GM microbe makes waves for large-scale production of seaweed biofuels

A team of researchers have genetically engineered a microbe capable of converting the sugars in seaweed into ethanol, overturning a main obstacle to biofuel production and touting seaweed as a “real renewable biomass contender.”

The potential of macroalgae (seaweed) as a feedstock for bioconversion into biofuels and commodity chemical compounds has been wildly contested. Macroalgae has shown promise as, in addition to its high sugar content, it has no lignin and does not require arable land or freshwater to grow. Studies have shown that macroalgae can yield approximately two-times and five-times more ethanol than that from sugarcane and maize, respectively.

Commenting on the work, Daniel Trunfio, CEO at Bio Architecture Lab, said that “about 60% of the dry biomass of seaweed are sugars, and more than half of those are locked in a single sugar – alginate … Our scientists have developed a pathway to metabolize the alginate, allowing us to unlock all the sugars in seaweed, which therefore makes macroalgae an economical alternative feedstock for the production of renewable fuels and chemicals.”

The potential is encouraging. A major advantage is that a seaweed industry has already been established, with populations farming seaweed for 1000 years in China and Japan and, more recently, seaweed farming pilot projects being established in Europe, Chile and the USA. Additionally, due to coastal waters often being polluted by nutrients washed into rivers from farmers’ fields, it has been noted that farmed seaweed requires no fertilizer.

However, its full potential as a biofuel feedstock has been limited, due to lack of tractable microorganisms that can metabolize alginate polysaccharides, one of the three most abundant sugars in macroalgae.

Now, research conducted at the Bio Architecture Lab in Berkeley (CA, USA) has presented the discovery of a 36-kilobase pair DNA fragment from Vibrio splendidus encoding enzymes for alginate transport and metabolism. The study, published in Science, reported that the genomic integration of the ensemble, together with an engineered system for extracellular alginate depolymerization, generated a microbial platform capable of simultaneously degrading, uptaking and metabolizing alginate.

The scientists also further engineered the platform for ethanol synthesis, highlighting that the platform could enable bioethanol production directly from macroalgae via a consolidated process. Results showed that the process was capable of converting 28% of the dry weight of macroalgae into ethanol, equivalent to approximately 80% of the maximum theoretical yield from the sugar composition in macroalgae.

Sources: Wargacki AJ, Leonard E, Win MN et al. An engineered microbial platform for direct biofuel production from brown macroalgae. Science 335(6066), 308–313 (2011); Press release: Science magazine showcases groundbreaking Bio Architecture Lab technology that efficiently converts seaweed to renewable fuels and chemicals: www.ba-lab.com/pdf/BALScience.pdf
UPM-Kymmene Corporation Company, a ‘biofore company’ specializing in bio and forest industries based in Helsinki, Finland, has announced that it is to build the world’s first biorefinery producing wood-based biodiesel from crude tall oil in Lappeenranta, Finland.

The company has stated that the new biorefinery will produce approximately 100,000 tonnes of advanced second-generation biodiesel annually. The company will begin construction of the biorefinery in the summer of 2012 at UPM’s Kaukas mill site, to be completed in 2014, announcing a total investment of approximately €150 million.

Jussi Pesonen, UPM President and CEO, stated in a press release that: “the biofuels business has excellent growth potential … Lappeenranta is the first step on UPM’s way in becoming a significant producer of advanced second-generation biofuels.”

Pesonen added that, “the construction of the biorefinery will offer work for nearly 200 people for approximately 2 years. When production commences, the biorefinery will directly employ nearly 50 people and indirectly about 150 people.” UPM has also announced plans to build another biorefinery either in Rauma, Finland, or in Strasbourg, France, which would use energy wood as raw material, and use different technology to that of the Lappeenranta biorefinery.

“Our biorefinery in Lappeenranta is the first significant investment in a new and innovative production facility in Finland during the ongoing transformation of the forest industry” said Pesonen.

Source: Press release: www.cisionwire.com/upm-kymmene-oyj-r/upm-to-build-the-world-s-first-biorefinery-producing-wood-based-biodiesel,e286346

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Microbubble technology to help reduce costs of algae biofuel production

Finding a cost-effective method to harvest and remove water from algae, in order for it to be processed efficiently and create a useful biofuel, has been a major challenge. Now, research conducted as the University of Sheffield, UK, has developed microbubble technology, which claims to help solve that challenge.

The research follows on from previous work using microbubble technology. Will Zimmermann, from the Department of Chemical and Biological Engineering at the University of Sheffield, explained: “we thought we had solved the major barrier to biofuel companies processing algae to use as fuel when we used microbubbles to grow the algae more densely … it turned out, however, that algae biofuels still couldn’t be produced economically, because of the difficulty in harvesting and dewatering the algae. We had to develop a solution to this problem and, once again, microbubbles provided a solution.”

The newly developed system uses up to 1000-times less energy to produce the microbubbles. In addition, the cost of installing the Sheffield microbubble system is predicted to be far less than existing flotation systems.

Speaking to Biofuels, Zimmermann said that, “I believe that algal biofuels have been on the horizon for about 35 years, and all during that period the cost of harvesting the algae/dewatering it has been about a third of the energy of the overall process.” Zimmermann explained that, “only technology can be the solution, so we need new technologies. Energy efficient microbubbles are a disruptive technology – low energy use (lower than the production of conventional bubbles) and low capital cost.”

Zimmermann told Biofuels of how his team developed the technology: “first we applied it to intensifying bioreactors, and now to harvesting, with boosts in performance and dramatically lower energy costs for gas exchange and bubble mediated flotation separation. But it may still not be enough to lower the production costs of algal biofuels to compete with petroleum fuels.”

He continued, “we have not stopped innovating, but I cannot tell you where the bubble will strike next, other than it will be ‘where no bubble has gone before!’”

Discussing the economics of the research, Zimmermann said, “we need to run at larger scale and with a full demonstration plant before we can assess the financial viability of these two microbubble innovations in algal biofuels” and explained that for future work, “I am trying to arrange pilot scale tests of microflotation … several algal bioreactor companies are interested.”

Sources: Hanotu J, Bandulasena HH, Zimmerman WB. Microflotation performance for algal separation. Biotechnol. Bioeng. doi:10.1002/bit.24449 (2012) (Epub ahead of print); Press release: Microbubbles provide new boost for biofuel production: www.shef.ac.uk/mediacentre/2012/microbubbles-boost-biofuel-production.html
New understanding of grass genes could improve bioenergy prospects

Scientists at the University of Cambridge and Rothamsted Research, UK, have discovered a family of genes capable of helping breed grasses with improved properties for diet and bioenergy.

Xylan is an important and highly abundant component of the tough walls that surround plant cells. It holds other molecules in place, helping make the plant rigid and robust – this is important for the plant, but also locks in the energy scientists need to obtain in order to produce biofuels efficiently.

Paul Dupree, from the University of Cambridge’s Department of Biochemistry, explained the rationale behind the study: “what we hope to do is to produce varieties of plants where the woody parts yield their energy much more readily – but without compromising the structure of the plant … one way to do this might be to modify the genes that are involved in the formation of a molecule called xylan – a crucial structural component of plants.”

In grasses there is a substantially different form of xylan as compared with other plants. In order to determine what was responsible for this difference, the UK-based scientists looked for genes that were turned on more regularly in grasses than in the model plant Arabidopsis. Once they had identified the gene family GT61 in wheat and rice, they were able transfer it into Arabidopsis, which in turn developed the grass form of xylan.

Rowan Mitchell, from Rothamsted Research, explained, “as well as adding the GT61 genes to Arabidopsis, we also turned off the genes in wheat grain. Both the Arabidopsis plants and the wheat grain appeared normal, despite the changes to xylan. This suggests that we can make modifications to xylan without compromising its ability to hold cell wall together.” Outlining the significance of this, Mitchell said that, “this is important as it would mean that there is scope to produce plant varieties that strike the right balance of being sturdy enough to grow and thrive, whilst also having other useful properties such as for biofuel production.”

Duncan Eggar, from the Biological Sciences Research Council, said, “This research demonstrates how, by understanding the fundamental biology of plants, we can think about how to produce varieties of crops with useful traits, specifically for use as a source of energy.”

Sources: Anders B, Wilkinson MD, Lovegrove A et al. Glycosyl transferases in family 61 mediate arabinofuranosyl transfer onto xylan in grasses. Proc. Natl Acad. Sci. USA 109(3), 989–993 (2012); Press release: Breeding better grasses for food and fuel: www.cam.ac.uk/research/news/breeding-better-grasses-for-food-and-fuel

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Biofuels from palm oil fail to meet GHG reduction threshold

The US EPA has announced that biofuels produced from palm oil will not count towards the USA’s Renewable Fuels Standard (RFS) mandates, due to not meeting the minimum GHG performance threshold.

The EPA’s Notice of Availability stated that both biodiesel and renewable diesel produced from palm oil have estimated life cycle GHG emission reductions of 17 and 11%, respectively, compared with the statutory baseline petroleum-based diesel, thus failing to meet the minimum 20% GHG performance threshold for renewable fuel under the RFS program.

In order to determine which fuel path pathways meet GHG reduction thresholds for renewable fuel categories, a comprehensive evaluation of life cycle GHG emissions of the renewable fuel has been completed, as compared with those of the gasoline or diesel fuel that it replaces.

To calculate the life cycle GHG emissions for palm oil biofuel pathways, the EPA utilized models developed for the final RFS2 rule. These models take into account energy and emissions inputs for fuel and feedstock production, distribution and use, as well as economic models that predict changes in agricultural markets. For palm oil, the EPA used the same general approach to estimate global land use change GHG emissions as for other biofuel pathways; however, analysis did also include new data for Indonesia and Malaysia, where almost 90% of world palm oil is currently produced.

The EPA’s analysis highlighted a number of key factors that contribute to the life cycle emission estimate for palm oil-based biofuels. One example highlighted that palm oil production produces wastewater effluent that eventually decomposes, creating methane. Another key factor highlighted that the expected expansion of palm plantations was onto land with carbon-rich peat soils, which would lead to significant releases of GHGs to the atmosphere.

The EPA’s Notice now provides the public an opportunity to comment on the analysis.

All stories written by Ruth Williamson, Assistant Commissioning Editor. Source: EPA issues notice of data availability concerning renewable fuels produced from palm oil under the RFS program: www.epa.gov/otaq/fuels/renewablefuels/documents/420f11046.pdf