

Cellulosic Biofuels and Bioproducts Overcoming Technical Challenges

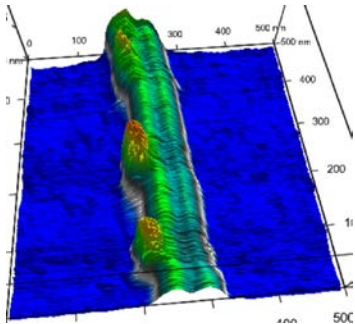
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ADVANCE Scholar Awards Symposium



In the beginning...



Steam Explosion Pretreatment of Waste for Fuel Ethanol

by

Tina Jeoh

Thesis submitted to the Faculty of the
Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree

MASTER OF SCIENCE

in

Biological Systems Engineering

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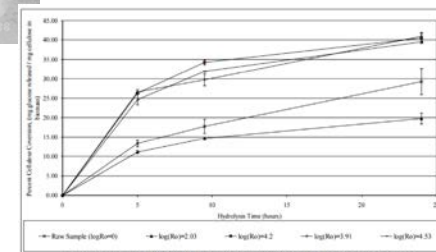
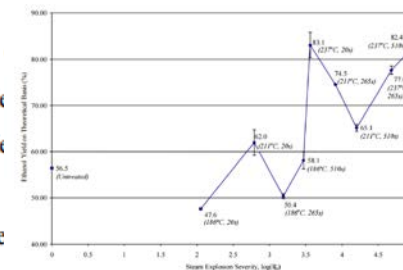
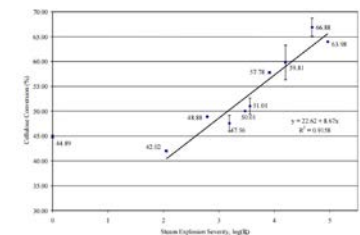
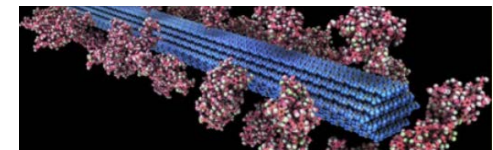
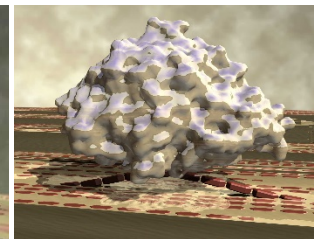
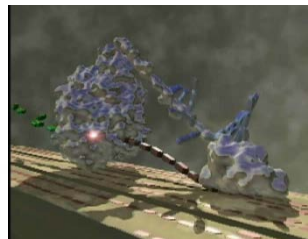
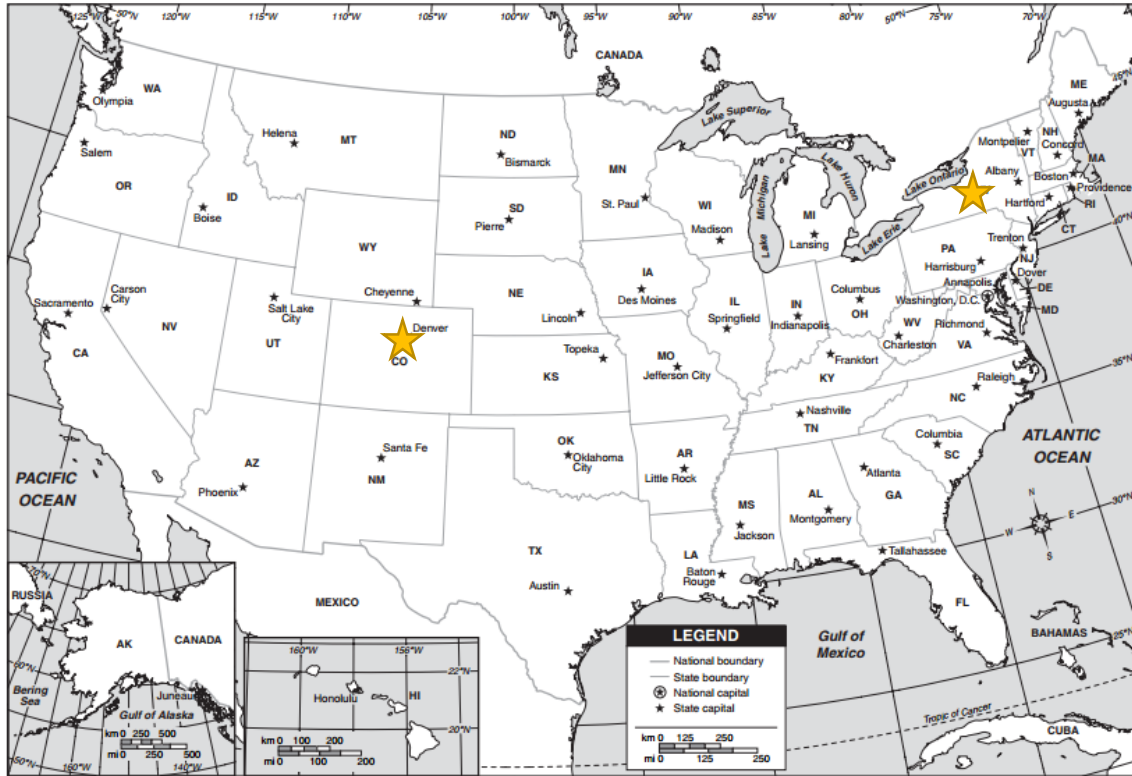
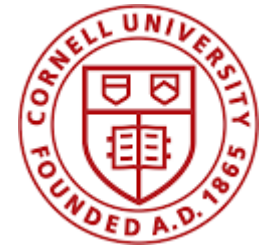
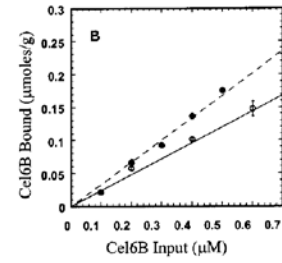
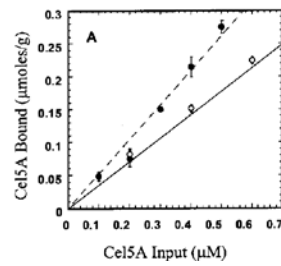
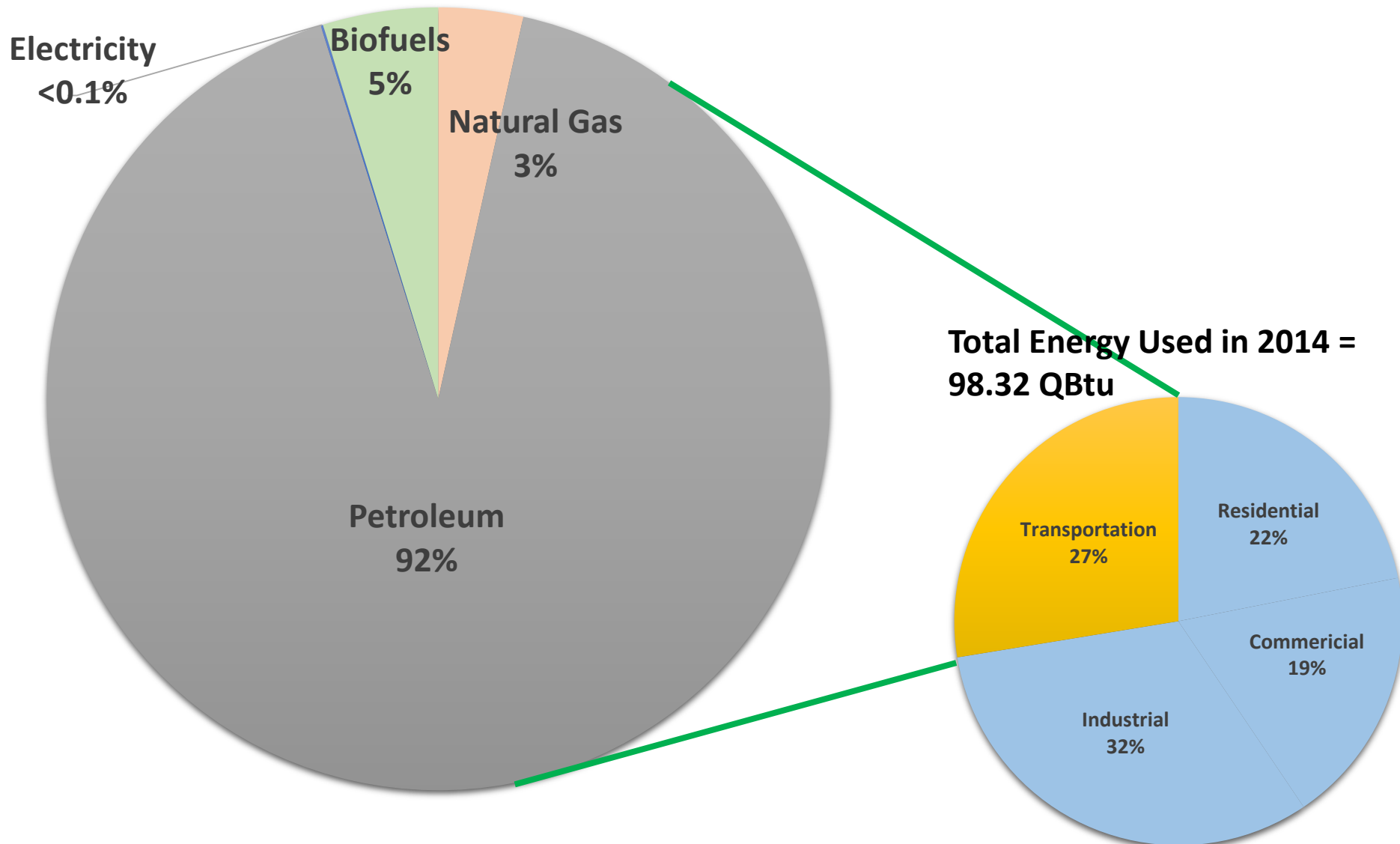


Figure 4.2. A summary of enzyme hydrolysis of steam exploded cotton gin waste at various severities. (Average percent cellulose conversion over two runs.)

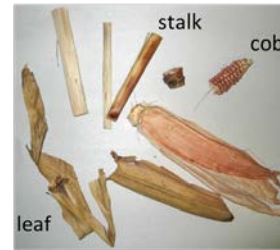




Transportation Energy in 2014



Cellulosic Biomass

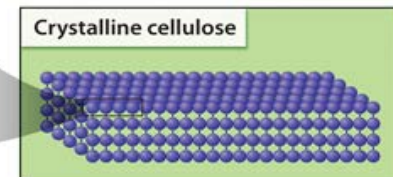
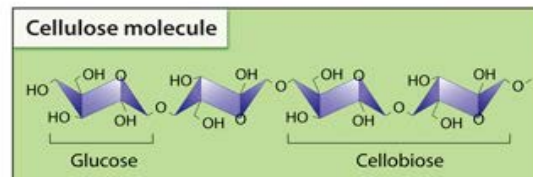
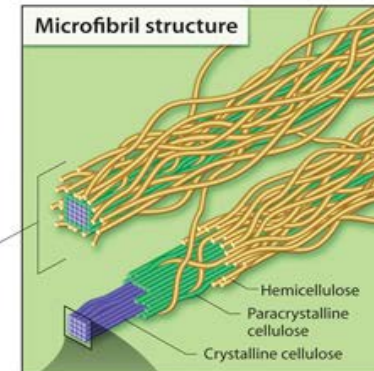


Glucose
other

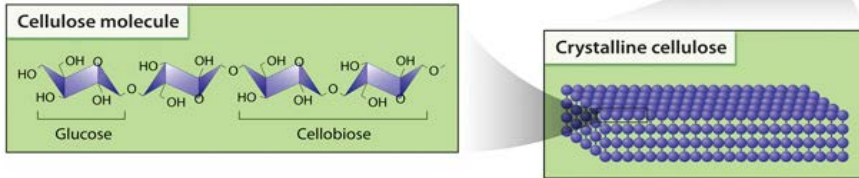
Getting the sugars from cellulosic biomass is a major bottleneck.



Layered mesh of microfibrils in plant cell wall

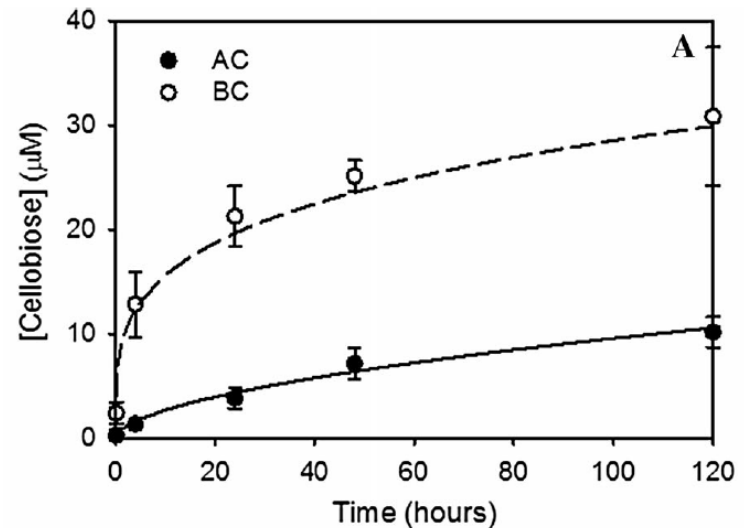
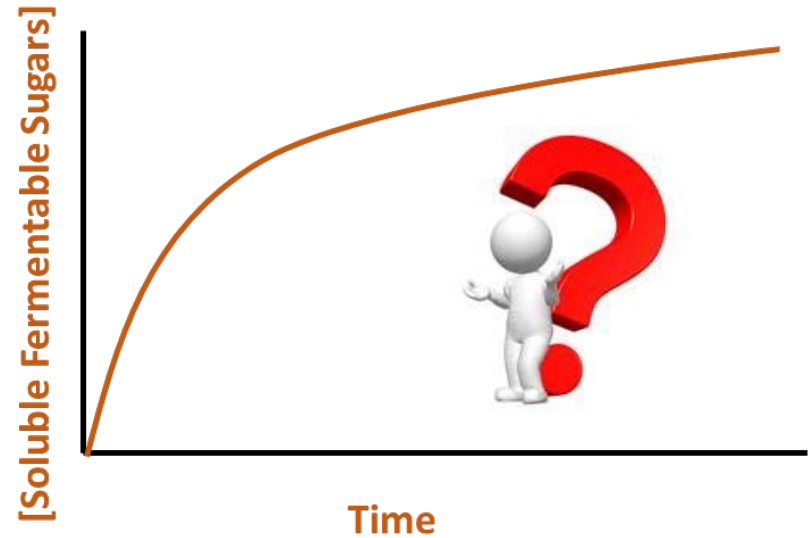


Cellulose Hydrolysis is still an unsolved puzzle

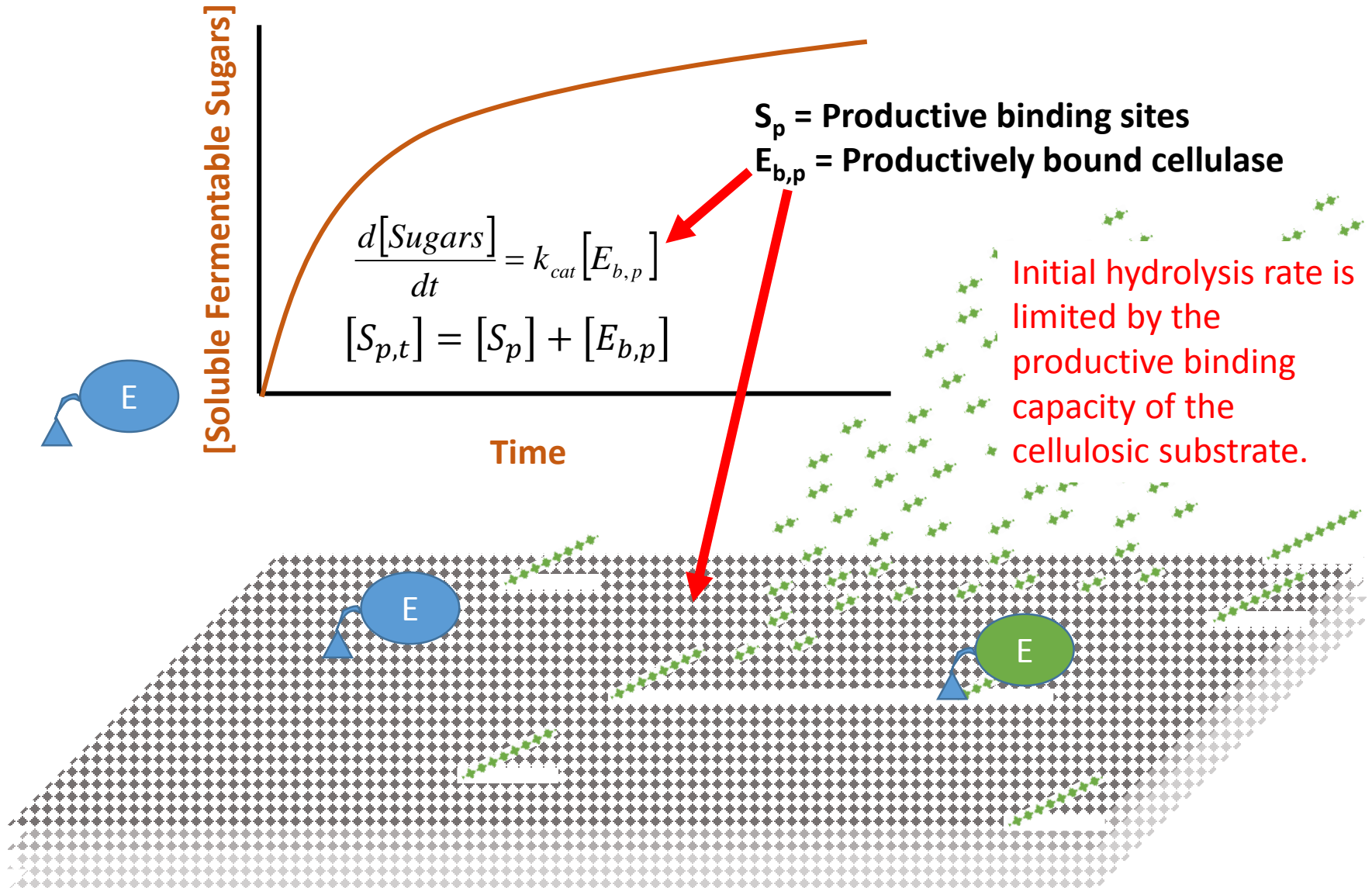


Why does the reaction slow down long before the reactant/substrate runs out?

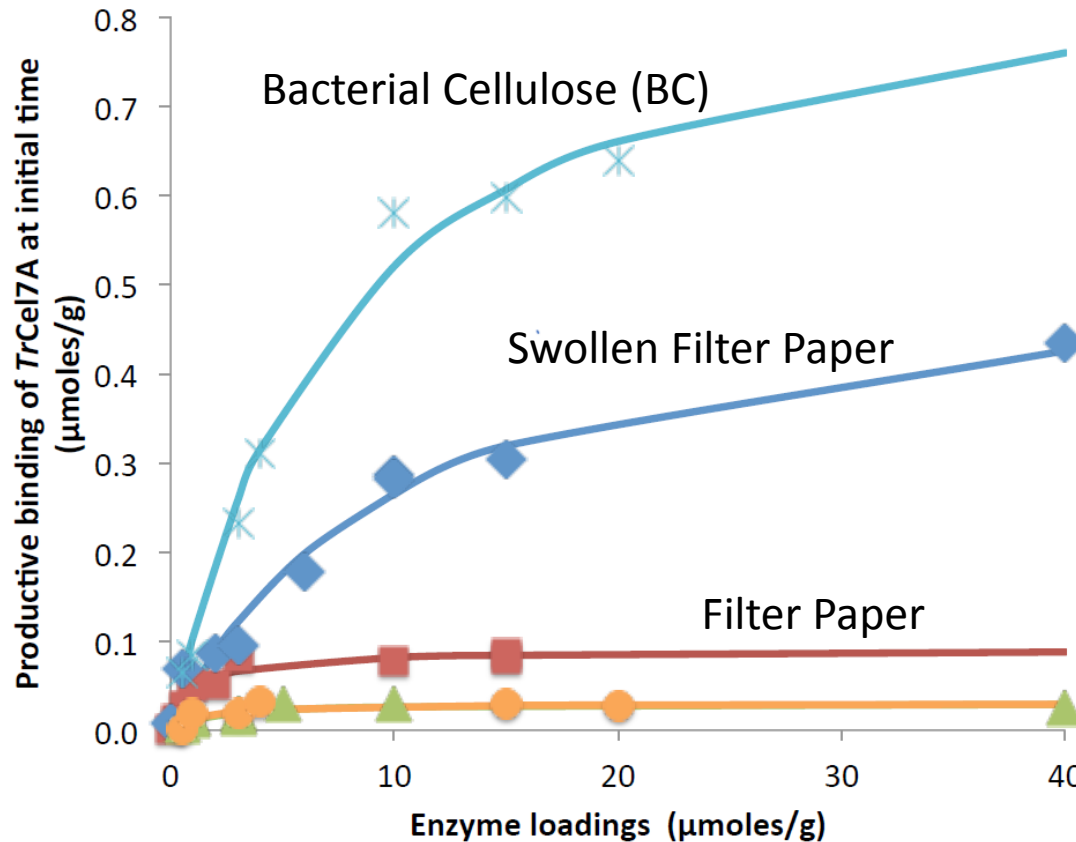
Why are not all cellulose hydrolyzed similarly?



Cellulase hydrolysis of Cellulose



The Productive Binding Capacity ($S_{p,t}$) of Cellulose Substrates

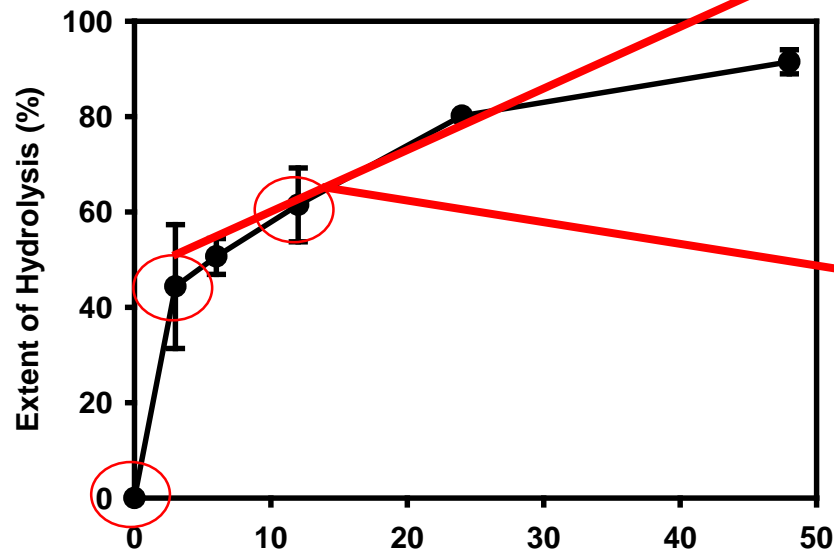
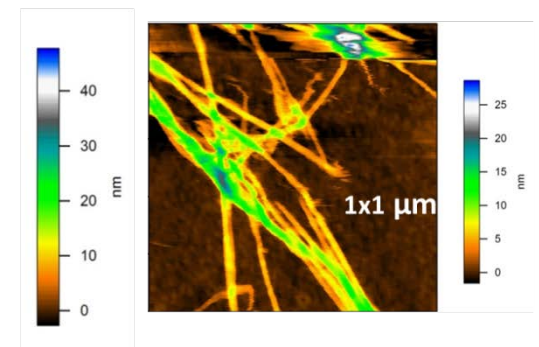
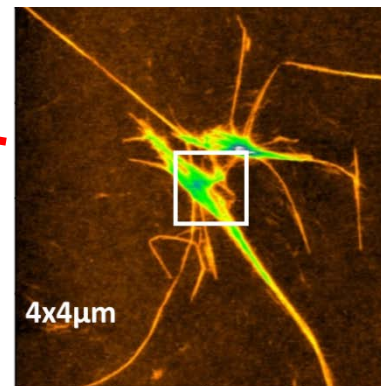
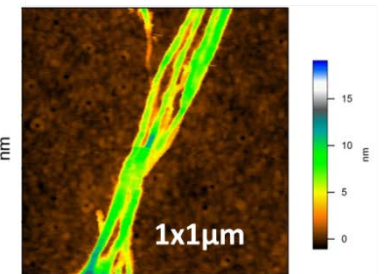
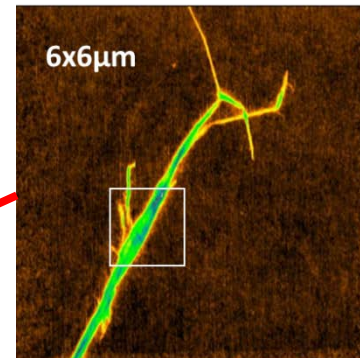
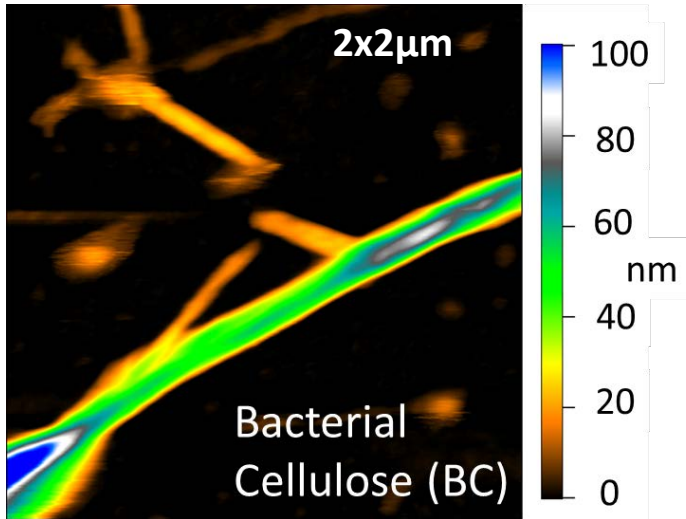


Cellulose	$[S_{p,t}]$ (μmole/g)
BC	0.9 ± 0.2
Swollen FP	0.4 ± 0.1
FP	0.09 ± 0.01
MCC	0.03 ± 0.01
AC	0.03 ± 0.02

Differences in cellulose can be distinguished by their initial productive binding capacity ($[S_{p,t}]$)

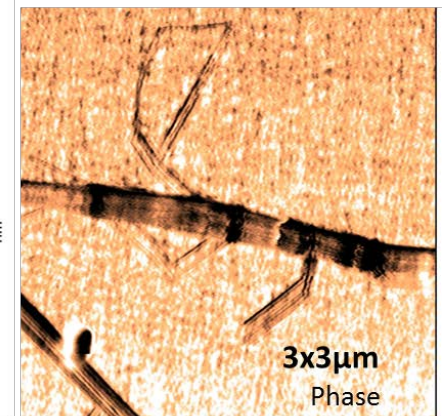
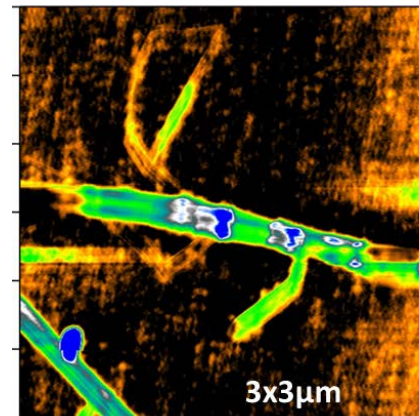
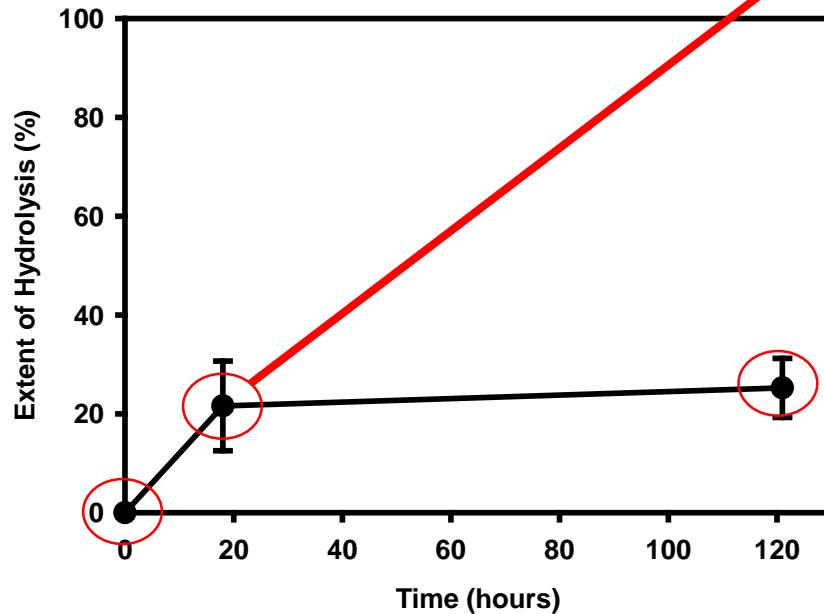
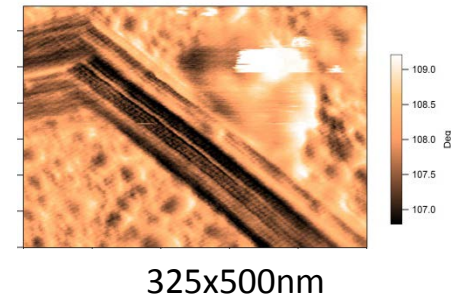
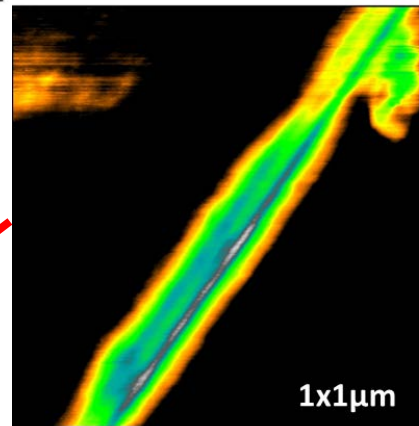
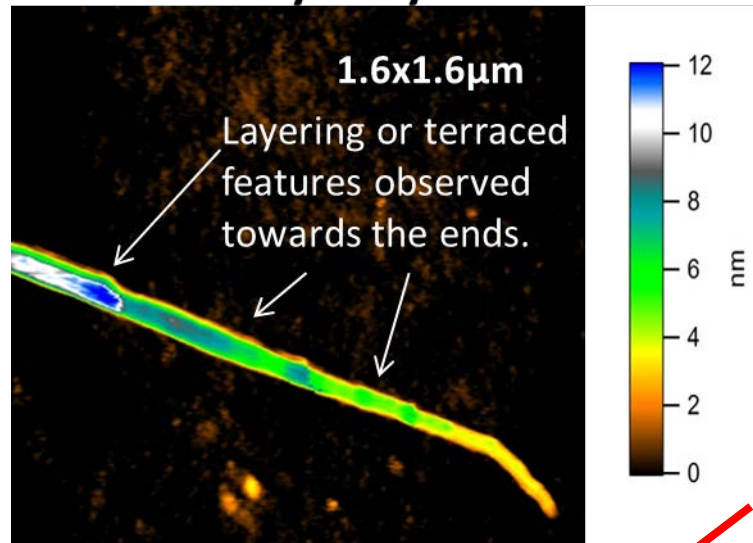
TrCel7A hydrolysis of Bacterial Cellulose

At 0% Hydrolysis



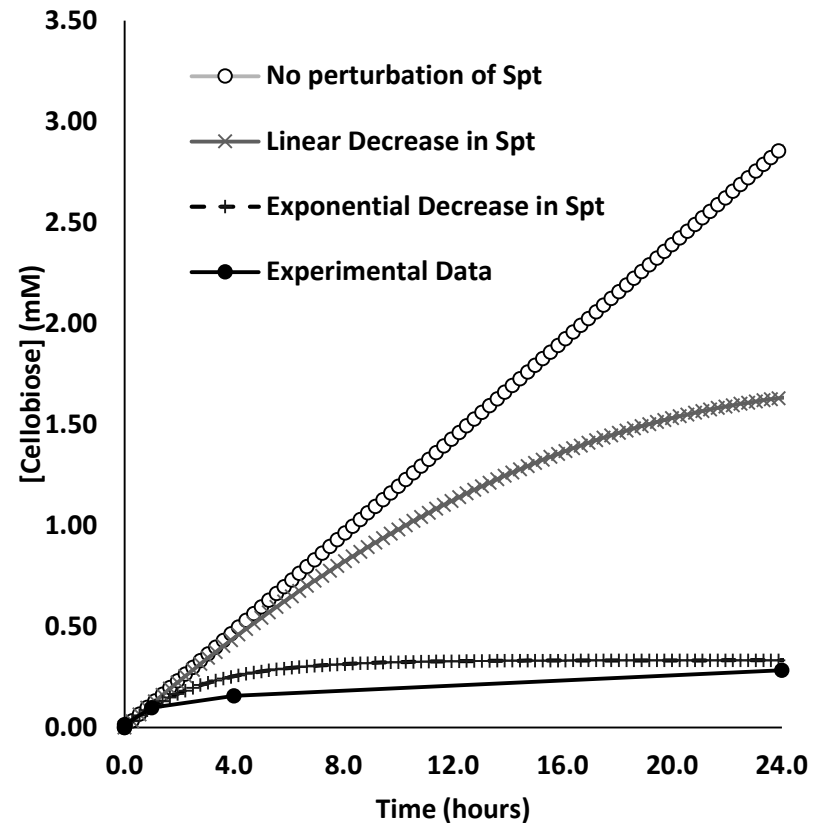
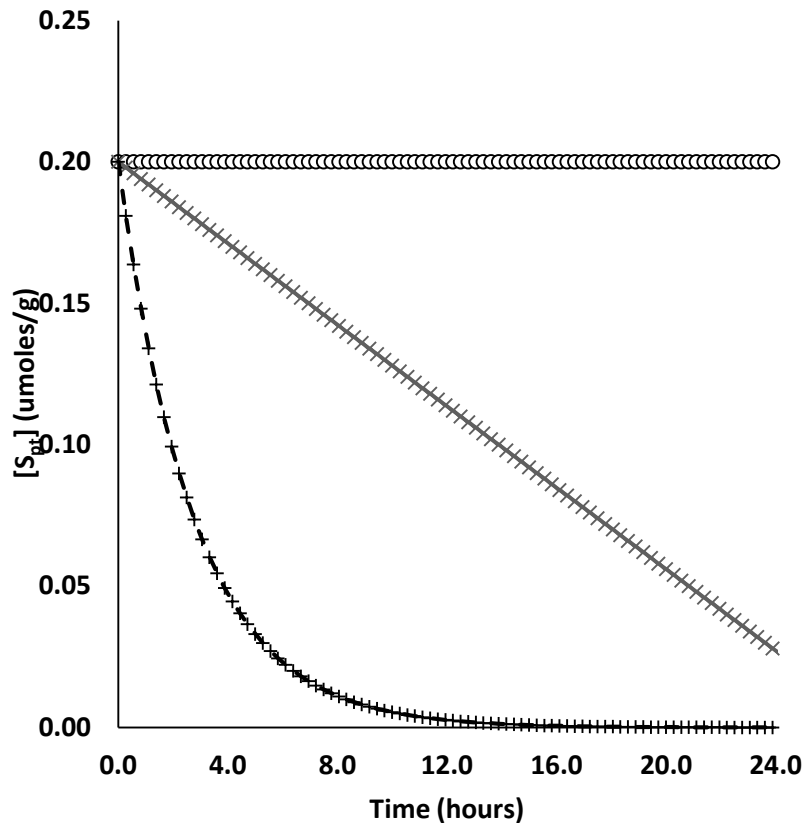
*Tr*Cel7A hydrolysis of Algal cellulose

At 0% Hydrolysis



Modeling the depletion of *accessible productive binding sites*

$$[S_{p,t}] = [S_p] + [E_{b,p}] \rightarrow \frac{d[S_{p,t}]}{dt} = \frac{d[S_p]}{dt} + \frac{d[E_{b,p}]}{dt} \neq 0$$

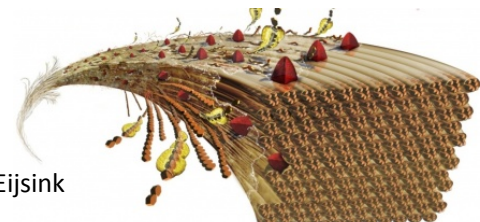


Take aways from my talk

Solving the mechanism of cellulose hydrolysis is a critical but unmet challenge towards enabling the Cellulosic Biofuels Industry.

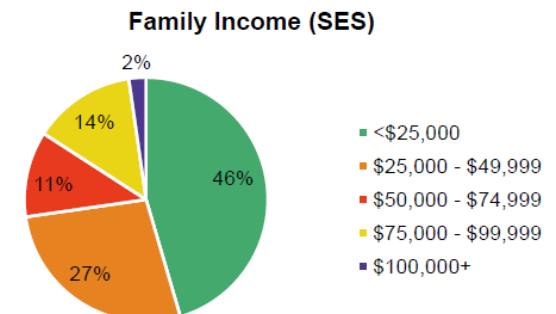
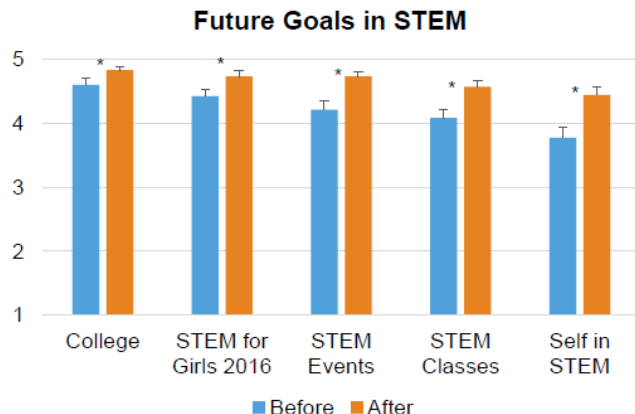
The productive binding capacity of cellulose limits the initial hydrolysis rate.

The evolution of the concentration of accessible productive binding sites limits long term rates and extent of hydrolysis.



STEM for Girls!

- Annual event for 10-12 year old (5-6th grade) girls from Sacramento and Woodland.
- In partnership with
 - Women in Science and Engineering (WISE)
 - Women's Research and Resources Center (WRRC)
 - ISIS Education
 - local (Davis) non-profit offering technology education programs for girls.
- Currently funded by NSF



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