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Introduction to Session 4

Biological Processing of Fossil Fuels

MICHAEL E. MCILWAIN[1] AND BRENDLYN D. FAISON[2]

[1]*Idaho National Engineering Laboratory, Idaho Falls, ID 83415; and* [2]*Oak Ridge National Laboratory, Oak Ridge, TN 37831-6194*

Recently, a variety of studies have shown that microorganisms have the ability to solubilize, depolymerize, and convert coals to other fuel and chemical forms. The presentations that compose this session are concerned with identifying how microorganisms promote these processes and the environmental conditions and process parameters that enhance the conversion process.

The production of liquid material(s) from coal solids when the material was allowed to be in contact with certain fungi was first identified by R. M. Fakoussa (*1*) and M. S. Cohen (*2*). Additional studies (*3–5*) into the nature of the organisms and properties of the coal found that the water solubilization was dramatically increased when the coal was preoxidized using either heating, strong acid, 30% hydrogen peroxide, or natural weathering. Further, the lower the rank of the coal, the greater the extent of solubilization. A wide range of organisms was shown to have the ability to promote coal solubilization. These organisms were both fungi and lignin degrading bacteria. Related studies demonstrated that treatment of the acid-oxidized coal with mild to strong base would promote coal solubilization. The products arising from chemical and microbial solubilization were found to be similar with respect to the chemical nature (*6*) and molecular weight distribution of the organic material.

Microbes are also known to convert carbon monoxide and hydrogen to acetate and other low molecular weight alcohols. This anaerobic process is very similar to the chemical Fisher-Tropes reaction path for methanol synthesis. Initial studies by Gaddy and Clausen (*7*) demonstrated that microbial consortia derived from sewage samples could be grown in specially constructed high pressure reactors at elevated pressure. Typical effluent gases associated with coal gasification were found not to be extremely toxic to the cultures, especially if a hydrogen sulfide oxidizer was present in the microbial population. Initial studies demonstrated that low molecular weight alcohols and acetate were liberated to the medium in the presence of carbon monoxide and hydrogen.

In the current session, J. K. Frederickson reported on efforts at Battelle Pacific Northwest Laboratory to solubilize a high rank coal, Illinois #6. He and his coworkers found that when the coal was air oxidized and allowed to stand in the presence of *Penicillium,* greater than 90% of the material was converted to an alkali soluble form. NMR analysis indicated that the microbial action had caused a dramatic increase in carbonyl functionality. A. Maka of the Institute of Gas Technology reported that mixed cultures containing both fungi and bacteria promoted solubilization of preoxidized coal. R. T. Moolick from Colorado State University reported the apparent isolation of a new group of coal-solubilizing microbes whose activity was enhanced by growth under pure oxygen. B. D. Faison, Oak Ridge National Laboratory, reported that coal solubilization by *Paecilomyces* is associated with carbon nutrition and that alkaline catalysis by biogenic material(s) plays a key role in the solubilization activity. D. R. Quigley, Idaho National Engineering Laboratory, reported that, based on a round robin analysis of 17 coals attacked and solubilized by 9 different microbes, the mechanism by which microorganisms solubilize coal is by production of alkaline materials that raise growth media pH and affect solubilization. W. Wood, Salk Institute of Biotechnology/Industrial Associates, described the ability of *Phanerochaete chrysosporium,* which produces a lignin peroxidase, to oxidatively depolymerize previously-solubilized coal liquids. Results of these tests were consistent with known actions of lignin peroxidase on lignin-like materials. Finally, E. Clausen, University of Arkansas, has continued to study microbial conversion of coal gasifier effluents to low molecular weight alcohols. Current studies have focused on the influence of reactor gas pressure, partial pressure of carbon dioxide, and nutrient levels, and include efforts to shift the amount of ethanol produced relative to acetate.

REFERENCES

1. Fakoussa, R. M. (1981), Coal as a Substrate for Microorganisms: Investigation of the Microbial Decomposition of Untreated Hard Coal. Thesis.
2. Cohen, M. S. and Grabriele, P. D. (1982), *Appl. Environ. Microb.* **44,** 23.
3. Ward, H. B. (1985), *Sys. Appl. Microbiol.* **6,** 236.
4. Scott, C. D., Strandberg, G. W., and Lewis, S. N. (1986), *Biotechnol. Prog.* **2,** 131.
5. Strandberg, G. W. and Lewis, S. N. (1987), *J. Indus. Microbiol.* **1,** 371.
6. Quigley, D. R., Wey, J. E., Breckenridge, C. R., and Hatcher, H. J. (1987), *Proc. Biol. Treat. Coals Workshop* Vienna, Va, submitted.
7. Barik, S., Vega, J. L., Johnson, E. R., Clausen, E. C., and Gaddy, J. L. (1987), *Biotechnology Applied to Fossil Fuels,* CRC Press, Boca Raton, FL.