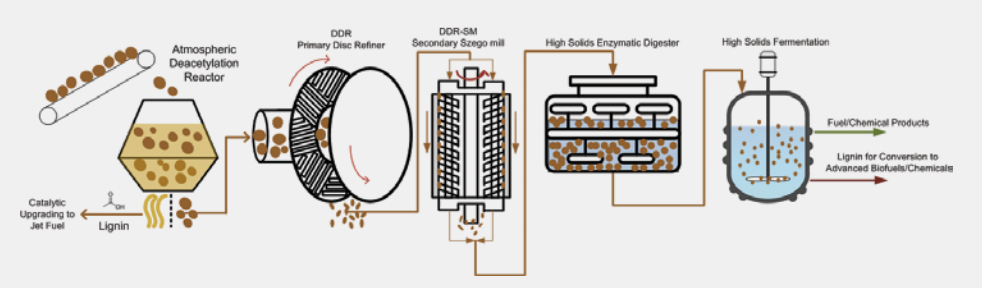
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

High Titer and Yields Achieved with Novel, Low-Severity Pretreatment Strategy

Highlights in Research & Development

A new, less toxic, NREL-developed deacetylation and mechanical refining (DMR) process achieves unexpectedly high sugar titers and yields for fermentation into advanced biofuels and chemicals.

Reducing biomass resistance to deconstruction of its biopolymers to fermentable and catalytically upgradeable sugars and lignin monomers with various thermal, chemical, and mechanical treatments has been a focus of intense research for the past century. However, most of the pretreatment methods utilize high-severity conditions involving high acid or alkaline loadings with high-temperature steam usage. This not only leads to high capital and operational costs, but also produces a significant amount of fermentation inhibitors.



NREL's deacetylation followed by mechanical refining (DMR) process. Image by Xiaowen Chen, NREL.

Researchers at NREL have developed a DMR process that uses a moderate temperature (80°C), low severity, dilute alkali chemical treatment, followed by a mechanical treatment, to produce highly digestible solids that produce high concentration, low toxicity sugar syrups and upgradable lignin streams at high yields with the possibility of reducing environmental and life-cycle analysis impacts.

Using lignocellulosic biomass feedstock, such as renewable corn stover, NREL research has shown that the second generation of biofuel can be as efficient as first generation bioethanol in respect to product titers and productivities with a cost-effective means to pretreat non-food biomass—with the potential for further improvement.

The DMR process can be integrated with current corn ethanol plants, as well as decommissioned pulp and paper plants being repurposed to ethanol production. The simpler DMR process efficiently reduces water and energy usage by recycling the waste product black liquor in the deacetylation process and thus lowers the production costs of sugars for biofuels production and reduces environmental and life-cycle impacts.

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References: Chen, Xiaowen, Erik Kuhn, Ed Jennings, Robert Nelson, Ling Tao, Min Zhang, and Melvin P. Tucker. "DMR (deacetylation and mechanical refining) processing of corn stover achieves high monomeric sugar concentrations (230 g/L) during enzymatic hydrolysis and high ethanol concentration (>10% v/v) during fermentation without hydrolyzate purification or concentration." *Energy & Environmental Science.* doi: 10.1039/c5ee03718b.

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Key Research Results

Achievement

NREL researchers obtained high concentration sugar syrups in enzymatic hydrolysis that are fermentable to ethanol and other advanced biofuels and intermediate products at high yields. The novel DMR process is simpler and bypasses all severe pretreatment methods, thus reducing the environmental impact.

Key Result

The results are unprecedented. Researchers achieved a high concentration of sugars (230g/L of monomeric sugar and 270 g/L total sugar) and this low toxicity, highly fermentable syrup yielded 86 g/L ethanol (> 90% conversion). In addition, the lignin streams from this process can readily be converted to jet or renewable diesel blendstocks through a hydrodeoxygenation step.

Potential Impact

The NREL-developed, low severity DMR process may potentially replace higher severity chemical pretreatments and associated expensive reactors constructed of exotic alloys with a simpler process, using commercial-scale equipment commonly associated with the pulp and paper industry, to produce high concentration, low toxicity sugar streams and highly reactive lignin streams from non-food renewable biomass for biological and catalytic upgrading to advanced biofuels and chemicals. The simpler DMR process with black liquor recycling could reduce environmental and life-cycle impacts, and repurpose shuttered pulp and paper mills to help revitalize rural economies.

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