MASTER

ENERGY AND PROTEIN PRODUCTION FROM PULP MILL WASTES

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ABSTRACT

Research efforts during the past quarter has centered on increasing yeast protein production using ozonated spent sulfite liquor (SSL) and improving the biodegradability of SSL by ultrasonic treatments. Continuous-flow fermentation experiments demonstrated the suitability of ozonated SSL as a substrate for Torula yeast growth. Yeast yields averaging between 2.0-2.2 g/l of SSL were obtained at the optimum retention time of 1.8 days. This contrasts to yeast production rates of 4.8-5.0 g/l of SSL in two day batch cultures. Lower yields were expected under continuous-flow conditions as compared to batch conditions, but production rates were sufficient to warrant further investigation.

In contrast, effluent from anaerobic digestors used for methane production supported very little yeast growth even though it contains appreciable amounts of acetate. A toxic product or products apparently are synthesized during fermentation which are inhibitory to the Torula yeast.

Experiments were also run to determine if sonic treatments would increase the content of fermentable substrates in SSL. Results indicated striking increases in BOD levels of SSL after sonication, especially when used in conjunction with ozonation. Such gains in available carbon would likely result in increased methane and yeast production.

A number of manuscripts were prepared on past results of ozone treatment of SSL and the production of methane and yeast from ozonated SSL.

BACKGROUND

Experimentation over the past 18 months has conclusively shown that ozone treatments increase the biodegradability of SSL and consequently, the growth of methane-producing bacteria and yeast. Methane yield from the continuous fermentation of ozonated SSL has been rather low, despite various treatments to raise this production. In contrast, Torula yeast show considerable growth on this substrate, particularly at shorter ozonation times. Efforts this quarter have been directed toward further evaluating the suitability of ozonated SSL for potential commercial production of Torula yeast and developing other methods or technology in addition to ozonation for treating SSL that will give increased methane yields.

STAFFING

The return of Dr. Jurgensen to the University in December allowed him to resume full time participation in the project. Dr. Patton was present in Houghton for one week in January to confer with the staff. This was in addition to his data analysis and manuscript preparation completed at New Mexico State University. Mr. Craig Bremmon, Research Associate, and Sushil Dugar, Ph.D. candidate, as well as three undergraduate laboratory assistants, continued work on the project.

RESULTS AND DISCUSSION

Yeast Production

Previous batch culture studies had shown appreciable Torula yeast growth on ozonated SSL. A continuous fermentation experiment was established this quarter to confirm the yield characteristics demonstrated

in the batch tests and to ascertain the potential suitability of this substrate in a commercial operation. A fermenter similar to those previously developed for the methane production studies was used. The fermenter was operated on 3 hour ozonated 100% SSL containing supplemental additions of nitrogen, phosphorus and potassium and adjusted to pH 4.6. Air was continuously bubbled through the fermenter while the substrate was magnetically stirred. Incubation temperature was 36°C. A culture of a high yield, rough colony variant of Torula was used as fermenter inoculum.

The yeast fermenter was run continuously for six weeks. Over this period substrate retention times varying from 1.5 to 2 days were tested. Highest yeast growth was obtained as a retention time of 1.8 days, which gave average weight yields between 2.0-2.2 g/l of SSL. This compares with yeast production rates of 4.8-5.0 g/l in two day batch cultures. Lower yield is expected under continuous-flow conditions as compared to batch.

Previous analysis of effluent from various methane-producing digestors indicated appreciable production of acetate during the anaerobic fermentation of SSL. It was speculated that significant yeast production should occur on this substrate, since Torula can effectively use acetate as an energy and carbon source. However, pure culture experiments conducted this quarter found only negligible yeast growth on previously fermented ozonated SSL. Since ozonation or total salt concentration are not inhibitory to this species of Torula yeast, it seems that some material toxic to the yeast was produced during the fermentation process. Studies are continuing to identify the cause of this growth inhibition.

Sonication of SSL

Since preliminary efforts to dramatically increase methane production from ozonated SSL by the addition of growth supplements or varying the reactor operating conditions have generally been in vain, the effects of other pretreatments of SSL prior to fermentation was examined. Previous research by Mr. Bremmon before he joined our staff indicated that sonication of sewage sludge greatly increased its biodegradability. Consequently, a study was established in which ultrasonic treatment of SSL was compared or used in conjunction with ozonation.

All sonication treatments were performed in the same reactor having a starting volume of 300 ml of 100% yeast plant effluent. The reactor was placed in an ice bath for temperature control. However, substrate temperature reached 60°C during the longer ultrasound treatments. A sound level of 41,000 hz was used in all experiments. Samples were removed from the reactor every half hour for COD and BOD determinations.

The results of these tests showed that ultrasound treatment does have an appreciable effect on the BOD and COD levels of SSL, especially when used in conjunction with ozonation (Figure 1). Some of these changes may result from the higher substrate temperature due to sonication or to the lowering of pH to 1.5 during the combined sound-ozone treatment. It is not clear why sound would have such a synergistic effect with ozonation as shown by these data. It is expected that the increased BOD levels would result in greater yeast or methane production.

Manuscript Preparation

It was felt by our staff that much worthwhile information had been accumulated on the ozonation of SSL and the resultant production of methane and yeast which would be of interest to other researchers working in this field. Consequently, considerable effort was expended during

this past three months on preparing manuscripts for presentation to professional society meetings and for publication. These papers deal mainly with the effects of ozone treatment on SSL and the production of methane and yeast from ozonated SSL as shown below:

- (1) Methane Fermentation of Pulp Mill Wastes - to be presented at ACS Microbial and Biochemical Technology Division Meeting, Miami Beach, Florida.
- (2) Protein Synthesis from Ozonated Pulp Mill Waste - to be presented at the annual ACS Meeting, Philadelphia, Pennsylvania.
- (3) Ozonation of Desugared Spent Sulfite Liquor - to be submitted to a journal.
- (4) Methane Production from Ozonated Pulp Mill Effluent - to be submitted to a journal.
- (5) Bioremoval of Lignosulphonates from Pulp Mill Effluents - to be submitted to the Journal - Process Biochemistry.

SUMMARY AND CONCLUSIONS

Results during the past three months have demonstrated the suitability of ozonated SSL for the continuous production of Torula yeast. As was expected, yields from continuous-flow fermentations were lower than those obtained under batch conditions. However, this production was more than sufficient to warrant further investigation on this process. In contrast, effluent from the methane fermenters supported very little yeast growth even though it contains appreciable amounts of acetate. A toxic product or products apparently are synthesized during the fermentation which are inhibitory to the Torula yeast.

Experiments were also run to determine if ultrasonic treatments would increase the content of fermentable substrates in SSL. Results indicated

striking increases in BOD levels of SSL after sonication, especially when used in conjunction with ozonation. Such gains in available carbon would likely result in increased methane and yeast production.

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PLANS FOR THE FUTURE

During the coming quarter, work will continue on improving the growth of yeast on ozonated SSL, particularly on the effluent produced by anaerobic digestion for methane synthesis. Attempts will be made to identify the materials present in this effluent which are inhibitory to the yeast. Also, a series of experiments are planned to more fully determine the relationship of methane production and carbon use efficiency to substrate retention time, ozonation rate and feed concentration.

Figure 1. Changes in COD and BOD vs. time for varied treatments of SSL with ozone and sound.