Biothermochemical Conversion of a Bituminous Coal

by

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Microbial degradation of organic compounds, in general, and of aliphatic/aromatic hydrocarbons, in particular, is well documented.[1-5] Microorganisms already have been utilized in the degradation of petroleum hydrocarbons and oil spill clean up.[6] Some of the microbial degradation work has been applied to coal. However, most of the research on bioprocessing of coal is limited to desulfurization. A sulfur oxidizing acidophilic bacterium, Thiobacillus ferrooxidans[7-12] and an acidophilic thermophilic organism, Sulfolobus[13-15] were used in several biodesulfurization studies and were found to be effective in the removal of pyritic sulfur. Limited success has also been achieved in the removal of organic sulfur from coal using S. acidocaldarius[15,16] and cultures containing dibenzothiophene.[18,19]

Recently, various organisms were tested for their ability to solubilize coal. The type of "liquid" products obtained from microbial interaction with various coals are listed in Table 1. These liquid products were very aromatic and contained polycondensed aromatic ring structures with many hydroxyl groups and very low volatility.[19] Extremely complex nature of these products precluded any characterization at molecular level.

Considering the complexity of the coal "structure" compounded by the presence of appreciable quantities of mineral matter, it is doubtful that the microorganisms can successfully degrade coal directly into end products. Furthermore, it has not been proven that the micoorganisms act specifically in attacking particular functional groups.

Table 1. Liquid Products From Microbial Interaction with Various Types of Coal[19]

Type of coal	Microorganism	Liquid product*
Mississippi lignite	Aspergillus sp.,	Clear, amber, and
	Candida sp. ML13,	black, inconsistent and
	P. waksmanii,	generally in moderate
	T. versicolor ATCC 12679	Clear; moderate amounts
North Dakota I lignite	Aspergillus sp.,	Clear; moderate amounts
	Candida sp. ML13,	
	Paecilomyces sp.,	
	P. waksmanii ML20,	
	Sporothrix sp.	
North Dakota II	Aspergillus sp.,	Brown to black;
	Candida sp. ML13,	moderate to profuse
	Paecilomyces sp.,	amounts; some clear
	P. monticola ATCC 11538	initially, turning
	Sporothrix sp.	brown to black after
	T. versicolor ATCC 12679	two weeks
Texas lignite	Aspergillus sp.,	Clear; trace to
	Candida sp. ML13,	moderate amounts
	Paecilomyces sp.,	
	Sporothrix sp.	
Vermont lignite	Candida sp. ML13,	Brown to black;
	Sporothrix sp.	trace amounts
	Paecilomyces sp.,	Clear; trace amounts
Wyodak	Aspergillus sp.,	Clear; trace amounts
	Candida sp.	
	Sporothrix sp.	
	T. versicolor	Clear to black; trace amounts

*Trace amounts - less than 10% of the coal surface covered with liquid moderate amounts - 10% to 50% of the coal surface covered with liquid; and profuse amounts - >50% of the coal surface covered with liquid.

(1.10)

While there are organisms that attack thiophenic group or pyrite inclusions, they may be capable of attacking other structural units in the coal as well. Many such organisms, could be somewhat non-specific in attacking various functional groups when they interact with coal, and may prove more beneficial in a process point of view.

Keeping this in mind, some exploratory experiments were conducted using Wellmore Kentucky No. 8 bituminous coal, (carbon 77.2%, hydrogen 4.9%, nitrogen 1.5%, sulfur 1.3%, oxygen 6.4% and ash 8.7%), and a microorganism, from the BNL collection, BNL-2-46 strain. The product of interaction of the "as-received" coal and BNL-2-46 strain, a solid, powdery material, after drying, was then pyrolyzed in an inert nitrogen atmosphere to 850°C at a heating rate of 100°C/min in a thermogravimetric apparatus. The microbial treatment with BNL-2-46 strain caused a positive enhancement in total yield of volatiles as shown in Figures 1 and 2. At the same time, another organism, BNL-3-25 strain, caused only a minor change in the volatiles yield.

This experiment has demonstrated that the microorganisms play a role in enhancing the production of volatile materials from coal. Microbial treatment alone can produce a cleaner starting material with less sulfur content, less ash content, less mutagenicity, and above all, a product that is more amenable for further thermal degradation. By itself, gasification can produce smaller molecules from coal and a variety of desirable products, the slate of which can be easily altered by changing the processing conditions. The integration of the developing biotechnology of bacterial treatment using different microorganisms, different strains of the same microorganism and/or combination of all in conjunction with the already well developed gasification technology is an interesting and desirable concept which should be pursued further.

ACKNOWLEDGMENTS

This work was performed under the auspices of the U.S. Department of Energy, Washington, DC under Contract No. DE-AC02-76CH00016.

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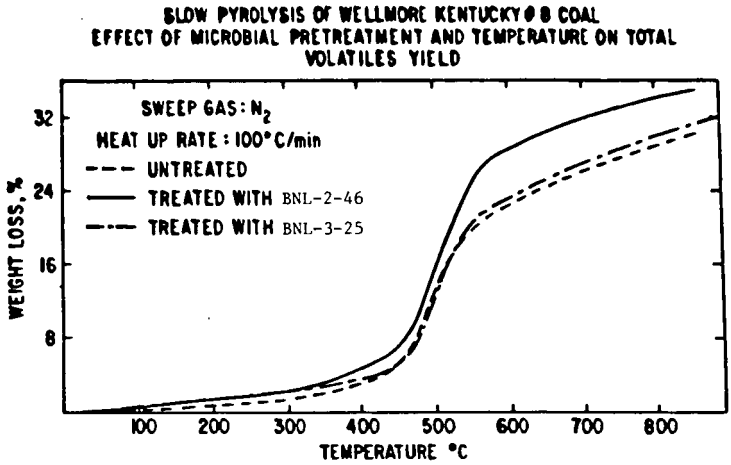

FIGURE 1

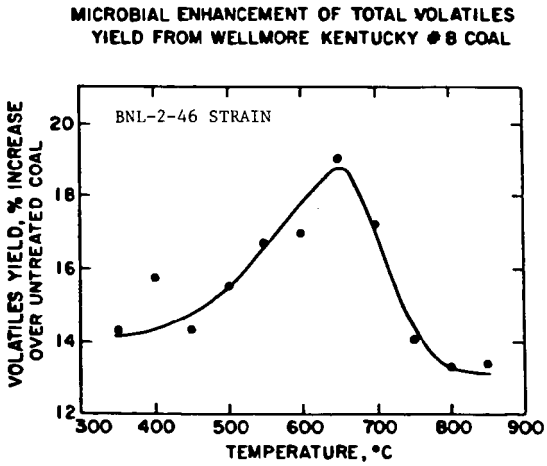

FIGURE 2