Ultrasound 'making waves' for enhancing biofuel production

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All chefs know that "you have to break some eggs to make an omelet," and that includes engineers at Iowa State University who are using high-frequency sound waves to break down plant materials in order to cook up a better batch of biofuel. Research by David Grewell, associate professor of agricultural and biosystems engineering, and his colleagues Melissa Montalbo-Lomboy and Priyanka Chand, has shown that "pretreating" a wide variety of feedstocks (including switch grass, corn stover, and soft wood) with ultrasound consistently enhances the chemical reactions necessary to convert the biomass into high-value fuels and chemicals.

The team will present its findings at the 21st International Congress on Acoustics (ICA 2013), held June 2-7 in Montreal.

In one example of ultrasound's positive impact on biofuel production, the Iowa State researchers found that they could significantly increase the efficiency of removing lignin from biomass in solution. Lignin is the chemical compound that binds cellulose and hemicellulose together in plant cell walls. Commonly, enzymes or chemicals are used to remove it from biomass and allow the freed sugars to be dissolved for further processing into biofuel. Grewell and his colleagues found that pretreating instead with ultrasound makes lignin removal so efficient that sugar dissolution occurs in minutes rather than the hours needed with traditional mixing systems.

Grewell's team also found that hydrolysis of corn starch could be greatly

accelerated using ultrasonics. In a conventional ethanol plant, ground corn is steamed with jet cookers at boiling point temperatures. This breaks down the corn, leaving a starch mash that is then cooled and treated with enzymes in a process known as hydrolysis to release glucose for fermentation. The Iowa State team replaced the initial steaming with ultrasound, sonically smashing the corn into tiny particles in the same way physicians use ultrasound to shatter kidney stones. The smaller corn fragments provided more surface area for enzymatic action, and therefore, resulted in fermentation yields comparable to jet cooking.

The potential cost savings for this method, says Grewell, are very encouraging. "Economic models," he explains, "have shown that once implemented, this technology could have a payback period of less than one year."

Grewell and his colleagues report a third application for ultrasound in biofuel production, showing that they can accelerate transesterification, the main chemical reaction for converting oil to biodiesel. In one case, the researchers found that subjecting soybean oil to ultrasound transformed it into biodiesel in less than a minute, rather than the 45 minutes it normally takes. Similarly, Grewell's team found that yeast populated with sugar and starved with glycerin, a co-product of biodiesel production, could prodfuce high yields of oil that could be extracted and simultaneously converted to biodiesel with ultrasonics in less than a minute. This is a dramatically faster and less complicated method than traditional techniques requiring multiple steps and relatively long cycle times.

More information: Presentation 5aPA3, "Enhancing biofuel production by ultrasonics," is in the morning session on Friday, June 7. Abstract: asa.aip.org/web2/asa/abstracts … h.jun13/asa1501.html

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