Continuation of Rice Straw and Rice Waste Bacterial Conversion to Poly Lactic Acid Biodegradable Plastic

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Summary:

Lactic acid can be produced from rice hulls and rice hull waste materials via bacterial fermentation. The overall goal of the research is to produce lactic acid from rice hull and rice straw waste to biodegradable plastics by using selective bacteria, which transforms sugars to lactic acid. The lactic acid is subsequently polymerized into the most common biodegradable plastic, namely, polylactic acid (PLA). The research project is a continuation of a feasibility research project on converting rice bran and hulls to lactic acid. The rice is M-206 medium grain of variety 206. The hulls and straw were collected by a local farmer and provided to Chico State for the research.

This project improved the conversion of rice hulls to lactic acid from 10% conversion in previous years to 40% conversion of the rice hulls to lactic acid, developed optimized polymerization methods for PLA, investigated thermophilic bacteria, investigated super critical CO_2 method for pretreatment of rice hulls and rice straw. Approximately 40% of the rice straw was converted to glucose. Additional carbohydrates were available on the outside of the straw and were converted to glucose. The conversion method is preliminary and more research is needed to improve the process and obtain more precise measurements.

The improvement in conversion of rice hulls to lactic acid was due primarily to improved sulfuric acid and sodium hydroxide base treatments of the rice hulls. Improved pretreatment methods included isolating the rice hulls with acid treatments, heating the waste materials in an autoclave, and then treating the effluent with enzymes for increased conversion of waste rice to glucose and production of lactic acid using one bacterium. The improved pretreatment process included grinding the rice bran and hulls in a blender, mixing the rice powder with 0.1 M sulfuric acid, 0.1 M sodium hydroxide, and then heating the buffered mixture in an autoclave for 50 minutes at 120°C and 1 atmosphere pressure. The optimized pretreatment process converted between 30 and 40% of the rice hulls or rice straw to glucose. The maximum amount of rice hulls or rice straw that can be converted to glucose and then lactic acid is 40% which represents the amount of available cellulose.

The conversion process of glucose to lactic acid was between 95 and 100% of the glucose from rice hulls or straw. The lactic acid was then purified with ion exchange process and then polymerized to polylactic acid powder plastic in a two-step process. Improved purification and polymerization processes were developed. Pretreatment processes were developed for rice straw that included grinding and pulverizing in a mortar and pedestal as a base process and then super critical CO_2 process. The machine for supercritical process was repaired and brought on-line for rice hulls and rice straw. Several leaks were identified and then fixed during the development of the machine.

The process of bacterial conversion of rice waste to glucose and lactic acid is technically feasible. However, with a conversion time of 5-days, it is not economically feasible. Low cost materials and faster conversion methods will be investigated in the future research.

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Major Accomplishments:

The research was beneficial to the agricultural industry by converting an agricultural waste product into sugars and then to lactic acid. Lactic acid can be polymerized into a biodegradable plastic, namely, polylactic acid. The research project converted rice bran and hull waste to lactic acid by using selective bacteria, which transforms sugars to lactic acid. The research was successful in

- converting up to 40% of rice hulls to glucose and then to lactic acid.
- converting up to 40% (preliminary) of rice straw to glucose and then to lactic acid.

Significant effort in the previous research was spent on pretreatment processes to convert the starches in rice straw and hulls to glucose. For rice straw and rice hulls, successful pretreatments include

- acidic wash followed by enzyme pretreatments.
- basic wash followed by enzyme pretreatments
- super critical CO_2 process developed and machine repaired and followed with by acid wash and enzyme treatments.

Impact Statements:

A significant accomplishment was converting to 40% of rice hulls and 40% of rice straw to glucose and then to lactic acid. Additional accomplishments included development of supercritical CO_2 process pretreatmen t of rice hulls and rice straw.

Dissemination, publications and presentations of research:

The work was presented at the following:

1. "Rice Hull and Rice Bran Waste Conversion to Biodegradable Plastics via Bacterial Transformation - Status Report," **Rice Research Council, (February 2010)**
2. "Rice Hull and Rice Bran Waste Conversion to Biodegradable Plastics via Bacterial Transformation – Status Report," **Rice Research Council, (November 2010)**
3. **Television coverage of Rice Research, News 10 Sacramento** http://www.news10.net/video/default.aspx?bctid=71052169001#/Chico%20State%20finds%20new%20use%20for%20rice%20waste/71052169001 March 2010

Budget:

Source	Year 1
ARI	$39,090
Rice Research	$10,000
Other Match	$27,700
Total	$76,790

Note:

- Salaries are for: 1 class release time for Dr. Greene
- Student wages:1 month summer salary for Dr. Greene
- Supplies
- Travel and Overhead