



ENZYME TECHNOLOGY TO INCREASE YOUR PRODUCTION AND PROFIT



ENZYME PRODUCTS FOR BIOGAS PRODUCTION

Solutions for anaerobic digesters

DuPont
Advanced
Biofuels

Enzyme Products for Biogas Production

Solutions for anaerobic digesters

Reduce anaerobic digestion costs by 10%

Increase biogas production by up to 15%

Reduce viscosity of substrate/digestate by 2-3x

What are biogas enzymes?

Enzymes are found in the cells of every living thing. Their purpose is to help catalyze, or speed up, certain biochemical reactions. Enzymes are used today in many industrial applications such as animal nutrition, detergents, and biofuels.

The enzymes developed by DuPont for biogas production break down plant fibers (carbohydrates such as cellulose and hemicellulose) and protein-rich materials, resulting in sugars and amino acids more suitable for biogas-producing microorganisms.

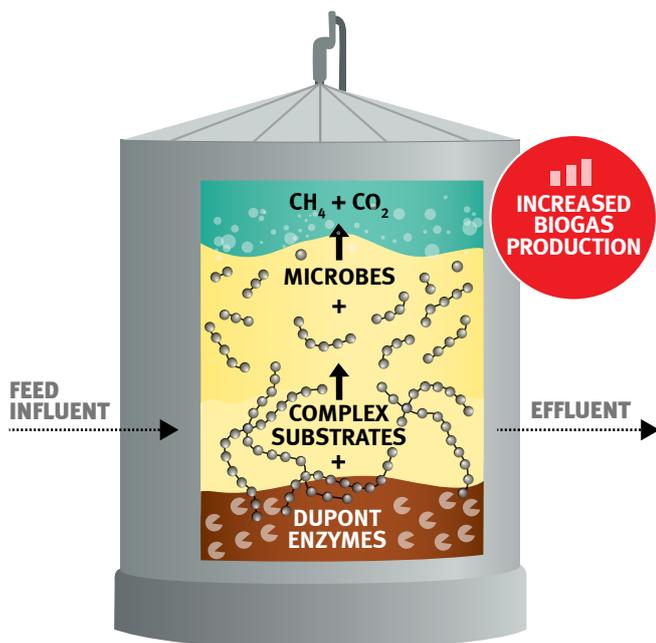


Figure 1. Schematic of an anaerobic digester containing DuPont enzymes. Enzymes break down large polymers from difficult substrates into smaller sugars and amino acids that are more suitable for biogas-producing organisms.

How are these enzymes produced?

In January 2016, DuPont acquired enzyme and technology assets from Dyadic International, Inc., including their C1 platform, a fungal expression technology for producing enzymes. The C1 platform complements DuPont's world-class enzyme expression systems and strong line of Optimash AD products. can now offer an expanded product platform for biogas production, including enzymes produced in two different fungal organisms, *Trichoderma reesei* and *Myceliophthora thermophila*.

How can enzymes help biogas producers?

- Increased biogas production from the same amount of feedstock OR decreased feedstock consumption to achieve the same level of biogas production.
- Improved biogas quality (methane/CO₂ ratio).
- Reduced viscosity of substrate and digestate – reduced mixing costs.
- Increased fermentation rate; shorter residence time.
- Increased process robustness: ability to break down more difficult substrates, as well as reduce risk of rafting.

Enzyme activity over a broad pH and temperature range

Enzyme products from DuPont's Optimash and C1 platforms span a broad range of pH and temperature, with product offerings that are effective between pH 4-8 and 30-75°C.



Figure 2. Broad pH and temperature profile of DuPont enzyme products for biogas applications.

What feedstocks can enzymes work with?

Any organic material that contains cellulosic fibers, including agricultural materials, as well as farm, animal, paper and food wastes. This includes enabling safe use of non-food feedstocks such as straw and deep litter muck. Additionally, enzymes can also help break down protein-rich materials such as food waste and manure.

Plant trial results

Decreased feedstock requirements

- 12% decrease in required feedstock to maintain biogas output in 1000 kW biogas plant
- Farm substrate (cow slurry with corn silage and triticale)
- Continuous stirred-tank reactor (CSTR) operating at 41°C
- 0.20 kg enzyme/tonne fresh matter

Decreased substrate viscosity

- Decrease in substrate viscosity by 2-3x in 1200 kWh biogas plant
- Farm substrate (chicken muck, whey permeate, beet, corn)
- Plug-flow reactor operating at 39.5 °C; 35 day RT
- 0.11 kg enzyme/tonne fresh matter

Increased methane production and decreased costs

- 8% increase in methane production at 2000 kW biogas facility
- 10% decrease in costs for digester operator
- 110 tonne/day of farm substrate (pig and cow manure, corn, sugar beet, oat meal, sheanut meal)
- Plug-flow reactor; 60 day RT; 40-44 °C
- 0.05 kg enzyme/tonne fresh matter
- Reduced substrate and digestate removal costs included

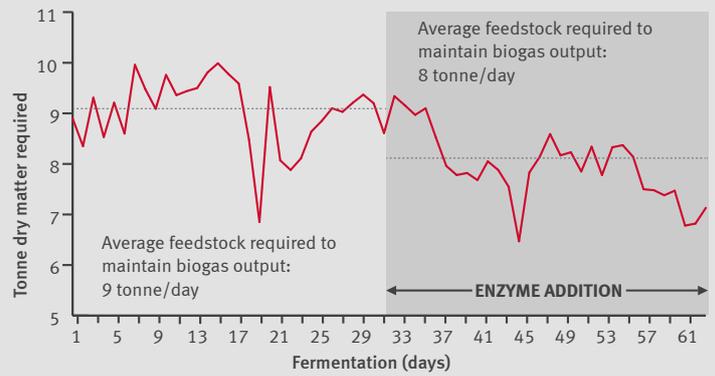


Figure 3. Plant trial results illustrating decreased feedstock requirements with added enzymes.

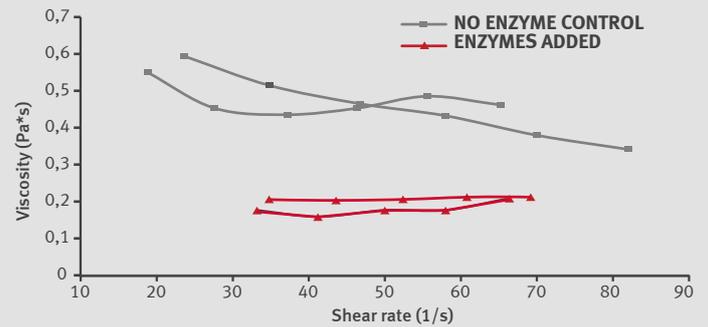


Figure 4. Results from plant trial illustrating decreased substrate viscosity with added enzymes.

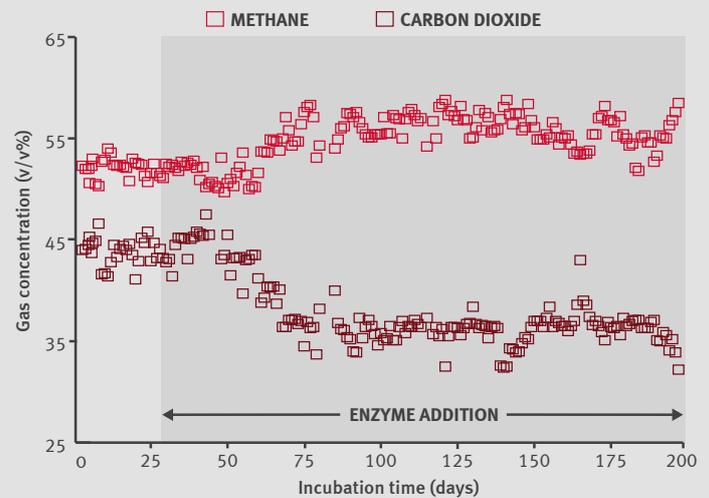


Figure 5. Results from plant trial in which addition of enzymes resulted in increased methane production and reduced carbon dioxide emissions.

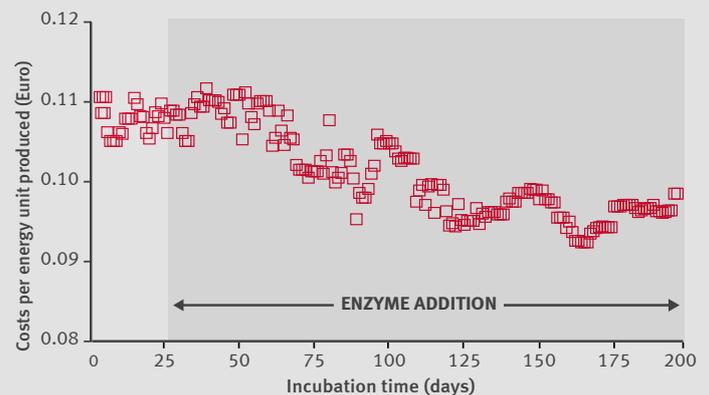
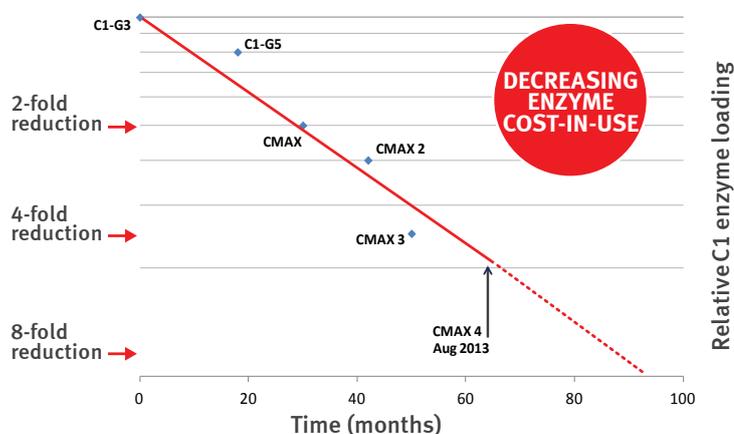


Figure 6. Lowered anaerobic digestion costs in biogas plant trial with added enzymes.

DuPont expertise and support

- More than three decades of enzyme expertise and over 200 years providing market-driven innovative products.
- Global customer technical support from 8 regional R&D sites in 6 different countries.
- Secure supply and logistics for our customers with 19 manufacturing sites spread across 8 countries.
- Combined expertise and technology platforms from DuPont and Dyadic.
- Extensive experience and knowledge of lignocellulosic feedstocks, including enzyme solutions for different feedstock chemistries and structures.
- R&D technology pipeline delivering continual improvements in performance and cost-in-use with each new generation of enzyme.



Product form and application

- Easy to use and minimally invasive enzymes that can be introduced into any biogas process (e.g. added directly into primary digester).
- Liquid and dried products available.
- Enzymes can be sold in a variety of sizes to fit customer's needs, ranging between 25 kg pail up to 1,000 kg tote.
- Recommended storage under refrigerated conditions at 4°C. Product may be stored at controlled room temperature for up to 3 months.

Parameters to consider

- Reactor type (plug-flow, CSTR)
- pH and temperature conditions (mesophilic, thermophilic)
- Retention time
- Raw material type and throughput
- Dry matter content
- Mixing type

For more information, please visit:
biosciences.dupont.com/biogas



Copyright© 2016 DuPont or its affiliates. All rights reserved. The DuPont Oval Logo, DuPont™ and all products denoted with ® or ™ are registered trademarks or trademarks of DuPont or its affiliates. Local regulations should be consulted regarding the use of this product, as legislation regarding its use may vary from country to country. Advice regarding the legal status of this product may be obtained on request. The information contained in this publication is based on our own research and development work and to our knowledge is reliable. Always read the label and product information before use. Users should conduct their own tests to determine the suitability of our products for their own specific purposes. Statements contained in this publication should not be considered as, and do not constitute a warranty of any kind, expressed or implied, and no liability is accepted for the infringement of any patents.

Learn more about advanced biofuel solutions from DuPont at biofuels.dupont.com

