DOE/MC/27226-3191

**DEVELOPMENT OF BIOLOGICAL COAL GASIFICATION (MicGAS PROCESS)**

DOE/MC/27226--3197

7th Quarterly Report

DE93 006360

DOE-METC Contract No. DE-AC21-90MC27226

Submitted to:

Department of Energy
Morgantown Energy Technology Center
P.O. Box 880
3610 Collins Ferry Road
Morgantown, WV 26507-0880

April 30, 1992

Submitted by:

ARCTECH, Inc.
14100 Park Meadow Dr.
Chantilly, VA 22021

**DEVELOPMENT OF BIOLOGICAL COAL GASIFICATION**
**(MicGAS PROCESS)**

**Biological Production of Methane from Coal: Optimization of the Process.**

Alternate Sources of Growth Factors

In order for the coal biogasification process to be economically feasible, an inexpensive nutrient amendment must be found to replace the Difco$^{tm}$ yeast extract and tryptic soy broth (YE/TSB) used in the current medium formulation. Five products have been identified which support greater methane production from Texas lignite than YE/TSB. The costs of these products are presented in Table 1. Sheftone T (Sheffield Products, Norwich, NY) which costs $1.42/pound, is the least expensive of these products. Further studies are being performed on this product.

Currently, yeast extract and tryptic soy broth are used at 0.1% (w/v) each. Previous studies have indicated that this is the minimum concentration of organic nitrogen amendment required for efficient methane production from Texas lignite. During initial screening experiments, potential nutrient sources were tested at 0.2% (w/v). However, it is desirable to use these nutrients at a lower concentration, thereby further reducing medium costs. An experiment has been initiated to determine the minimum concentration of Sheftone T required for efficient production of methane from Texas lignite. Reaction medium containing Sheftone T at 0.2%, 0.1% or 0.05% (w/v) were inoculated with Mic-1. Reaction bottles were prepared with and without Texas lignite (-325 mesh, 0.1% w/v). A set of reaction mixtures with YE/TSB at 0.1% (w/v) each was also prepared. Methane production is being monitored weekly.

In order to compare the economic efficiency of methane production using different nutrient amendments at various concentrations, the following equation was derived:

$$\frac{P \times N}{M \times C} \times K = \$/ft^3 \text{ of methane}$$

where P is the price of the nutrient in dollars/pound, N is the percent concentration of the nutrient in the medium, M is the methane produced per gram of coal, and C is the percent concentration of coal in the medium. The constant K is a conversion factor to calculate the cubic feet of methane produced. Using this equation, it is possible to determine the cost of nutrient required to produce one cubic foot of methane from Texas lignite. With this information, the most cost effective concentration of nutrient for the biogasification process can be determined.

Table 1. Costs of several potential nutrient sources used in the biogasification medium.

| Product | Source | Cost ($/lb) |
| --- | --- | --- |
| YE/TSB | Difco | 35.45 |
| BHI Solids | Marcor Development Corp. | 21.77 |
| Meat Peptone | Marcor Development Corp. | 8.85 |
| Tastone 900 | Universal Foods | 4.35 |
| Sheftone M | Sheffield Products | 1.72 |
| Sheftone T | Sheffield Products | 1.42 |

The cost of methane production in the presence of various nutrients used at different concentrations, after 14 days of incubation, is presented in Table 2. Sheftone T at 0.2% (w/v) has the lowest cost ($2.01/cubic foot of methane) compared to YE/TSB at similar concentrations. Although the cost of Sheftone T at 0.1% (w/v) is still significantly lower than YE/TSB at 0.2%, the methane production has declined. Methane production is curtailed when less than 0.1% Sheftone T is used, thereby increasing the relative cost. Based on this information, Sheftone T, when used at 0.2%, is the most economical nutrient source.

## Isolation and Characterization of Bacterial Isolates

Thirteen bacterial isolates have been obtained from the Mic-1 and Mic-4 biogasification consortia. In order to determine whether these isolates are primary coal degraders, they were grown in medium containing Texas lignite. The degradation of lignite would produce an increase in soluble carbon in the liquid phase of the reaction mixture. Therefore, bacteria producing a significant increase in soluble carbon in reactions containing coal could be considered potential primary coal degraders.

Bottles containing new termite medium supplemented with Texas lignite (0.1% w/v, -325 mesh) were inoculated with each isolate. Bottles without coal were used as controls. The liquid phase from each bottle was sampled at 0, 7 and 14 days. The carbon content of the liquid phase was determined by measuring the chemical oxygen demand (COD). The volatile acids content of the liquid phase was also determined.

There was no significant increase in COD for cultures containing any of the isolates during the course of the experiment. These results indicate that none of the isolates currently available are primary coal degraders. However, the volatile fatty acid analyses, when available, will enable us to determine whether any of the isolates are acetogens.

During the course of this experiment, the coal in cultures of several of the isolates formed large clumps. Although the coal was not degraded, it is possible that it has been modified by the bacteria. An experiment will be initiated to determine if methane production will be enhanced using this "pretreated" coal. The coal will be harvested and used in reaction mixtures containing Mic-1 or Mic-4. Methane production will be monitored and compared to reactions containing untreated Texas lignite.

It is possible that the primary coal degrading bacteria can only grow and degrade coal synergistically, ie. in the presence of one or more other bacteria. Therefore, subcultures of mixed bacteria will be obtained, rather than pure isolates. These subcultures will be studied to determine if they can degrade coal.

Table 2. Costs of methane production from Texas lignite in relation to nutrient amendments.

| Nutrient[a] | % in medium | Methane[b] | Cost[c] |
|---|---|---|---|
| YE/TSB | 0.2 | 24.7 | $178.82 |
| Sheftone T | 0.2 | 87.9 | $2.01 |
| Sheftone T | 0.1 | 36.4 | $2.43 |
| Sheftone T | 0.05 | 7.0 | $6.32 |

[a] Texas lignite used at 0.1% w/v.

[b] Cumulative methane produced (cc/gram of coal); 14 d incubation.

[c] Cost of nutrient source required for the production of 1 $ft^3$ of methane from Texas lignite.

Bioreactor Studies

The major emphasis of the research during the coming months will be placed on bioreactor studies. Studies will focus on upflow fluidized bed (UFB) reactors and trickling bed reactors. A number of parameters, including coal solids loadings, the effects of sequestering agents and the addition of trace metals will be used in this study. The primary emphasis will be on shifting the process from batch to continuous mode and scaling up the process to a bench scale system.

In previous studies, bioreactors were constructed from Plexiglass. Because of the large number of seams between various parts, these reactors were prone to gas leaks. Leaks of this nature make it extremely difficult to accurately determine total gas production. In addition, such leaks may result in the introduction of oxygen into the anaerobic system, which inhibits methanogenesis.

In order to alleviate these problems, new bioreactors are being fabricated using glass materials. Three fluidized bed reactors are expected to be in operation by the end of the month. These reactors measure 2 inches in diameter by 24 inches in height. The advantages of using these reactors include less of a likelihood of leakage, and easy conversion from batch operation to continuous mode.

## Conclusions and Future Work

Based on results obtained during this quarter, the following conclusions have been drawn:

- Sheftone T can replace yeast extract and tryptic soy broth as an inexpensive nutrient amendment.
- None of the bacterial isolates currently on hand are primary coal degraders.

Work planned for the next quarter includes:

- Continued acquisition and testing of inexpensive nutrient amendments.
- Examine the factors that lower methane production at high solids loadings.

# END

# DATE FILMED

3 / 19 / 93