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Crop, forestry residues used as new sources to produce ethanol

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The U.S. farm community and industry will produce about 2 billion gallons of automotive fuel from cornstarch in 2001, meeting more than 1% of U.S. domestic automotive fuel needs.

More than half the petroleum that the U.S. produces each year is used for automotive fuel–an amount roughly equivalent to total imported oil.

Ethanol and MTBE (methyl tertiary butyl ether) are primarily used as oxygenates in reformulated gasoline, as fuel extenders, and to increase octane ratings. With the phasing out of MTBE due to toxicity in groundwater and with the instability in the supply of imported oil, there is a critical need to increase fuel ethanol production–as well as a longer term need to increase renewable domestic fuels.

THE AUTHOR EXAMINES A PETRI PLATE CONTAINING BACTERIA ENGINEERED TO PRODUCE ETHANOL FROM THE HEXOSE AND PENTOSE SUGAR CONSTITUENTS OF PLANT BIOMASS.

TARA PIASIO

While ethanol production from cornstarch can potentially expand to around 5 billion gallons per year, additional renewable agricultural feedstocks must be developed.

During the past 10 years, with support from USDA's National Research Initiative (NRI) Competitive Grants Program, researchers at the University of Florida have developed basic technologies that can convert lignocellulosic crop and forestry residues into fuel ethanol.

New Biocatalyst

About 70% of the weight of lignocellulose is represented by two carbohydrate polymers–cellulose and hemicellulose–which can serve as a source of sugars for microbial metabolism into useful products. The balance is primarily lignin, which is used as a fuel for boilers and distillation.

Although cellulose is a homopolymer of glucose, hemicellulose contains a mixture of hexose and pentose sugars. These pentoses cannot be metabolized by conventional yeasts, severely limiting ethanol yields.

While ethanol production from cornstarch can potentially expand to around 5 billion gallons per year, additional renewable agricultural feedstocks must be developed.

The researchers developed the first new biocatalyst, which can convert all of the sugar constituents of plants into ethanol. The resulting invention was selected by the Department of Commerce to become Landmark Patent No. 5,000,000.

The new biocatalyst was produced by isolating the unique genes needed for an ethanol pathway and inserting them into *Escherichia coli. E. coli* is the modern workhorse of biotechnology for nutriceuticals (amino acids as food and feed supplements), pharmaceuticals (insulin), and components of the sweetener aspartame (phenylalanine).

This organism has the native ability to metabolize all types of sugars but normally produces a mixture of lactic and acetic acids with no commercial value.

Improvements

The researchers have made many improvements in the original biocatalyst and in processes that can reduce the capital and operating costs of fuel ethanol production from lignocellulose.

These processes include the engineering of enzymes for the solubilization of cellulose, increased ethanol tolerance, and metabolic changes that decrease nutrient costs.

To facilitate further improvement, current studies are taking advantage of the full *E. coli* genome sequence by simultaneously investigating changes in the function of all genes during fermentation. Results from these studies should identify new opportunities for further simplifying and improving the lignocellulose-to-ethanol process.

Impact

Developing and expanding the lignocellulose-to-ethanol industry through agricultural cooperatives could provide new manufacturing and employment, increasing revenues in rural economies.

Other benefits include reducing U.S. dependence on imported petroleum, reducing the annual trade imbalance, reducing greenhouse gases, and improving the quality of our environment.

Commercial projects are currently being developed that will use new biocatalysts for the production of fuel ethanol from agricultural residues such as corn stalks, rice straw, wheat straw, sugarcane bagasse, and wood waste.

Eric Zamora

Residues from the processing of sugarcane — called bagasse — represent an abundant and renewable source of carbohydrates for bioconversion into fuel ethanol and other useful chemicals.

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