**Xtreme Xylanase, the most thermal- and acid-stable xylanase enzyme known, was discovered by INL researchers in a catalogued bacterium originally isolated from Nymph Creek in Yellowstone National Park's Norris Geyser Basin. The enzyme is stable and active at temperatures ranging from hot tap water to nearly boiling, and in acidic conditions ranging from battery acid to acid rain, which is 10,000 times weaker than battery acid.**


# Xtreme Xylanase Discovery Aims to Revolutionize Biorefineries

Xtreme Xylanase is an enzyme that helps a microbe to thrive in hot, acidic waters in Yellowstone National Park, and it may enable U.S. industry to economically produce fuels and chemicals from biomass – helping achieve the Bush Administration goal of replacing 75 percent of oil imports from the Middle East by 2025. This enzyme is a highly acid- and thermo-stable xylanase enzyme from *Alicyclobacillus acidocaldarius,* a microbe originating in Yellowstone National Park. It is capable of efficiently converting the hemicellulose and cellulose components of biomass into energy rich sugars. These sugars are building blocks used in place of petroleum to make fuels and high-value chemicals.

## Significant Discovery

Xtreme Xylanase is the most thermal- and acid-stable xylanase ever discovered. It is chemically active and stable in an amazingly wide range of conditions including temperatures ranging from hot tap water to nearly boiling. It is stable in battery-acid-like conditions (pH 1) and is active in acids that are 10,000 times weaker (pH 5). The metabolic versatility of this enzyme will enable economic enzyme production, biomass pretreatment process versatility, and significant equipment and operational cost savings that could make affordable cellulosic ethanol a reality.

What makes Xtreme Xylanase a breakthrough technology is that it can break down both hemicellulose and cellulose at temperatures and pHs considered considered very moderate for pretreatments, but are extreme for commercially available enzymes and organisms. In addition, its wide range of applicable process conditions can improve downstream efficiencies and enable further cost savings. Finally, it is derived from a bacterium and can be commercially produced in industrial quantities more cost effectively than fungal enzymes.

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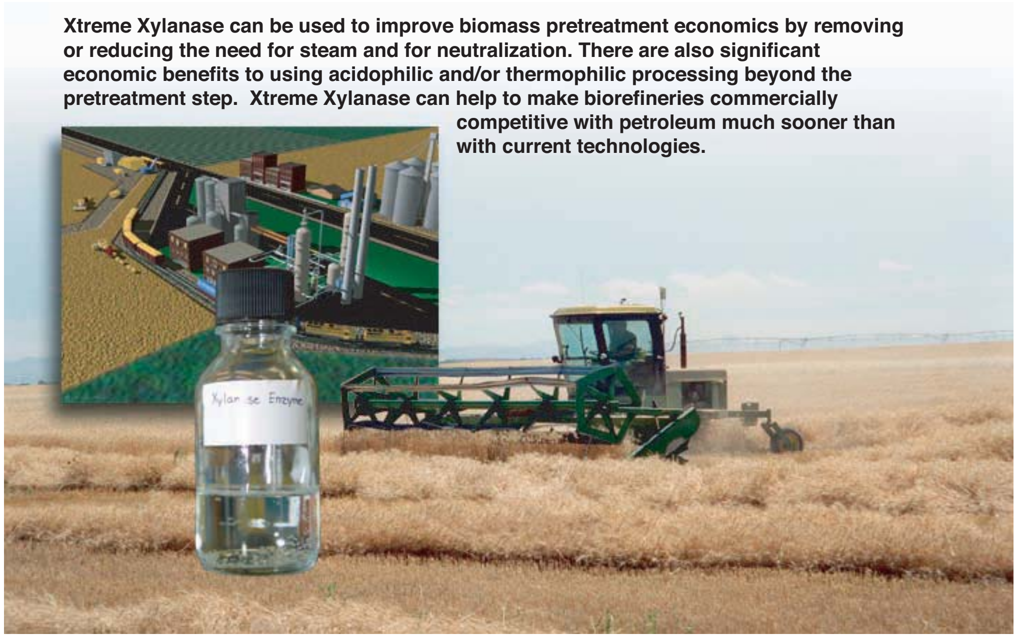
**Xtreme Xylanase can be used to improve biomass pretreatment economics by removing or reducing the need for steam and for neutralization. There are also significant economic benefits to using acidophilic and/or thermophilic processing beyond the pretreatment step. Xtreme Xylanase can help to make biorefineries commercially competitive with petroleum much sooner than with current technologies.**





## For more information

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INL is a U.S. Department of Energy national laboratory operated by Battelle Energy Alliance

## Cost-Effective and Efficient

Lignocellulosic biomass such as forestry wastes, agricultural residues, and dedicated energy crops can potentially offer sustainable domestic fuels and offset significant amounts of petroleum. The primary impediment to its utilization is economics. After feedstock costs, the pretreatment and its associated unit operations together represent the highest capital expense limiting the economic viability of biorefinery production of fuels and chemicals from biomass. There are also significant economic benefits to using thermophilic and acidophilic processing in the biorefinery beyond the pretreatment step. Breakthroughs like Xtreme Xylanase that reduce the cost of these process steps are therefore critical to the energy independence of the U.S.

Xylanase enables the integration of acid-free, reduced-temperature pretreatments with consolidated bioprocessing strategies. These strategies combine enzyme treatments with simultaneous fermentations to simplify process flowsheets. This allows the potential elimination of the extreme temperatures and expensive materials that make current dilute acid pretreatments so costly. As a result of this innovation, biorefineries may be competitive with petroleum much sooner than with current technologies.

## Energy Independence and Reduced Greenhouse Gases

By lowering the costs of converting our nation's estimated 1.3 billion tons of sustainably available biomass to fuels and chemicals, Xtreme Xylanase will help put the U.S. on the road to energy independence. A recently completed DOE Biomass Program report outlines a national strategy in which biomass can displace 30% of the nation's petroleum consumption for transportation by 2030. According to the DOE Energy Information Administration, by 2030 our consumption of motor fuel gasoline will be more than 200 billion gallons annually. Hence, Xtreme Xylanase can help enable the annual replacement of more than 60 billion gallons of gasoline by 2030. Each year this would displace more than 545 million tons of gasoline-derived $CO_2$ with annually recycled biomass $CO_2$, which mitigates greenhouse gas accumulation in the atmosphere.

By virtue of its extreme acid- and thermo-stability, Xtreme Xylanase will revolutionize biorefineries in several ways:

- Reduce or eliminate pretreatment costs
- Improve fermentation efficiency
- Improve downstream economics
- Streamline biorefinery flowsheets
- Complement consolidated bioprocessing strategies.

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