

Anaerobic Digestion of Thin Stillage to Produce Methane and Class-A Biosolids

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BIOTECHNOLOGY BYPRODUCTS CONSORTIUM

A PARTNERSHIP BETWEEN IOWA STATE UNIVERSITY *and* THE UNIVERSITY OF IOWA

Background

- Iowa – number 1 ethanol-producing state
- 12 plants currently operating, 8 proposed
- 745 million gallons
- 275 million bushels (approximately)



**2005 Projected
Capacity**

975 million gallons

360 million bushels

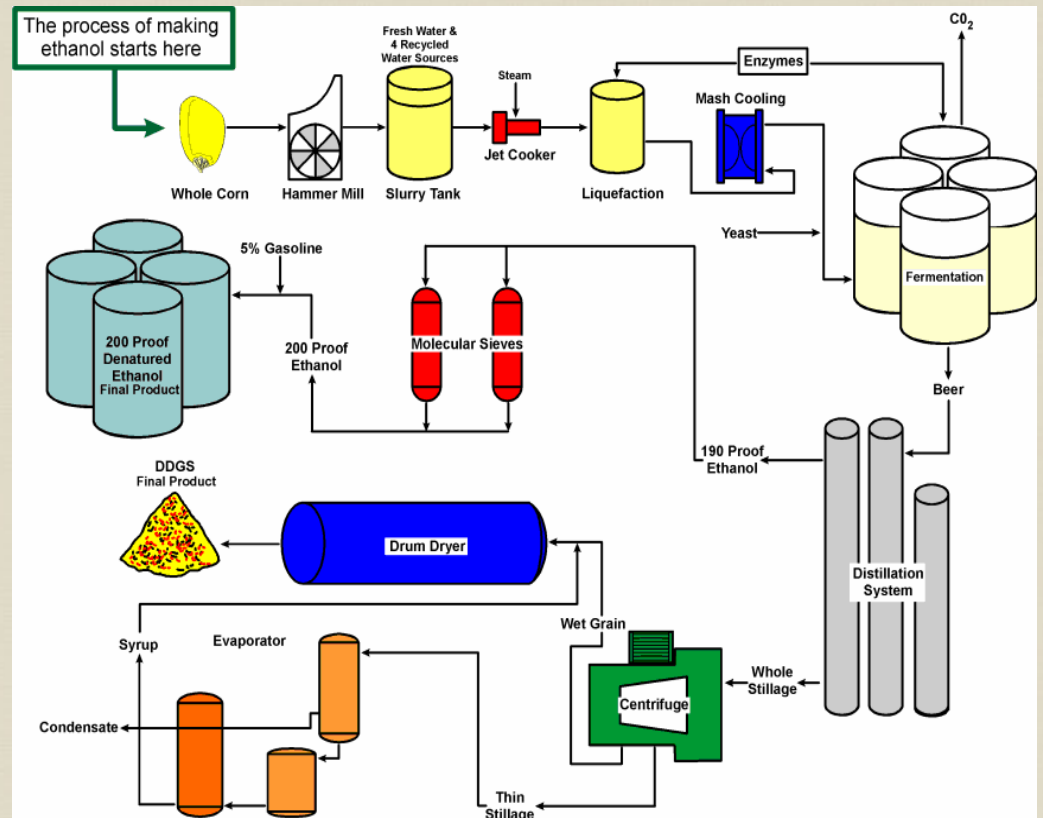
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Background (cont.)

❑ Drying of thin stillage costly

❑ 400 MBTU/day heating potential for MGP plant

❑ Stillage available at 130-150°C



Background (cont.)

Stillage characterization

Parameters	Thin stillage sample
%TS*	6.1
%VS*	5.3
VS/TS ratio	0.87
%TSS*	2.1
%VSS*	2.1
TCOD, g/L	94
SCOD, g/L	49
COD/VS ratio	1.8
pH	4.46
VFA, mg/L	1,310
ALK, mg/L as CaCO₃	0
Carbohydrate, mg/L as glucose**	13,600
TKN, mg/L as N	1,720
NH ₃ -N, mg/L**	32.1
TP, mg/L as P	1,292

* 1% = 10,000 mg/L; ** Tested on soluble portion of the sample

Anaerobic degradation of organic matter

(1)

Complex Organics
Carbohydrates
Proteins
Lipids

Simple Organics

1. Hydrolysis

(2)

Volatile Organic Acids
Propionate, Butyrate, etc.

Acetate

H₂ + CO₂

2. Acidogenesis

(3)

CH₄ + CO₂

3. Methanogenesis



Objectives

- Evaluate anaerobic digestibility of stillage from a dry mill ethanol plant
- Optimize the anaerobic digestion with respect to biogas production and volatile solids destruction
- Evaluate the effect of ultrasound on the digestibility

Research Methodology

- ❑ Two bench-scale thermophilic anaerobic digester (10 L)
- ❑ Seeded with thermophilic anaerobic sludge (Newton, IA)
- ❑ Thin stillage from Midwest Grain Processors (Lakota, IA)



Research Methodology (cont.)

Ultrasound pretreatment of thin stillage





Research Methodology

(cont.)

Process optimization of anaerobic digester

- Nutrient, trace element, alkalinity requirement
- VS loading rate and feed concentration
- Hydraulic retention time (HRT) = 20, 15, 12, and 9 days
- Maximized methane yield (L-CH₄/gVS) and VS reduction
- Process stability, Effluent quality (TS, TCOD, N, P)

Pilot scale study at MGP ethanol plant

- Commercial viability
- On-site requirement

Economic analysis

- Methane generation and Class-A biosolids

Results

Batch experiment

- Feasible to anaerobically digest MGP corn stillage
- Rate-limiting hydrolysis step
- Methane potential:
 - 0.4-0.5 L-CH₄/gVS fed or 0.2-0.3 L-CH₄/g COD fed
- Recommendation:
 - HRT >10 days
 - Organic loading rate (OLR):
1.0-1.3 gVS/L-day or 2.0-2.6 gCOD/L-day

Results (cont.)

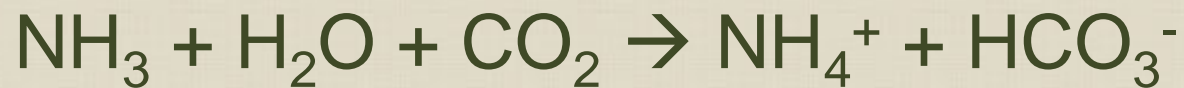
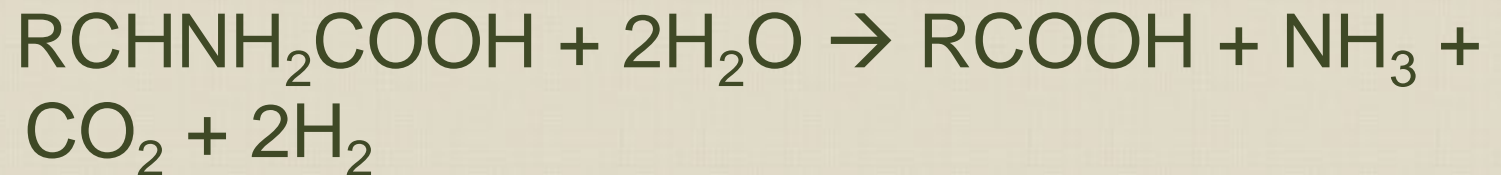
	Sonicated		Control	
HRT, days	20	15	20	15
% Removal				
Total COD	87.8	85.6	88.4	85.5
Total Solids	81.9	70.9	83.6	74.5
Volatile Solids	88.5	83.4	89.8	84.9

Results (cont.)

HRT, days	Sonicated		Control	
	20	15	20	15
VFAs, (mgAc/L)	170	481	200	543
Alkalinity (mg CaCO ₃ /L)	4,030	4,125	3,950	4,125
Methane, L/day	23.3	26.5	20.7	26.1
Methane, %	57.2	58.2	56.8	57.8

Results (cont.)

- No external alkalinity addition; stable pH



Energy Balance

- ❖ Methane generation = $40 \text{ m}^3/\text{m}^3$ stillage fed
- ❖ Stillage produced by MGP = 50 gal/min ($\sim 275 \text{ m}^3/\text{day}$)
- ❖ Total methane generation = $11,000 \text{ m}^3/\text{day}$
- ❖ Energy value of $1 \text{ m}^3 \text{ CH}_4$ = $35,310 \text{ BTU}$
- ❖ Total energy value $\sim 400 \text{ MBTU/day}$
- ❖ MGP pays $\$6/\text{MBTU}$
- ❖ Total value of energy recovered = $\$2,400/\text{day}$

million/year

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Future Plans

- Different organic loading rates (OLR) to find optimal loading conditions
- Pilot plant at MGP
- Economic analysis



Summary

- Stable digester operation without alkalinity supplementation
- COD removal >85%
- VS destruction ~ 90%
- 40 m³-CH₄/m³-stillage fed
or 0.7 L-CH₄/gVS fed

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