Renewable fuels from algae boosted by NREL refinery process

February 16 2016

A new biorefinery process developed by scientists at the Energy Department's National Renewable Energy Laboratory (NREL) has proven to be significantly more effective at producing ethanol from algae than previous research.

The process, dubbed Combined Algal Processing (CAP), is detailed in a new paper by NREL's Tao Dong, Eric Knoshaug, Ryan Davis, Lieve Laurens, Stefanie Van Wychen, Philip Pienkos, and Nick Nagle. The paper, "Combined algal processing: A novel integrated biorefinery process to product algal biofuels and bioproducts," appears in the journal *Algal Research*.

The research follows work previously done at NREL and published in 2014 in The Royal Society of Chemistry's journal Green Chemistry. In that work, scientists examined two promising algal strains, Chlorella and Scenedesmus, to determine their applicability as biofuel and bioproduct producers. They concluded Scenedesmus performed better in this process with impressive demonstrated total fuel yields of 97 gallons gasoline equivalents (GGE) per ton of biomass.

Cost of algal biofuel production is still a major challenge and the Energy Department has made reducing the costs of both algae production and conversion of algal intermediates to fuels significant goals. In traditional processes, the algae produce lipids that get converted into fuels. However, simply increasing the amount of lipids in algae isn't expected to bring costs down enough. NREL determined further progress could be

made by more completely using all algal cellular components instead of just relying on the lipids. By applying certain processing techniques, microalgal biomass can produce carbohydrates and proteins in addition to lipids, and all of these can be converted into co-products.

In their initial work, NREL researchers determined that through the use of a solid-liquid separation process, the carbohydrates can be converted to fermentable sugars, which can then be used to produce ethanol. However, as much as 37 percent of the sugars were lost during that process. Those trapped sugars "cannot be used for fermentation without a costly washing step, resulting in a loss of overall fuel yield," according to the *Algal Research* report.

In their most recent work, NREL researchers hypothesized the amount of ethanol could be significantly increased by simplifying the processing. By skipping the solid-liquid separation process and exposing all algae components directly to fermentation conditions, both ethanol (from the carbohydrate fraction) and lipids can be recovered simultaneously. Using Scenedesmus and the CAP, and after upgrading the lipids to renewable fuels, scientists were now able to produce a total fuel yield estimated at 126 GGE per ton. That's 88 percent of the theoretical maximum yield and 32 percent more than the yield from lipids alone.

The NREL researchers also were able to recover 82-87 percent of the lipids from the CAP, even after ethanol fermentation and distillation, indicating that the initial fermentation of sugars in the pretreated biomass slurry doesn't significantly impede lipid recovery. These results led to the conclusion that the novel CAP process is capable of reducing the cost of algal biofuel production by nearly $10/GGE compared to a "lipids only" process, taking the modeled cost down to $9.91/GGE. While this is not nearly low enough to compete with petroleum, this approach can be combined with reduced costs for biomass production to provide a path forward to achieve that goal.

More information: Tao Dong et al, Combined algal processing: A novel integrated biorefinery process to produce algal biofuels and bioproducts, *Algal Research* (2016). DOI: 10.1016/j.algal.2015.12.021

L. M. L. Laurens et al. Acid-catalyzed algal biomass pretreatment for integrated lipid and carbohydrate-based biofuels production, *Green Chem.* (2015). DOI: 10.1039/C4GC01612B

Provided by National Renewable Energy Laboratory