

UNIVERSITY OF FLORIDA

Development of Biofuel Production Processes from Synthetic and Biomass Wastes

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Description: With the ever-increasing price of petroleum and its finite supply, it is of high priority to develop domestic sources of transportation fuel, as well as other chemicals. Ethanol is an attractive alternate fuel that is being produced from corn starch. It is necessary to target other feedstocks for biofuel production and develop processes that have a minimal environmental impact. There is considerable ongoing research on developing processes and catalysts for conversion of biomass to biofuels like ethanol (called cellulosic ethanol process). But this project addresses other feedstocks with the following objectives: 1) development of biocatalysts for the conversion of waste biodegradable poly lactic acid based plastics to ethanol and 2) development of processes that processes for the production of additional fuels like biogas, bio-oil and biochar from the waste and byproducts of a cellulosic ethanol plant for the clean up and reuse of these waste streams

Budget: \$192,000

Universities: UF

External Collaborators: UCF

Progress Summary

Process development for biogasification and clean up of cellulosic ethanol stillage

- Demonstrated that struvite (a slow release fertilizer containing ammonia and phosphate) can be recovered from the anaerobically digested stillage.
- A process was developed to recover struvite along with other organic carbonaceous residue remaining in the digested stillage.
- Showed that this process can be applied with or without prior anaerobic digestion of stillage.
- Estimated that sufficient phosphorous is contained in the recovered sludge to grow the biofuel crop. The application of this sludge to grow the bioenergy crop offsets the need for addition of phosphate fertilizer.
- Demonstrated that nanoceria enhances anaerobic digestion of biomass.

Process development for preparation of enzymes to saccharify pectin rich biomass feedstocks.

- Developed a process that can be implemented in the biorefinery to prepare biocatalysts for saccharification of pectin-rich biomass and a method for saccharification of such biomass. This process has applications for pretreating citrus pulp, sugar beet pulp, apple pomace, fruit and vegetable wastes etc prior to production of liquid fuels.

Biocatalyst development for conversion of waste PLA based plastics to ethanol

- An *E.coli* mutant was constructed that is incapable of utilizing lactic acid.
- Into this mutant a Lactate dehydrogenase (LDH) gene was inserted. Currently experiments are underway to verify the expression of this gene.

2010 Annual Report

Patent applications:

Bin Gao, Mandu Inyang, Wenchuan Ding, Pratap Pullammanappallil. Methods for removing metal from water.

Invention Disclosures:

- Pratap Pullammanappallil, Kerry Johanson, Ioannis Polematidis, John Owens, David Chynoweth. System for anaerobic digestion of solid and soluble organic wastes, by-products and residues.
- Pratap Pullammanappallil, Sachin Gadekar, Ram Mohan Gayathri. An apparatus and method for recovering struvite from wastewater.
- Pratap Pullammanappallil, Lonnie Ingram, Abhay Koppa. A method for in-situ saccharification of pectin rich biomass.

Presentations by PI:

1. Biogasification of sugarbeet tailings: Design, Construction and Operation of a Demonstration Plant. American Institute of Chemical Engineers National Meeting, 8th – 13th November, 2009, Nashville.
2. Post-processing of Cellulosic Ethanol Stillage for Fuel Production and Recovery of Plant Nutrients. 2010 ASABE Annual International Meeting, July 20-23, 2010, Pittsburgh, PA.
3. Post-processing of Cellulosic Ethanol Stillage for Fuel Production and Recovery of Plant Nutrients. 2010 Florida Energy Systems Consortium, UCF Orlando, September 27-29, 2010.

Presentations by students

1. Diane Chauliac. 2010. Metabolic Engineering of a Microbial Biocatalyst for Conversion of Polylactic Acid to Ethanol. Florida Section ASABE Meeting June 9 -12, 2010, Jupiter Beach Florida. Awarded Second Prize for Best Paper at Symposium.
2. Cesar Moreira. 2010. Hydrothermolysis of polylactic acid packaging waste for recovery of lactic acid. Florida Section ASABE Meeting June 9 -12, 2010, Jupiter Beach Florida.
3. Zhuoli Tian. 2010. Post-Processing of Cellulosic-Ethanol Stillage for Fuel Production and Recovery of Plant Nutrients. Florida Section ASABE Meeting June 9 -12, 2010, Jupiter Beach Florida.
4. Gayathri Ram Mohan. 2010. Development of process for removal and recovery of nutrients from wastewater by its precipitation as struvite. Florida Water Resources Conference FWRC 2010. May 16-19, 2010 Renaissance Orlando Sea World Resort, Florida.
5. Anna Joykutty. 2010. Ethanol Production: Optimum Conditions for Enzymatic Saccharification of Sugarbeet Pulp. Florida Section ASABE Meeting June 9 -12, 2010, Jupiter Beach Florida

Awards:

Diane Chauliac. Awarded second prize for Best Paper at Florida Section ASABE Symposium, Jupiter Beach

Book Chapters:

1. Lyberatos, G. and P. Pullammanappallil. 2010. Anaerobic digestion in suspended growth bioreactors. **Environmental Biotechnology**, *Handbook of Environmental Engineering Series*, Volume 10, Editors: Lawrence K. Wang, Joo-Hwa Tay, Volodymyr Ivanov, Yung-Tse Hung, pp 395-438. Springer. ISBN:978-1-58829-166-0.

2. Lai, T. E.*, A. K. Koppar*, P. C. Pullammanappallil and W. P. Clarke. 2009. Mathematical modeling of batch, single stage, leach bed anaerobic digestion of organic fraction of municipal solid waste. In *Optimization in the Energy Industry*, Editors: J. Kallrath, P.M. Pardalos, S. Rebennack and M. Scheidt. pp 233-276. Springer. ISBN: 978-3-540-88964-9.

Refereed Papers:

1. Mandu Inyang*, Bin Gao, Pratap Pullammanappallil, Wenchuan Ding and Andrew R. Zimmerman. Biochar from Anaerobically Digested Sugarcane Bagasse. *Bioresource Technology* (Accepted) 6 pp
2. Polematidis, I.*, A. Koppar* and P. Pullammanappallil. Biogasification potential of desugarized molasses co-product stream from sugarbeet processing plants. *Journal of Sugar Beet Research* (Accepted) 10 pp.
3. Koppar, A.*, I. Polematidis* and P. Pullammanappallil. 2010. Anaerobic digestion of desugarized molasses from sugarbeet processing plants in a continuously fed anaerobic filter at thermophilic temperature. *International Sugar Journal*. 112(1336), pp 201-208.
4. Koppar, A. K.* and P. Pullammanappallil. 2009. Comparison of thermophilic and mesophilic single-stage, unmixed, batch anaerobic digestion of sugarbeet pulp. *Sugar Industry/Zuckerindustrie*. 134 (9), pp 586-591.
5. Gadekar, S.* and P. Pullammanappallil. 2009. Validation and applications of a chemical equilibrium model for struvite precipitation. *Environmental Modeling and Assessment*. 15 (3), pp 201-209.

* Graduate Student - Dr. Pullammanappallil is the Chair/Co-chair of graduate committee