Energy-dense biofuel from cellulose close to being economical

June 4 2012, by Brian Wallheimer

A new Purdue University-developed process for creating biofuels has shown potential to be cost-effective for production scale, opening the door for moving beyond the laboratory setting.

A Purdue economic analysis shows that the cost of the thermo-chemical H2Bioil method is competitive when crude oil is about $100 per barrel when using certain energy methods to create hydrogen needed for the process. If a federal carbon tax were implemented, the biofuel would become even more economical.

H2Bioil is created when biomass, such as switchgrass or corn stover, is heated rapidly to about 500 degrees Celcius in the presence of pressurized hydrogen. Resulting gases are passed over catalysts, causing reactions that separate oxygen from carbon molecules, making the carbon molecules high in energy content, similar to gasoline molecules.

The conversion process was created in the lab of Rakesh Agrawal, Purdue's Winthrop E. Stone Distinguished Professor of Chemical Engineering. He said H2Bioil has significant advantages over traditional standalone methods used to create fuels from biomass.

"The process is quite fast and converts entire biomass to liquid fuel," Agrawal said. "As a result, the yields are substantially higher. Once the process is fully developed, due to the use of external hydrogen, the yield is expected to be two to three times that of the current competing technologies."

The economic analysis, published in the June issue of *Biomass Conversion and* Biorefinery, shows that the energy source used to create hydrogen for the process makes all the difference when determining whether the biofuel is cost-effective. Hydrogen processed using natural gas or coal makes the H2Bioil cost-effective when crude oil is just over $100 per barrel. But hydrogen derived from other, more expensive, energy sources - nuclear, wind or solar - drive up the break-even point.

"We're in the ballpark," said Wally Tyner, Purdue's James and Lois Ackerman Professor of Agricultural Economics. "In the past, I have said that for biofuels to be competitive, crude prices would need to be at about $120 per barrel. This process looks like it could be competitive when crude is even a little cheaper than that."

Agrawal said he and colleagues Fabio Ribeiro, a Purdue professor of chemical engineering, and Nick Delgass, Purdue's Maxine Spencer Nichols Professor of Chemical Engineering, are working to develop catalysts needed for the H2Bioil conversion processes. The method's initial implementation has worked on a laboratory scale and is being refined so it would become effective on a commercial scale.

"This economic analysis shows us that the process is viable on a commercial scale," Agrawal said. "We can now go back to the lab and focus on refining and improving the process with confidence."

The model Tyner used assumed that corn stover, switchgrass and miscanthus would be the primary feedstocks. The analysis also found that if a federal carbon tax were introduced, driving up the cost of coal and natural gas, more expensive methods for producing hydrogen would become competitive.

"If we had a carbon tax in the future, the break-even prices would be competitive even for nuclear," Tyner said. "Wind and solar, not yet, but maybe down the road."

The U.S. Department of Energy and the Air Force Office of Scientific Research funded the research. Agrawal and his collaborators received a U.S. patent for the conversion process.

More information: Economic Analysis of Novel Synergistic Biofuel (H2Bioil) Processes, Navneet R. Singh, Dharik S. Mallapragada, Rakesh Agrawal, Wallace E. Tyner, *Biomass Conversion and Biorefinery*.

ABSTRACT
Fast-pyrolysis based processes can be built on small-scale and have higher process carbon and energy efficiency as compared to other options. H2Bioil is a novel process based on biomass fast-hydropyrolysis and subsequent hydrodeoxygenation (HDO) and can potentially provide high yields of high energy density liquid fuel at relatively low hydrogen consumption. This paper contains a comprehensive financial analysis of the H2Bioil process with hydrogen derived from different sources. Three different carbon tax scenarios are analyzed: no carbon tax, \$55/metric ton carbon tax and \$110/metric ton carbon tax. The break-even crude oil price for a delivered biomass cost of \$94/metric ton when hydrogen is derived from coal, natural gas or nuclear energy ranges from 103 to 116/bbl for no carbon tax and even lower (\$99–\$111/bbl) for the carbon tax scenarios. This break-even crude oil price compares favorably with the literature estimated prices of fuels from alternate biochemical and thermochemical routes. The impact of the chosen carbon tax is found to be limited relative to the impact of the H2 source on the H2Bioil break-even price. The economic robustness of the processes for hydrogen derived from coal, natural gas, or nuclear energy is seen by an estimated break-even crude oil price of \$114–126/bbl when biomass cost is increased to \$121/metric ton.

Provided by Purdue University

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