NATIONAL RENEWABLE ENERGY LABORATORY

Algal Pretreatment Improves Biofuels Yield and Value

Highlights in Science

Advanced process for algal biofuel production captures the value of both the lipids and carbohydrates for conversion to biofuels.

The major challenges associated with algal biofuels production in a biorefinery-type setting include improving biomass utilization, increasing the process energetic yields, reducing waste and greenhouse gas emissions, and providing economically viable and scalable coproduct concepts. Researchers from the National Renewable Energy Laboratory (NREL) have demonstrated the effectiveness of a new integrated technology that paves the way for increased yield and reduced costs of algal biofuels. This process uses moderate temperatures and low pH to convert the carbohydrates in wet algal biomass to soluble sugars for fermentation and makes lipids accessible for downstream extraction and upgrading. It also leaves behind a protein-enriched fraction for potential high-value food and feed application.

Illustration of the morphological changes of the cellular structure of late harvest Scenedesmus after pretreatment (right) relative to the original biomass (left). Photo by Nick Sweeney, NREL 33338

NREL researchers used algal strains *Chlorella* and *Scenedesmus* to study the effect on the conversion yields and effectiveness of culture harvest timing, which represents distinctive compositional ratios of protein, carbohydrate, and lipids. Experimental data showed a clear difference between the two algal strains: late harvest *Scenedesmus* biomass, with high carbohydrate (>35%) and lipid (>40%) content, showed the maximum theoretical biofuel potential at 143 gasoline gallon equivalent (gge) combined fuel yield per dry ton biomass. Late harvest *Chlorella* followed at 128 gge per ton. This represents an energetic fuel yield that is two to three times greater than terrestrial feedstocks can produce.

Researchers can take advantage of the recovery of sugars and fatty acids—after algal biomass is pretreated as a form of nondestructive biochemical conversion or fractionation—to use most of the assimilated carbon for biofuel components. This process provides a new route to valorizing algal biomass and a potentially viable route for more cost-effective algal biofuels development with high efficiency and clean product streams demonstrated for wet biomass extraction. This technology can also be applied in the realm of bioproducts, carbon fiber, and food and feed ingredient research and development, thanks in part to the high-purity fractions produced.

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Key Research Results

Achievement

As the first-ever design case of a two-fuel pathway from algae, this study uses the lipid and the carbohydrate portions of the biomass to close the gap between a lipid-only and a whole-biomass-based biorefinery setting. The process more than doubles the recoverable energy in fuel products compared with a terrestrial feedstock-based cellulosic ethanol fuel pathway.

Key Result

NREL researchers used an approach originally developed for cellulosic biomass to optimize a method of acid pretreatment of whole, freshly harvested algal biomass at moderate temperature. This process releases soluble sugars in a liquor stream and leaves the lipids accessible for high-efficiency extraction.

Potential Impact

This new research develops a path for meeting aggressive yield and cost targets for producing biofuels from oleaginous feedstocks such as algae. Techno-economic analysis indicates that this process has the potential to improve per-gallon fuel costs by up to 33% relative to a baseline lipid-extraction-only approach.

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