Research Posters

Biobased Industry Outlook Conference
Iowa State University · Ames, Iowa
Monday, August 29, 2005 · 5:30-7:30 p.m.

Investigators affiliated with the Office of Biorenewables Programs, Center for Crops Utilization Research, Center for Catalysis, and Iowa Biotechnology Byproducts Consortium will present the following posters that summarize the results of their research and highlight their projects' economic, environmental and societal impact. Contact information is provided for investigators denoted with a *.

1. Analysis of Sulfide Inhibition in Anaerobic Biofilm Reactors Fed a Sulfate-Rich Wastewater

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Many industries produce wastewaters high in organic and sulfate content. Anaerobic treatment results in methane formation by methanogens (MA) and sulfide from sulfate reducers (SRB). Sulfide can inhibit the activity of these organisms. Previous research has shown biofilm processes can withstand higher sulfide levels than suspended growth systems. However, little is known about the structure and composition of biofilms developed when treating sulfate wastewaters. A better understanding of the types of SRB and MA present in the biofilm and their spatial orientation in the biofilm will yield clues to this advantage. Biofilm reactors treating sulfate wastewater have been constructed and operated for 450 days. Sulfate and carbon wastewater concentrations have been increased over time. Biofilm samples will be analyzed using molecular techniques and microscopy in order to determine how increasing sulfide levels affect the microorganisms.

2. Biobased Content Determinations for the USDA Item Designation Process

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The 2002 Farm Security and Rural Investment Act authorized development of the Federal Biobased Products Preferred Procurement Program (FB4P). In January 2005, the USDA published a final rule on guidelines that will be used to identify and evaluate biobased products. Under the USDA final rule, third-party verification of a product's "biobased content" is required before that product can qualify for preferential procurement" status. The "biobased content" is defined as the amount of biobased carbon in the product as a percent of the weight (mass) of the total organic carbon in the product. In support of the USDA program, Iowa State University is coordinating testing to determine the "biobased content" of manufactured products. Conventional radiocarbon analytical approaches are being used to determine the biobased contents. Those analyses have proven to be a reliable and valuable tool for determining the biobased content of manufactured products. In addition, the radiocarbon analyses have been extremely useful as a quality control tool for the product manufacturers.

3. Conversion of Monounsaturated Fatty Acids Derived from Biodiesel into Commodity Chemicals

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The monounsaturated fatty acid, oleic acid, is present naturally in biodiesel derived from soybean, corn, and other plant oils. However, partial hydrogenation of this biodiesel is able to create a biodiesel that consists of 85% monounsaturated fatty acids. This project seeks to convert these monounsaturated fatty acids to new compounds that are useful as lubricants and surfactants (soaps and detergents).

We are exploring catalytic reactions that will convert the 85% mixture of monounsaturated fatty acids in partially hydrogenated biodiesel into one compound that contains a borane group at one end of an 18-carbon chain and an acid group at the other. At this stage of our studies, we have found an iridium catalyst that performs this reaction in approximately 25% yield. Although this yield is not sufficiently high to be commercially viable, it does demonstrate that this challenging conversion is possible and merits further efforts to improve the yield. The borane group at one end of the 18-carbon chain is particularly valuable because it can be readily converted to an alcohol group, which can be transformed into ammonium groups for surfactants. It can also be converted into small or large polymers that could be used as lubricants. Details of the catalytic studies will be presented in the poster.

4. Hydraulic Investigation of an Aerated Subsurface-flow Constructed Wetland in Anamosa, Iowa

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It is well documented that hydraulic patterns in subsurface flow constructed wetlands are non-ideal due to an array of factors, including vertical stratification, preferential flow, dispersion, and degree of hydraulic loading, among others. As a result, it has become clear that flow patterns cannot be represented solely by inlet/outlet data sets. Data obtained in this study aids in the ongoing efforts to produce flow models that are more representative of actual flow patterns in vegetated submerged bed (VSB) wetland systems. A tracer study was conducted in order to assess the flow patterns and degree of dispersion within the pilot-scale subsurface flow constructed wetland at the Jones County Solid Waste Landfill in Anamosa, Iowa. Potassium bromide (KBr) was used as a conservative tracer, and samples were analyzed using a bromide ion selective electrode. Internal tracer profiles indicate that short circuiting is not occurring in the wetland. The effluent exit curve indicates that the wetland behaves as 6.2 tanks-in-series when the data was fit using the Gamma distribution function. Tracer mass recovery for the study was 92%, and the volumetric efficiency of the wetland was determined to be 93%.

5. Development of a Biomass-Fueled Stirling Engine for Combined Heat and Power Production

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The objectives of this project are to demonstrate the operation of a biomass-fueled 55 kWe Stirling engine and assess the technical and economic parameters key to the widespread implementation of the technology. Although biomass conversion technology and Stirling engine technology are both proven concepts, a system integrating the two concepts is not commercially available. This project will integrate the two concepts to gain the technical and economic understanding of the issues needed to advance the system to commercial viability.

The successful deployment of biomass-fueled Stirling engine distributed generation systems would be attractive to numerous organizations including municipalities, utilities, and remote power applications. However, we anticipate the initial application of this technology to agricultural processing and industrial companies who generate reasonable quantities of waste materials that have little or negative economic value. Additionally, these companies typically have significant energy costs that have fluctuated radically in the last few years. Integrating a combined heat and power system will enable these companies to hedge their energy and waste costs. It is the expectation of the project team that this technology will be ready for commercial deployment at the conclusion of this demonstration project.

6. Oxidation in Catalysis and Green Chemistry

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Oxidation is one of the major chemical reactions in industrial processes, water purification, and hazardous waste remediation. It is also involved in unwanted situations, such as aging and disease in living organisms, as well as decay and deterioration of abiological matter. In industrial oxidations, harmful chemicals need to be replaced by oxidants that are not toxic to life and environment and that do not generate hazardous by-products. Our research in this area has focused on the use of oxygen in its many forms, including molecular oxygen or air, as active oxidant in various reactions. In our search for efficient but environmentally friendly oxidants, we are also exploring the use of light (ideally sunlight) as the energy source. The combination of air and light in the same process would provide the ultimate oxidant in terms of low cost and human and environmental safety.

7. Conversion of Cellulose to Alkyl Glucosides

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Heating a stirred suspension of cellulose in an acidic alcohol at 160-200°C for a short time produces a significant yield of the alpha and beta alkyl glucosides. The dialkyl ether and alkyl levulinate are also produced to a lesser extent. Products of several different alcohols (isopropyl, butyl, hexyl, octyl) were studied. The effects of specific acid, acid concentration, reaction temperature, and reaction time on yields of the various products were also examined. Facile interconversion of the alpha and beta forms of glucose makes purification by crystallization difficult, but the alpha and beta forms of glucosides do not readily interconvert. This offers the possibility of obtaining a highly pure glucoside that can be conveniently converted to glucose. Future work will involve the use of other forms of biomass.

8. Iowa-Grown Kenaf for Natural-Fiber Composites

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Kenaf (Hibiscus cannabinus L.) is a sub-tropical herbaceous annual plant of African origin. Kenaf produces long "bast fiber" that is well-suited for use in eco-friendly composite materials. Although the kenaf plant has been cultivated and studied in the United States for several decades, little information is available to guide production in Iowa. Recent studies have shown that Iowa-grown kenaf responds well to agronomic management, producing up to six tons of dry matter per acre. Kenaf grown during the 2004 season in Iowa had an average of 33.1 percent bast in the leaf-free (stalk) bone-dry biomass, ranging from 30 to 36.9 percent. Iowa-grown varieties listed in order of high to low bast percentage were SF459, Gregg, Whitten, Everglades 41, and Tainung 2.

Kenaf is valued as a source of natural fiber primarily due to the long bast fibers. The "technical fibers" for industrial use are actually aggregations of many thousands of anatomical elements (single cells) or "ultimates". A typical material would contain a "nonwoven" kenaf bast fiber mat contained within a thermoplastic matrix. The bast lends high tensile strength, lower density (than matrix) and thus lowered part weight for a given strength requirement, insulation, and sound damping properties. In addition, the renewable, non-toxic nature of the fiber and its potential for recycling are important attributes as manufacturers seek viable alternatives to problematic inorganic fibers such as glass.

9. De-Icer Preparations

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Reducing sugars degraded in aqueous alkaline solution were effective in neutralizing the alkali, increasing the ionic strength and consequently the depression of the freezing point of water. The desired freezing point depression, to the temperature of -28 oC, can be achieved by adjusting the amount and concentration of the alkali metal hydroxide used, with the necessary counter ions (hydroxy acids) being derived from the degradation of reducing sugar. The resulting products are environmentally safe, biodegradable and eliminate the corrosive effects associated with conventional deicing materials of chloride salts. Corn steep water and cheese whey, as potential sources of starting materials for this purpose, have been exploited to degrade glucose by NaOH or KOH. The reaction products showed the freezing point depression of -26 to -29 oC (-15 to -20 oF) in the range of the solute concentration of 52 to 59 % by weight.

10. Microemulsion Expoxidation of Soybean Oil: Enhanced Epoxidation at a Lower Cost

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We have investigated the epoxidation of soybean oil in a microemulsion reactor system. The production of value-added chemicals from renewable agricultural resources is a national priority. New products based on renewable feedstocks must compete with existing materials in terms of both cost and product performance. The effect of surfactant system and oxidant concentration was investigated. Reaction kinetics are also reported.

11. Novel Bioplastics from Agricultural Oils

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A variety of promising new polymeric materials, ranging from soft rubbers to hard, tough and rigid plastics, have been prepared by the cationic, free radical, and thermal copolymerization of readily available vegetable oils with alkenes used as co-monomers and/or crosslinkers. The resulting polymers possess good thermal and mechanical properties, excellent damping and shape memory properties, and show considerable promise as replacements for a variety of petroleum-based polymers. Bioplastic composites of these materials have also been prepared using a variety of fillers, which enhance their mechanical characteristics. Future work will investigate the use of other monomers and/or oils and will also look into the biodegradability of these materials.

12. Thermal Stability of Soybean Seed Coat Peroxidase

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Soybean seed coat peroxidase (SBP) is a major protein present in soybean hulls. It is a glycoprotein, containing about 18% carbohydrate; two calcium ions are also closely associated SBP and appear to be important for maintaining the integrity of the heme pocket. SBP is capable of using H2O2 to oxidize a wide variety of organic compounds, including aromatic molecules such phenols and amines. More remarkable is its ability to oxidize molecules, such as anthracene, that are normally difficult to degrade. The oxidation of anthracene by SBP is only carried out at low pH (<pH 3) due to the high redox potential required for the reaction. SBP is capable of performing this reaction because it displays unusual stability to heat and pH. This poster will present research on the stability of SBP to a range of pHs and temperatures, using a variety of techniques, including enzyme assays, circular dichroism and UV/Vis spectroscopies.

13. Fungal Saccharification of Corn Fiber

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Corn milling, both wet and dry, leaves a low-value fraction, mainly consisting of fibers. These are mainly hemi-celluloses and celluloses. The research is focused in using the whiterot mold Phanerochaete chrysosporium and the brownrot mold Gloeophyllum trabeum to degrade these components to sugars. Both groups of molds were able to partially degrade the fibers and produce some sugars. Low concentrations of chemical inducers such as sulfuric acid or hydrogen peroxide have been studied to help promote the saccharification. Initial results indicate that less chemicals are required after fungal degradation than with these chemicals only. Other inducers such as veratryl alcohol or manganese sulfate were less effective. Concentrations of sugars produced are still small and the work continues to improve the process. The research is important in order to find a cheaper route to use lignocellulosic material as a substrate to produce ethanol. This in turn could make a significant contribution to produce more fuel from biorenewable materials.

14. Fungal Production on Corn Processing Wastewater

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Corn milling, both wet and dry, creates large volumes of wastewater containing organic material. This needs to be treated before disposal. Activated sludge systems used in wet milling have as major product a bacterial biomass of no value. This research has investigated the cultivation of valuable filamentous molds using the organic material in the wastewater supplemented with nitrogen and phosphate as substrate. It has been found possible to grow Rhizopus oligosporus continuously on this wastewater at pH 4, without the need for sterilization of the wastewater. The fungi grow rapidly in both suspended cultures and in attached growth mode.

Suspended growth required a microscreen to help select and retain the molds and allow passage of the competitive bacterial growth. Selective disinfection using various oxidants has been successful to suppress bacterial growth and even improve COD removal to over 80% and increase fungal yields. The attached growth system provided 80% COD removal and a fungal yield of 0.33 mg VSS/mg COD removed. The fungal biomass accounted for 93% of the total biomass whereas the bacterial population was at just about 7% at this pH.

15. Catalytic Conversion of Free Fatty Acids in Beef Tallow

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Propylsulfonic acid-functionalized mesoporous silica materials were synthesized using a one-step co-condensation technique. The catalytic performance of the resulting acidic mesoporous material was evaluated in the methanol esterification of free fatty acids in beef tallow as a pretreatment step for biodiesel production. The multi-cycle stability of the synthesized acid-modified mesoporous silica catalyst was studied. Issues concerning impurities in the feedstocks as well as a means of improving catalytic performance of the acidic solid catalyst through alternative strategies are discussed. Introduction of hydrophobic groups into the organosulfonic acid-functionalized mesoporous silica catalyst significantly enhanced the catalytic performance of the catalyst. The catalytic activity of the synthesized catalysts was compared to commercially available heterogeneous acidic catalysts. The results signify the potential of designing organosulfonic acid-functionalized mesoporous catalyst at the molecular level for the esterification of fatty acids.

16. Mass Transfer Enhancement for Syngas Fermentation

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The goal of this research is to identify and develop mass transfer enhancement strategies in a continuous stirred tank reactor (CSTR) to increase synthesis gas (syngas) uptake in a fermentation broth. This is part of a long term project focusing on engineering and biological bottlenecks to convert biomass into useful products through syngas fermentation, with the long term goal of replacing petroleum-based products with biobased products.

Syngas fermentation normally exhibits low gas-liquid mass transfer rates as a result of low solubilities of the syngas components (primarily CO and H2). To enhance the mass transfer in CSTRs, various strategies are reviewed, including aeration methods and impeller and baffle design. Mass transfer enhancement measurements for different impeller designs/schemes have been completed in a 14L CSTR by measuring dissolved O2 (from air) concentrations using a dynamic gassing-out method. In addition, power draw has been measured for each impeller scheme to compare power draw and mass transfer efficiency. Dissolved oxygen mass transfer measurements have shown that certain impeller schemes may improve volumetric mass transfer. Similar tests are now being completed with carbon monoxide to determine the generality of the results to syngas fermentation.

17. More Economical Conversion of Biorenewables to Value-Added Products

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A promising solid recyclable catalyst has been developed for the conversion of plant oils to biodiesel fuel. A catalyst has also been developed for the conversion of plant oils to efficient drying oils for alkyd resins and inks.

18. Development of a Solid-Fuel Appliance Test Program

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Corn stoves and furnaces have become a popular method of heating homes, shops, and buildings in Iowa and around the country. However, a preliminary search yielded little information that would be useful for a consumer or user of this technology. A search of the Internet determined at least twenty-two manufacturers of corn stoves or furnaces for residential and commercial application. Most corn stoves or furnaces investigated had a thermal rating of 30,000 to 160,000 Btu per hour. This thermal rating is comparable to most home furnaces. No distinction will be made between stoves or furnaces. Instead, solid-fuel heating appliances, or simply appliances, will be inclusive of all designs, regardless of the application or choice of solid fuel.

Rapid growth in any industry brings challenges and growing pains. The demand for alternatives to conventional natural gas or propane-fueled furnaces is opening the market for manufacturers of both high quality and low quality solid-fuel appliance products. Manufacturers and consumers alike may be misinformed regarding many aspects of solid-fuel appliances and their fuels. In theory, the burden of correct information and proper representation lies with the manufacturer. In reality, many manufacturers do not have the resources, know-how, or conviction to follow through. As a result, little credible information is publicly available for those seeking such information.

Objectives of a solid-fuel appliance test program:

- Identify technical parameters to be tested.
- Establish test procedures. Test procedures will be developed/established to collect data pertinent to the identified technical parameters. Other similar industries (furnaces, space heaters, woodstoves) and regulations (EPA, UL) will be referenced to understand similarities in test procedures.
- Assess consumer and industry interest. Manufacturers of solid fuel appliances will be contacted to assess their response to a solid-fuel appliance test program and gauge their interest in an industry-wide test program. A direct survey of consumers will not be conducted due to cost considerations. An inquiry will be made of the appliance manufacturers and/or distributors regarding consumer frequently asked questions.
- Identify a funding mechanism to support an on-going test program.
- Develop an administrative approach.

19. Ammonium Chloride and Sulfate Biotechnology Byproduct Effects on Soybeans in Central Iowa

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Ammonium salts of chloride and sulfate are byproducts resulting from production and purification of synthetic amino acids. These salts are essential plant nutrients needed in varying quantities by soybeans. In addition, they are strong acid producers when added to soil. Corn has responded to both byproducts with greater yields and nutrient contents. In this study we wanted to determine if their application to alkaline soils in central Iowa would be beneficial to soybeans. We side-dress applied the byproducts when soybeans were blooming at nitrogen rates equivalent to 50 and 100 lbs per acre with 100 percent of the nitrogen supplied by either the ammonium sulfate byproduct or combination of 67 and 33 percent from the ammonium sulfate and chloride byproducts, respectively. An untreated check was included in the study area. Several weeks after application, we noted minor soybean aphid infestations in chloride treatments; the other treatments were heavily infested. Soybeans were harvested by a yield monitor equipped, GPS-enabled combine. Yields were determined by soil type across the field. The greatest yield response was noted where 50 lbs. of nitrogen was applied with the sulfate/chloride mixture.

20. Production, Purification, Crystallization, and Structural Determination of Family 44 Endoglucanases

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We are trying to produce, purify, and crystallize several Family 44 endoglucanases (EGs), and to determine the three-dimensional (tertiary) structure of at least one of them. To do this we are growing the bacterial species Paenibacillus lautus, Clostridium acetobutylicum, and Escherichia coli, the third already containing the Ruminococcus flavifaciens EG gene. We are cloning EG genes from the first and second species into E. coli.

21. Developing Engineering Tools for Biomass Fractionation

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A key component in utilizing biomass as an energy source is efficiently separating the biomass anatomical products at harvest. Studies have demonstrated that glucan and xylan sugar content variability can be greater than 10% for stover and cereal straw anatomical fractions. Lignin content variability between anatomical fractions can approach 6%. Additionally, total structural sugar content can vary between 45-88% as a function of variety and environment. Since ethanol yield is a function of feedstock structural carbohydrate content, biomass anatomical fractions of higher product yield can have a significant beneficial impact on minimum ethanol selling price. However, currently available separation options with combine harvesters are not able to achieve sufficient separation of the straw/stover and chaff streams to realize the full potential of selective harvest. Our research is aimed at developing a set of advanced engineering design tools that support the more effective and efficient engineering design of high fidelity and high throughput separation systems for biomass components. In this toolset a virtual engineering framework is used to enable the system designer to manipulate and use the integrated set of tools in realtime. These tools include the physical geometry of the harvester, the detailed computational fluid dynamics analysis models to understand the harvester flow field, and an interface for the user to make changes to the system and control the environment.

22. Analysis of Suspended and Biofilm Atrazine Degrading Cells

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Increasing public concern over the safety of the s-triazine herbicide atrazine is fueling demands for methods to remove atrazine from water. Bioremediation can be a safe, cost-effective method of reducing atrazine concentrations in water. Atrazine is the most commonly used herbicide in the United States and possibly the world. Atrazine can be found in levels exceeding the EPA's 3 ppb limit in agricultural runoff, groundwater, and precipitation. Several European countries have already banned atrazine. In this research the ability of microbes in suspended and biofilm cultures to degrade atrazine is evaluated. Preliminary studies determined the kinetic parameters, max and Ks, of Pseudomonas sp. ADP (P. ADP) in suspension to be 0.07(.0.04) h-1 and 1.66(0.75) mg/L, respectively. P. ADP uses atrazine as a nitrogen source but needs to be supplemented with additional carbon sources. Preliminary studies have also concluded that P. ADP forms a biofilm. The research studies the relationship of this biofilm to atrazine consumption and the degradation rate of atrazine and the cell growth rate in the biofilm. This work will also focus on the relationship between atrazine and its metabolites and which step in the metabolic pathway has the greatest significance on catabolizing atrazine to carbon dioxide. Ultimately, the project will lead to the development of a membrane-based bioreactor for the degradation of atrazine in water.

23. Value-added Biocatalytic Conversions of Abundant, Renewable Aromatic Chemicals from Corn - The Case for Ferulic Acid

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Biocatalysis harnesses the synthetic powers of microorganisms or enzymes to produce chemicals of value. Biocatalysis is widely used in chemical, agrochemical, nutritional and pharmaceutical industries. Crops are a renewable source of huge quantities of potentially useful chemicals. Corn is grown in billions of harvested bushels annually. Corn kernel hulls are available already as abundant byproducts of corn processing. Hulls concentrate ferulic acid, a phenolic, aromatic natural chemical. This poster surveys the use and potential of biocatalysis applied to ferulic acid, a field we have studied for nearly 15 years. We emphasize the power of biocatalysis as a means of converting ferulic acid into value added products.

24. Ensiling Corn Stover with Enzyme Addition as a Feedstock Preservation Method for Particleboard Manufacturing

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Ensilage can be used to both preserve and pretreat biomass feedstock for further downstream conversion into chemicals, fuels, and/or fiber products. This study examined the ensilage of enzyme treated corn stover as a feedstock for particleboard manufacturing. Corn stover at three different particle sizes was ensiled with and without a commercial enzyme mixture having a hemicellulase:cellulase ratio of 1:2.54, applied at a hemicellulase rate of 1670 IU/kg dry mass. Triplicate 20 L mini-silos were removed and analyzed on days 0, 1, 7, 21, 63, and 189. During this period, the kinetics of produced organic acids and water soluble carbohydrates, fiber fractions, pH, and microorganisms including lactic acid bacteria and clostridia were monitored. On days 0, 21, and 189, the triplicate samples were mixed evenly and assembled into particleboard using 10% ISU 2 resin, a soy-based adhesive. Particleboard panels were subjected to industry standard tests for modulus of rupture (MOR), modulus of elasticity (MOE), internal bonding strength (IB), thickness swell (TS), and water absorption at 2 hr boiling and 24 hr soaking. Enzymatic addition did improve the ensilage process, as indicated by sustained lower pH ($p < 0.0001$), higher water soluble carbohydrate ($p < 0.05$), and increased lactic acid production ($p < 0.0001$). The middle particle size range (<10 mm) demonstrated the most promising results during the ensiling process.

Compared with fresh stover, the ensilage process increased the IB of stover particleboard by 32.62% ($p < 0.05$) and decreased water adsorption during 2 hr boiling and 24 hr soaking ($p < 0.05$). Particleboard panels produced from substrate ensiled with enzymes had a 12% reduction in water adsorption in a 2 hr-boiling test. Based on these results, ensilage can be used as a long-term feedstock preservation method for particleboard production from corn stover. Enzyme amended ensilage not only improved stover preservation, but also enhanced the properties of particleboard products.

25. Anaerobic Bioconversion for Methane and Class-A Biosolids Production

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The project aims to investigate the anaerobic digestibility of thin corn stillage for methane and Class-A biosolids production. The research on stillage digestion is very limited. This research will provide economical solution in managing the thin stillage that will have broad application in all the corn-based ethanol industries in Iowa and the nation. The thin stillage was obtained from Midwest Grain Processors and was fully characterized. Since the thin stillage at outlet of centrifuge has a high temperature of 150 oF, thermophilic digestion system was employed in this study to facilitate the hydrolysis of particulate stillage and to produce Class-A biosolids.

In spite of low pH of about 4.5, alkalinity supplementation was needed only during the digester start-up. At the later stage, no alkalinity supplementation was necessary due to self-generation alkalinity from the proteinous matters in thin stillage. The digester alkalinity was in the range of 4,000 mg/L as CaCO3. Sustainable methane yield of 40 m3/m3 stillage fed was obtained at a hydraulic retention time of 20 days. The chemical oxygen demand (COD) and volatile destruction efficiencies were 85% and 90%, respectively. The ultrasound pretreatment of thin stillage did not show significant improvement in treatment performance.

26. Anaerobic Bioconversion Coupled With Thermal/Catalytic Process for Alcohol Production from Agri-Wastes

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The goal of this proposed project is to investigate the feasibility of alcohol production in an integrated anaerobic and thermal/catalytic process using agri-wastes as a feedstock. The agricultural and industrial organic wastes or byproducts will be fed in a two-stage anaerobic fermentation process: hydrogen fermentation followed by methane fermentation to produce hydrogen and methane gas. The biodigester gases will then be used as feedstock to produce alcohol in EcoFuels' EcaleneTM plant. The conversion of biogas to alcohol takes place through two steps: Biogas conversion to syngas (CO, H2, CO2) followed by alcohol synthesis from syngas in presence of modified MoS2 catalyst. The molar feed ratio of H2/CO has been one of the important factors affecting alcohol production. The enhanced alcohol formation was reported at higher molar ratio of H2/CO. This integrated process also generates hydrogen biologically, thus the needed optimum molar ratio of H2/CO ratio could easily be maintained to enhance alcohol production. This project can contribute to the advancement of the Iowa Biotechnology Byproducts Consortium (BBC)'s mission of conducting fundamental and applied investigations aimed at enhancing the recovery and utilization of byproducts from waste streams generated by agribusiness.

27. Environmental Enhancement through Cornstover Utilization

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We propose a new system for maintaining soil fertility that employs cornstover or corn fiber for production of a nitrogen-rich, biologically active char that both enriches the soil and sequesters carbon from the atmosphere. In this system, cornstover or corn hulls are collected and preprocessed locally to yield fine, porous char and energy-rich bio-oil. The bio-oil, which can be thought of as densified biomass, is transported by tanker truck to a central facility for steam reforming to hydrogen followed by some part of it being converted to anhydrous ammonia (the process yields excess hydrogen). Using existing infrastructure of the agricultural fertilizer industry, anhydrous ammonia is transported back to the distributed preprocessing facilities where it is reacted with carbon dioxide, water, and char, which are byproducts from pyrolysis of biomass, to yield ammonia bicarbonate precipitated within the pores of the char. The nitrogen-rich char is injected into the soil where it serves three purposes: nitrogen fertilizer, biologically-active soil amendment, and a means for sequestering carbon from the atmosphere.