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Rethink Tomorrow

Biofuels at Novozymes

Biomass South Conference

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2008

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Novozymes – North America

- Novozymes in Franklinton, NC
 - 400+ Employees
 - Multi-purpose Production Site
 - R&D and CS
 - Center of Excellence for Fuel Ethanol
- Novozymes in Davis, California
 - 90 Scientists
 - Molecular Biology, Protein Chemistry, Chemical Engineering, and Microbial Physiology
- Novozymes Biological in Salem, Virginia
 - Applied Microbiology Business
 - Live Microbial Products for a Variety of Applications (e.g. Industrial Cleaning)



PLANT CARE

BIOAUGMENTATION & BIOREMEDIATION

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Enzymes are used to produce many of the products we use in our daily lives



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Committed to Sustainability

Enzymes:

- Reduce energy & water consumption
- Reduce the need for harsh chemicals
- Reduce the amount of by-products
- Improve yields

Net CO₂ reduction using 1 kg enzyme in different industries:

Minus

| Industry | CO ₂ Reduction (kg) |
|--------------|--------------------------------|
| Animal feed | -30 kg |
| Leather | -40 kg |
| Textiles | -100 kg |
| Biofuel | -150 kg |
| Detergent | -150 kg |
| Food | -200 kg |
| Paper | Up to 600 kg |
| Oils & fats | 100 kg |
| Biocatalysis | -3,400 kg |
| Cereal | -1,800 kg |



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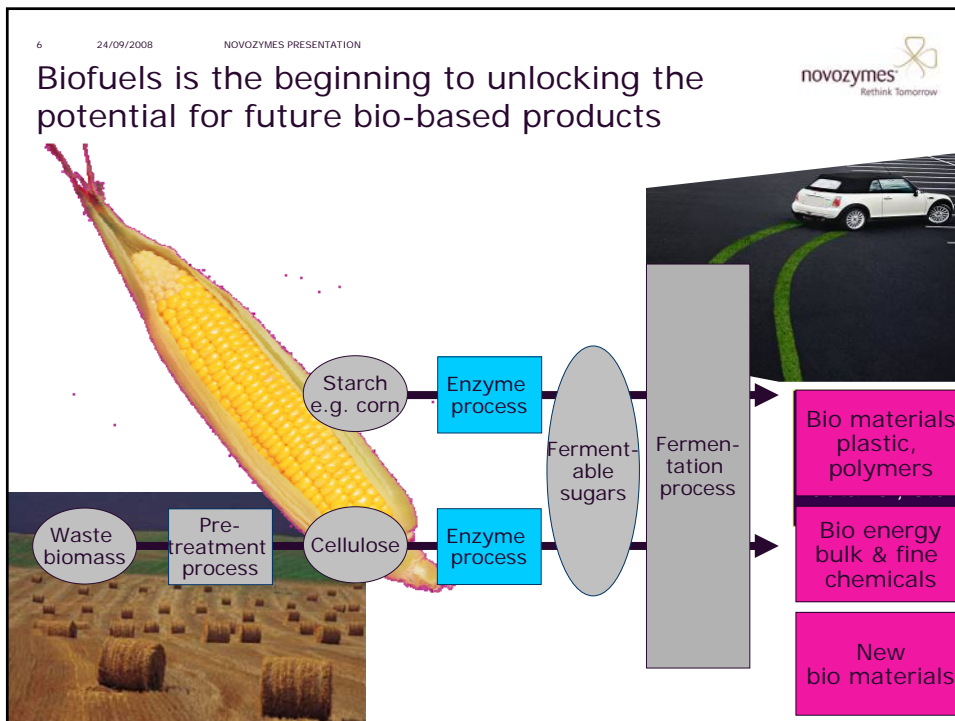


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Biodiesel at Novozymes

- The Danish National Advanced Technology Foundation has granted DKK 15 million towards research in biodiesel over the next 3.5 years.
- With a process based on enzymes we will be able to use raw materials of poorer quality, such as animal fats, recycled restaurant oils, and waste products, all materials that cannot be used as food.
- Hope to include local biodiesel producer as a partner in this project

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A successful step towards the future...

Novozymes and Cargill have joined forces to develop commercial solutions for Bio-Acrylic Acid

Renewable Resources

- Super absorbers
- Fibers
- Coatings & Adhesives
- Polymers

Kimberly-Clark

P&G

Lubrizol

L'ORÉAL

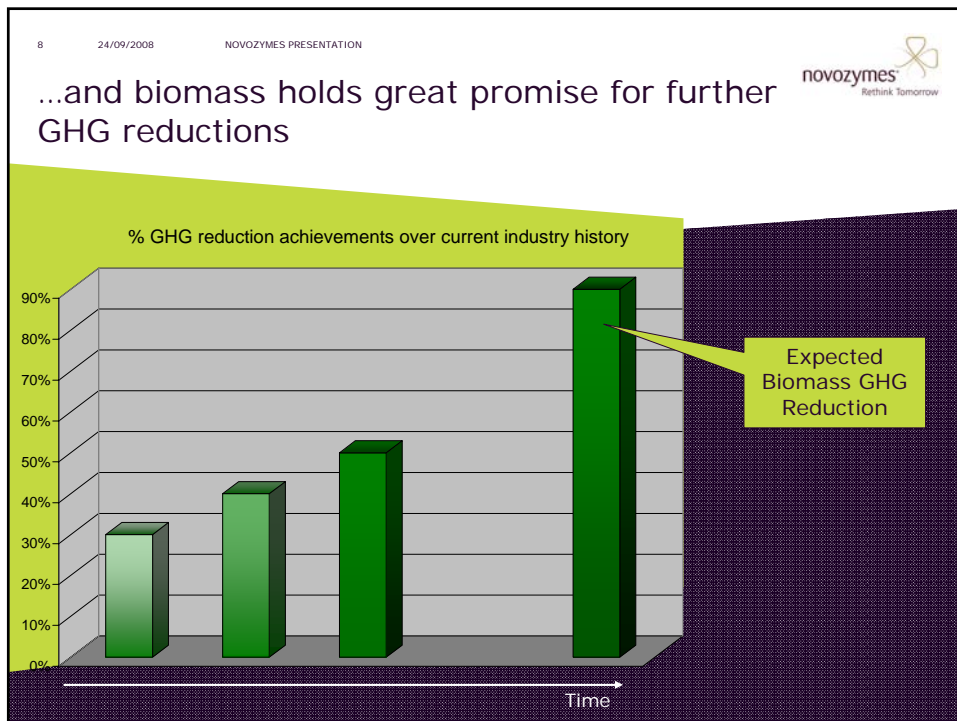
EVONIK INDUSTRIES

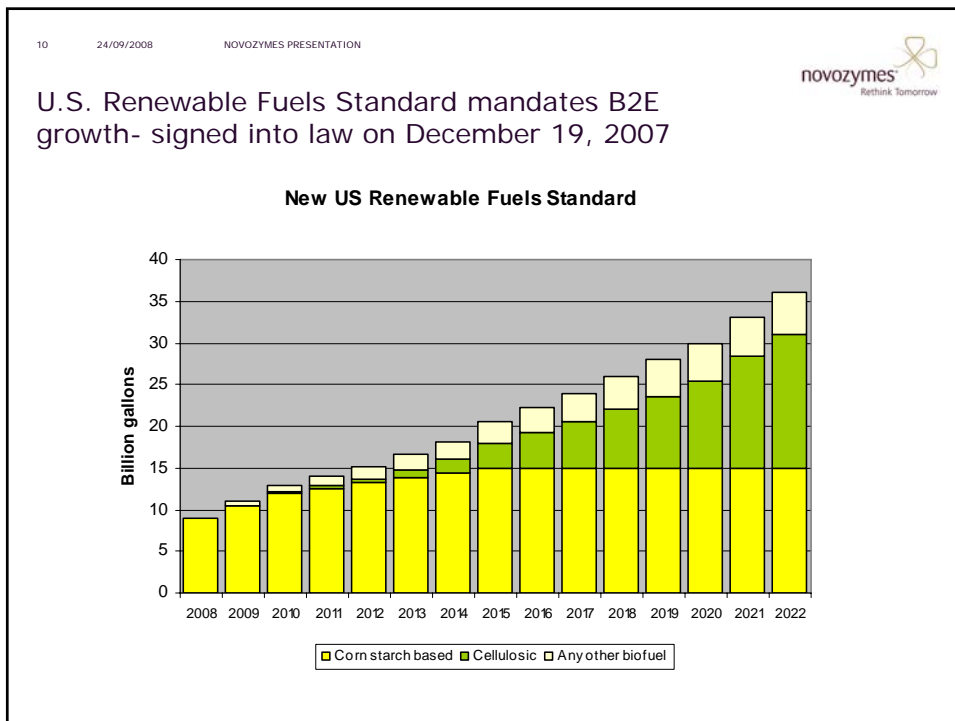
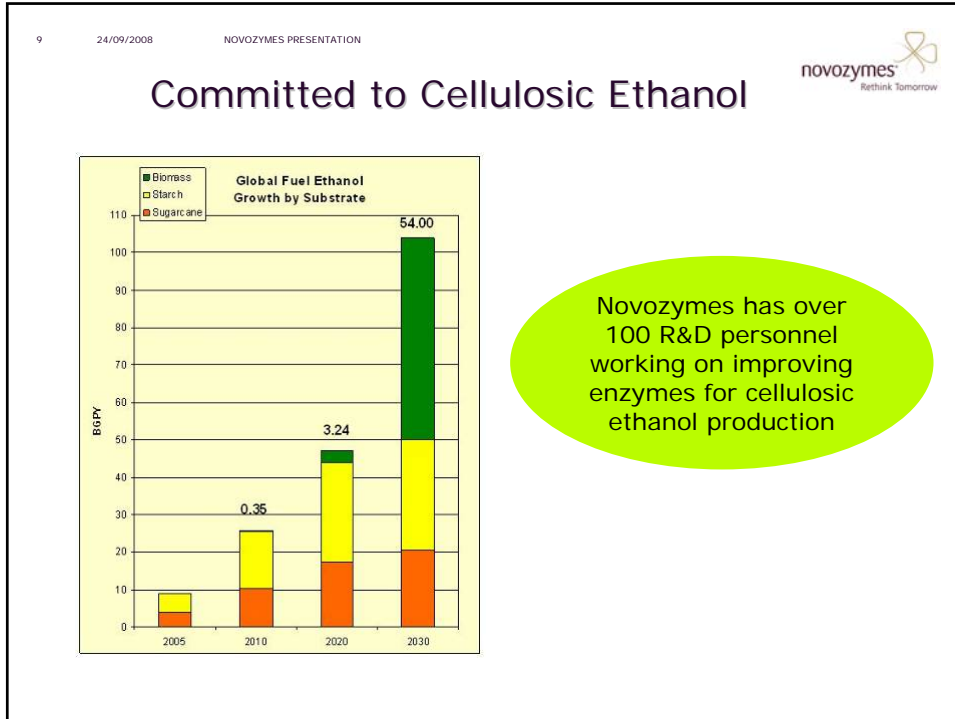
BASF

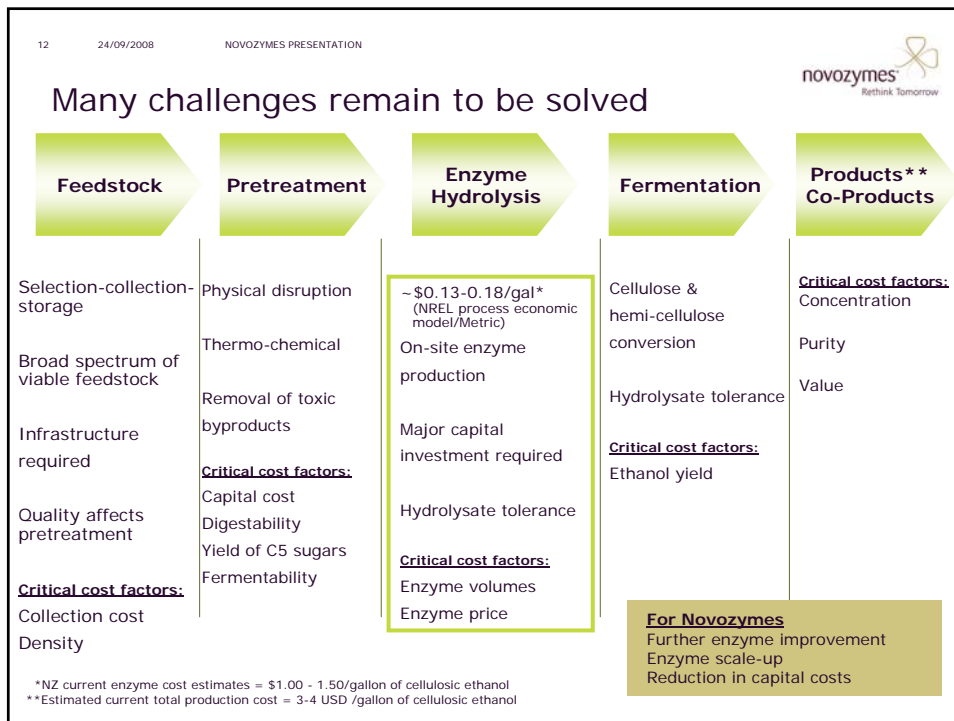
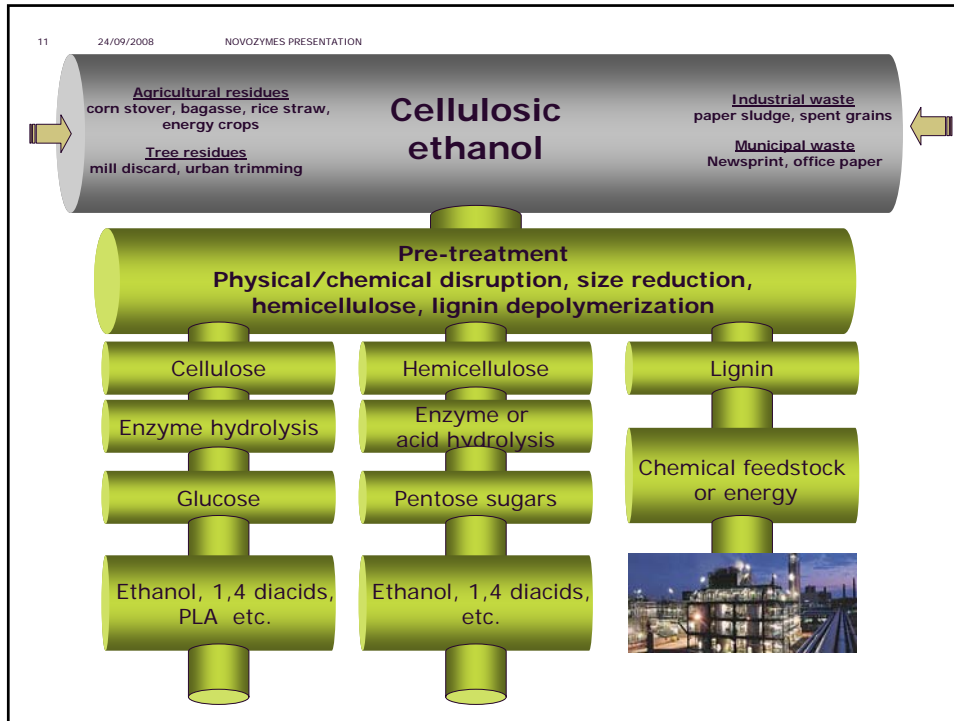
ROHM&HAAS

ASHLAND


* Illustrative example of companies who could use this technology







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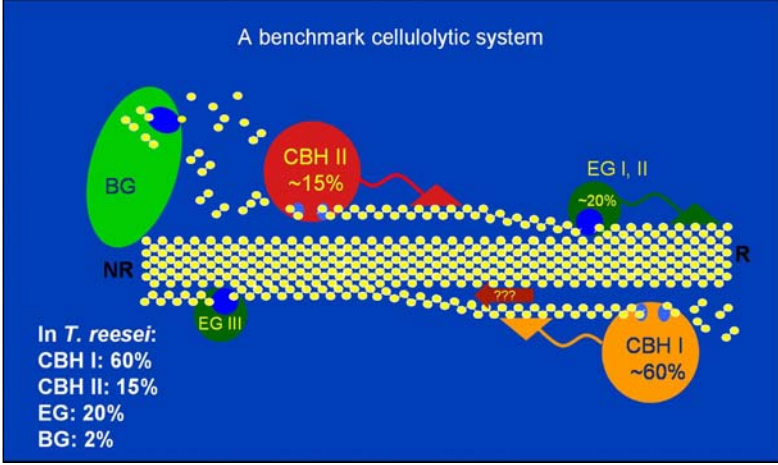


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Our Role in Cellulosic Ethanol


A benchmark cellulolytic system



In *T. reesei*:

- CBH I: 60%
- CBH II: 15%
- EG: 20%
- BG: 2%

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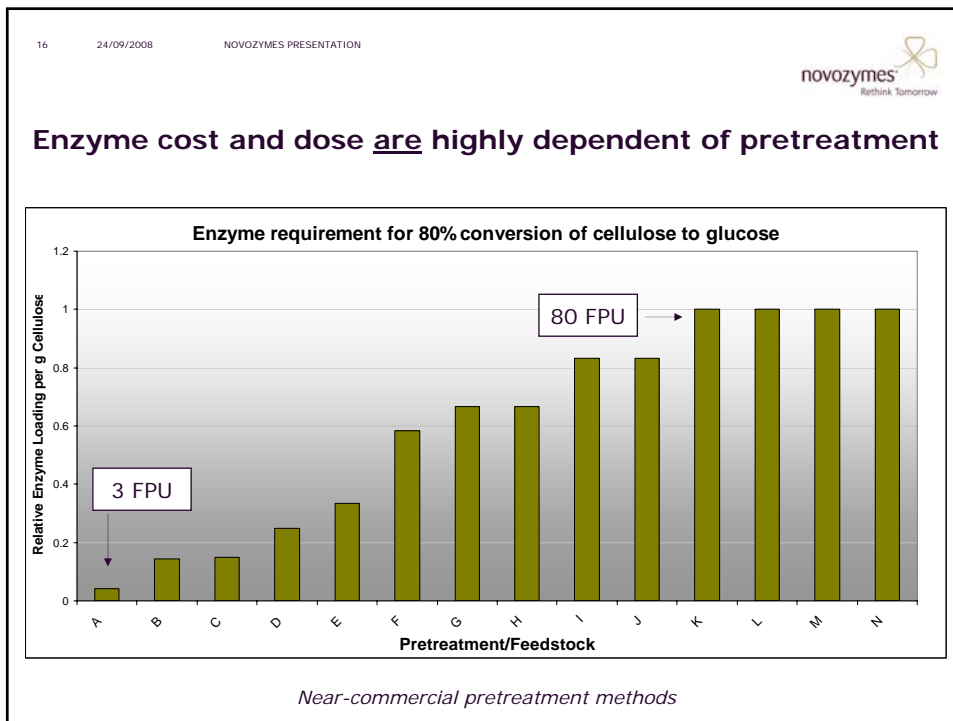
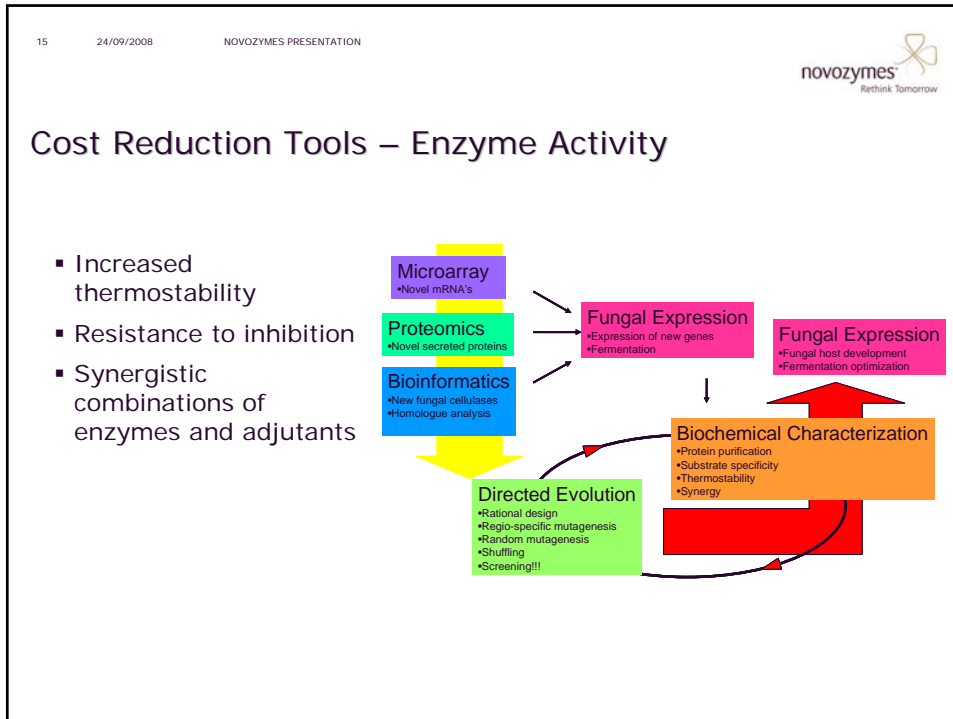
Further cellulase developments

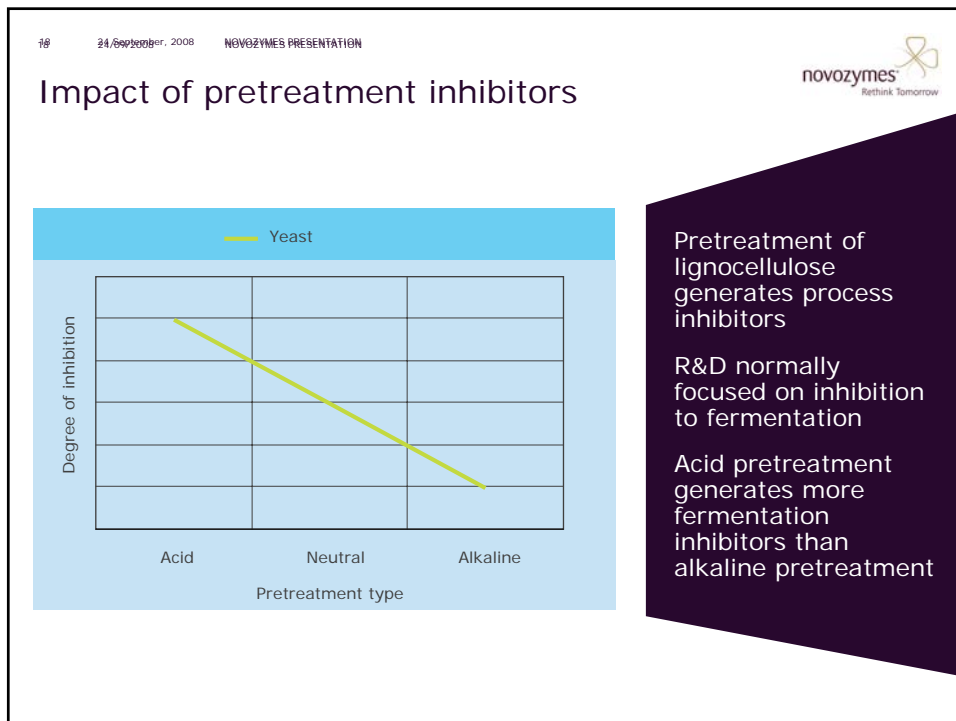
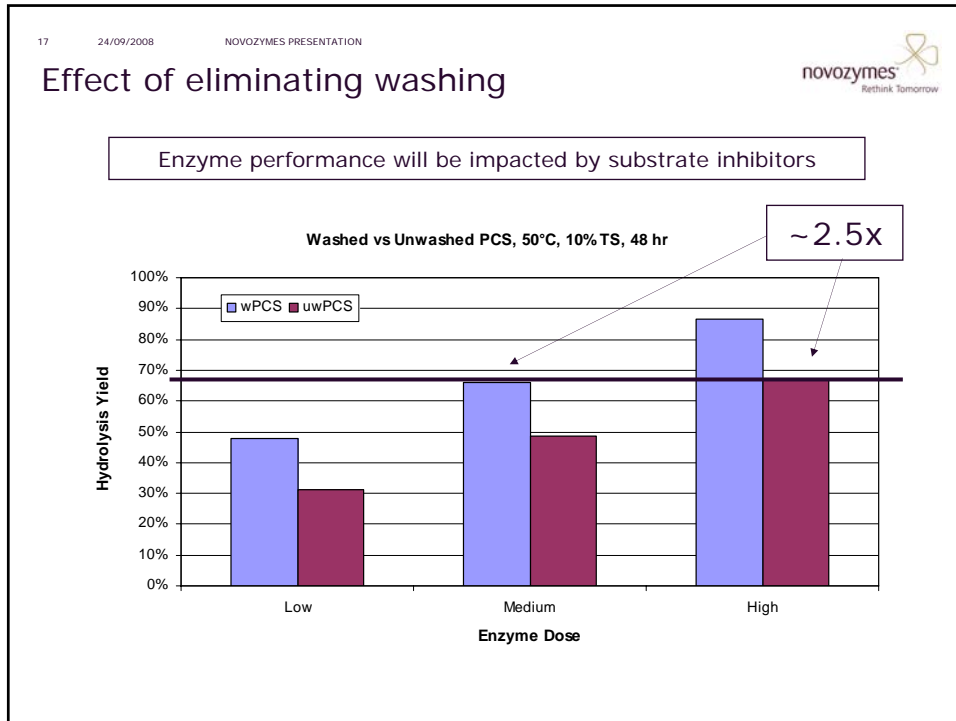
US DoE to fund Novozymes project for cellulosic ethanol



- Novozymes' project DECREASE (Development of a Commercial-Ready Enzyme Application System for Ethanol)
- Goals: Improve performance of Novozymes' most advanced cellulase system, further decreasing the cost of cellulosic ethanol production

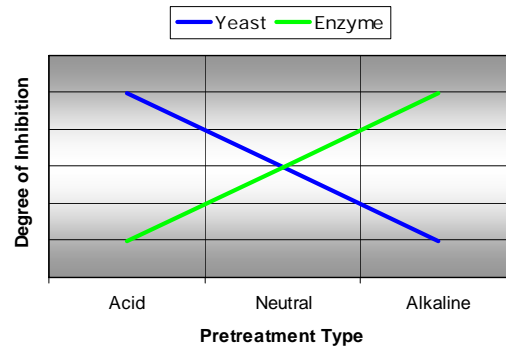
- Global collaboration between Novozymes researchers
 - California
 - North Carolina
 - Denmark
 - China
- External partners:
 - Pacific Northwest National Laboratory
 - National Renewable Energy Laboratory
 - Cornell University
 - Centre National de la Recherche Scientifique, France





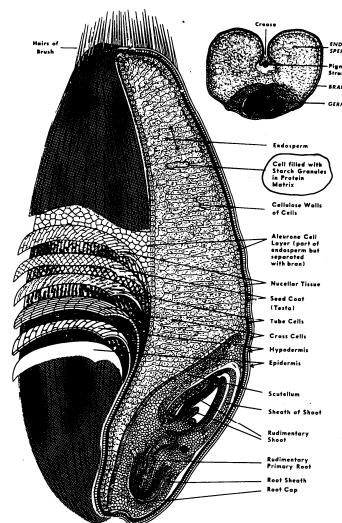
Impact of pretreatment inhibitors on enzymes

- It is not the same compounds that are inhibitory to yeast and enzymes
- Alkaline pretreatment generates more enzyme inhibitors than acid pretreatment
- Pretreatment selection can not be based solely on generation of fermentation inhibitors



Cost Reduction Tools - Hemicellulose

- Digestion of arabinoxylan (AX): A representative substrate for determining the potential to reduce enzyme cost for hemicellulose hydrolysis
- Based on recognition of the importance of hemicellulose hydrolysis in overall economics



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To Meet These Challenges, Public/Private Partnerships Will Be Key!


Valued partners include: Department of Energy, NREL, Abengoa (U.S. and Europe), POET (U.S.), COFCO (China), CTC (Brazil)










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Thank You