzed. The oil and water naturally phase-separate and are independently analyzed.

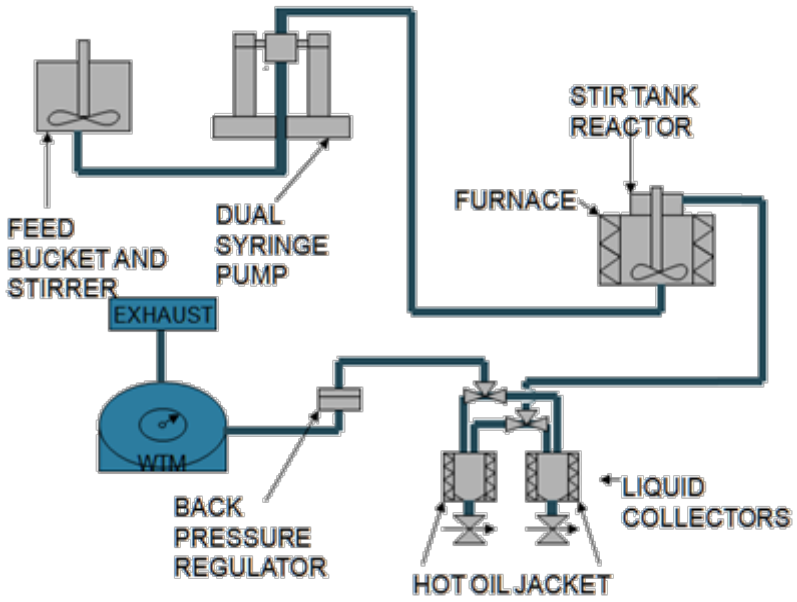

Figure 2. HTL reactor set-up at PNNL

In initial baseline runs, NABC researchers obtained oil yields of 30 weight % (53% yield on a carbon basis). The oil contains 10% oxygen on a dry basis, which is significantly lower than the oxygen content in fast pyrolysis oil. The low oxygen content correlates to an improvement in the total acid number (TAN) of the oil of 30. The oil is thermally stable, which is a benefit for upgrading to final hydrocarbon fuels. The HTL oil will be hydrotreated to further remove the remaining oxygen and produce petroleum refinery intermediates to hydrocarbon fuels in the gasoline and diesel range.

Figure 3. Actual biomass slurry feed and the resultant HTL oil
(NABC materials, photos courtesy of PNNL)

Challenges still exist. HTL requires reactors that can operate at high operating pressures, which adds capital cost; the oil that is produced is thick and viscous like corn syrup; and too much of the biomass is converted to something other than the oil. NABC researchers are trying to solve these issues to lower the cost of oil production for fuels that can blend at high ratios within our current fuel supply.