Discussion by

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ABSTRACT

Dr. Ghosh has presented a novel technique for the conversion of Municipal Waste (MSW) to methane rich gas. Prior work has either permitted fermentation to proceed naturally (landfill gas extraction) or used conventional stirred reactors (DOE RefCOM facility). Proposed is to recycle leachate through a mass of solid waste to achieve volatile acids and then to convert the acids to methane in a separate fermenter. The results reported indicate that such a system is technically viable.

DISCUSSION

There are three basic technologies for the conversion of MSW to useful products. One, mechanical processing produces a solid fuel and materials for recycle. The second, thermochemical, produces heat energy or fuels quickly but under harsh conditions and with very variable products. The third, biochemical, produces liquid or gaseous fuels slowly but at mild conditions and with very specific products. The proposed technology is of the latter type.

Previous work has principally been confined to the recovery of landfill gas and to fermentation in continuously stirred reactors. Landfill gas (LFG) as practiced is uncontrolled. Attempts to add nutrients, recycle leachate, etc to enhance methane production have not been of notable success on a large scale. The continuously stirred reactor (CSR) is best represented by the 90 t (100 ton) per day RefCOM facility near Pompano Beach. RefCOM shows promise. The preliminary results indicate the economic production of methane at a reasonable waste disposal fee. The experimental work reported upon by Dr. Ghosh combines some of the better features of the landfill and the continuously stirred tank when viewed as anaerobic fermenters. It is a good first step, but should be emphasized as only a first step on a long research road.

ADVANTAGES

The advantages proposed by Dr. Ghosh should be separated since some apply to LFG and some to CSR. For example, minimum feed processing, no slurrification, no mixing, nutrients need not be added, and reduced operating energy requirements all apply to CSR. Experience at RefCOM indicates that only minimal feed processing and nutrients are needed. Elimination of the slurry in the tank and the mixing would have major advantages; however, the CSR may be much more efficient. At an 18 day retention time, the RefCOM digesters were producing 0.44-0.56 scm/kg versus added (1-9 scf/lb) biogas versus 2.5 scf/lb for the proposed system.

This is not totally a fair comparison since RefCOM was acclimated and operating on a relatively continuous basis for two months when these measurements were made while Dr. Ghosh’s experiment was in its eighteenth day after start up and was a simple batch feed. The comparison has been made to note that care must be taken in drawing
conclusions from any given experiment and that the new system may not have a high net energy production.

The cited advantages applicable to LFG are accelerated decomposition, in-situ gasification with ultimate disposal, and the feasibility of energy storage in the form of fatty acids. The first may not be an advantage. While the gas may be produced rapidly, the capital cost will also have to be recovered quickly. The second is not significant. The third may be. Since MSW is not easily storable and is bulky, it must be used immediately. In one sense an LFG project uses energy from waste stored for the last 10 years or so. However, unlike a natural gas well, the landfill can not be conveniently tapped and shut off for storage. A feasibility study is necessary to determine whether storage if required, is most economic as fatty acid or as compressed or liquid methane.

Two advantages that I have not discussed are possibilities of auto heat digestion and recovery at controlled and predictable rates. The paper does not present evidence to support either. Although upflow anaerobic digesters in general may be effective at lower temperatures, there is no inherent reason this system should be operated at lower temperatures or produce more heat than a CSR. The LFG system now proceeds without external heat sources. Finally, considering the heterogeniety of waste, I doubt that any system using it will be predictable. The fact that the principal product will be biogas, a mixture of methane and carbon dioxide, is predictable and is very important.

EXPERIMENTAL

The anaerobic digestion system has been viewed by some as a three phase system of hydrolysis of carbohydrates, acidogenesis to acetic acid, and fermentation to methane. In the solid phase digestion concept presented, the system is described as two phase with the hydrolysis and acid formation occurring in the solid bed and the methanation occurring in an upflow anaerobic digester. The experimental discussion adds a third reactor called a facultative acid phase digester. The tank is necessary, but the description is inappropriate. First, experimentally the leachate collected in this tank is principally acetate in the initial 15 days of operation. This is the acid form preferred for fermentation to methane. At the Argonne National Laboratories, methanogens have been suppressed by the use of oxygen and the production of volatile acids such as acetic and prorionic promoted, as suggested by Dr. Ghosh in the paper. Apparently, he did not test that thought experimentally since considerable biogas was generated in the bed. In addition, DOE sponsored experiments indicate the volatile acids can be recovered by membrane technology.

CONCLUSION

This initial experimental work is very valuable. It can lead to a commercial system for converting MSW to methane. In addition, it may overcome some of the problems encountered in attempting to enhance the production of LFG by recycle of leachate, buffering, nutrient addition. etc. Since the proposed system uses the leachate, reference to the literature on the large scale experiments sponsored by Gas Research Institute, Pacific Gas and Electric and the Department of Energy (DOE) at Mountain View and the laboratory experiments sponsored by the Environmental Protection Agency and DOE should be helpful.

Discussion by

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No comment on technical aspects which were beyond my realm of expertise.

Accepting the procedures and results of the testing facilities and the resulting conclusions that “... rapid gasification and stabilization of a refuse bed can be achieved by a two phase solid-bed digestion involving acid-phase bioleachate production and methanation of the bioleachate in an external methane phase digestor”, how can such a procedure be implemented in an active landfill? If such a procedure is impracticable due to the extensive activity associated with active landfills, would it be beneficial following closure of a landfill?

The recirculation of leachate is currently not permitted in the State of New York. Regulatory requirements are that all leachate collected must be treated and disposed of in an acceptable manner excluding the deposit of it or the treated effluent back to the landfill.

AUTHORS’ REPLY

To Donald K. Walter

The author is thankful to Mr. Walter for presenting a stimulating discussion of our technical paper on the development of a novel technique for the conversion of MSW to volatile fatty acids and a methane-rich gas. It is encouraging to note his observation that the proposed solid-phase process is technically feasible and that it is a good first step. We also agree that much more work remains to be done to demonstrate the commercial viability of the process.

Mr. Walter has compared the solid-bed process with CSR digestion. A comparison of the solid-bed and the CSR processes is appropriate from the viewpoint of system
selection, but not enough information is available yet to do so at this time. However, a CSR feed needs to be free of metal cans, glass, and similar large abrasive objects, and so some degree of feed processing is absolutely essential in the case of this process. In contrast, a solid bed process does not necessarily require such separation. Also, a CSR process cannot accept high solids-content feed without volatile acids accumulation and the consequent inhibition or cessation of methane fermentation. The solid-bed two-phase process as developed can accept high-solids-content (15-40 wt % solids) feed and requires no external nutrients because the nutrients indigenous to MSW are conserved within the system. In the CSR system, addition of either sewage sludge (nutrient sources) or external nutrient salts is needed, as we have observed and as has been the case in the RefCOM facility. As Mr. Walter has indicated, the CSR digester affords higher gas yields within a shorter retention time, but with added nutrients and with a more dilute feed slurry, as opposed to a solid-bed batch system which could afford the same yield but with a much longer retention time, and without the cost of nutrients. We have obtained a much higher methane yield of 5 SCF/lb versus added, but after batch operation for more than two months, indicating that yields comparable to those of CSR could be obtained in a solid-bed system. These data were not reported in this paper. Another advantage of the two-phase approach was that a high methane-content (~80 mol %) biogas is obtained from the methane digester. This is usually not the case with a CSR.

We mentioned in our paper that the solid-bed process should afford a higher net energy production. The reason for this is that heating of the digester feed, which accounts for a large part of the CSR operating energy requirement, is not required in the case of the solid-phase process.

Mr. Walter could be correct in stating that accelerated decomposition of refuse landfills may not be an advantage for some landfill operators. However, accelerated decomposition may be an advantage for communities that are interested in extending the life of a landfill because other landfill sites are difficult to come by. In such cases, the innovative solid-phase fermentation system would be desirable.

Still another advantage of the solid-phase process is its ability to produce fatty acids in high and recoverable concentrations. These acids have a much higher sale price than methane, and can be recovered, as pointed out by Mr. Walter.

We note with interest that work at Argonne National Laboratory indicated that oxygen prevented the proliferation of methanogens. This observation agrees with ours, but holds true for suspended growth cultures. In our solid-phase system we aerated the recirculating leachate stream introduced into the refuse bed, but it had no perceptible effect on slowing down methane fermentation in the bed. The aeration process generated considerable foaming, and we were forced to stop it because it was ineffective in any case. In a batch process, gasification of the bed starts as soon as the volatile acids concentration in the bed liquid drops below about 5000 mg/l and when the methane digester effluent is recycled to the refuse bed.

Finally, this author is aware of the GRI-supported project at Mountain View, California. However, there is considerable difference between the Mountain View approach and the two-phase solid-bed approach. Admittedly, the Mountain View experience would be useful to us in our process development work.

In closing, we are indebted to Mr. Walter for his thoughts, helpful suggestions, and constructive criticisms.