

**“Advancing Clean Coal Technologies”
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Preface

Dr. Richard A. Wolfe, a recognized coal scientist, was requested to write a series of three articles for this journal discussing the future frontiers of clean coal technologies.

Dr. Wolfe earned his BS degree at Virginia Tech in Chemical Engineering and MS and Ph.D. degrees in Engineering at the University of Cincinnati. He served as program manager with the US Department of Energy before joining United Coal Company in Bristol, Va in 1979 as Vice President of Research and Development. In 1988, he formed Coal Technology Corporation in Bristol, Virginia. He served on the energy research staffs at the University of Kentucky, West Virginia University, Appalachian State University, and currently serves on the Advisory Board at the Virginia Tech's Center for Coal and Energy Research.

Introduction

To understand the future of the Appalachian Coal Region and its people, we must first understand our past. This region of the United States is a world unto itself, a collection of contrasts. The Appalachia is both spectacular and forbidding in its terrain, obliging and begrudging in yielding its mineral wealth, fluid and stagnant in its evolution.

The people are hopeful and despairing, affluent and poverty-stricken, cosmopolitan and folksy, innovative and stubborn, peaceful and contentious. However, for those of us who live here in these Appalachian Mountains, there are some constants. We have a deep sense of heritage and a kinship with our God, a brotherly love where we may fight among ourselves but yet be united when threatened by “foreigners”, and blessings of an abundance of natural resources that will serve this region for centuries to come. The treasures in these mountains do not glitter like gold or silver. Rather, they are black as a moonless night; yet, when burned, give off heat like the sun and melt iron ore into a flowing lava.

“The Trail of the Lonesome Pine”, a book written by John Fox Jr. and published in 1908, offered the first real understanding to the “outside” world of the Appalachian people referred to as “The Over the Mountain People” in early historical documents. Yes, our heritage has been molded by our forefathers and it is up to us to now determine our future.

The future of our region is bright due to our abundant natural resources but we must use these resources in a way which allows for growth and prosperity while maintaining a balance with our environment. We have a golden opportunity to become the shining star of our Commonwealth and the Nation. Our challenge is to always be open-minded with regards to new technology as it becomes available, be smart in the utilization of our resources, and to preserve the environment in which we all live. I believe we, as the proud people of these Appalachian Mountains, have been making our mark upon civilization now for two centuries by fueling the industrial revolution with our abundant coal resources, which has brought enormous economic prosperity to our country and the world. Today with new technologies, we are sitting on threshold of creating another revolution with green economy by making coal to be the solution to many challenges we face today. In this series, I will describe the breakthrough novel approaches of using coal and for creating economic growth for our communities in Appalachia and contribute in growth of our country and the world.

THE ADVANCING MicGAS™ CLEAN COAL BIOTECHNOLOGY WITH NEW BREAKTHROUGHS IN THE BIOTECHNOLOGY FIELD

The biggest technology breakthroughs during the past 20 years have been in the field of electronics ranging from computers to cell phones and biotechnology for producing our medicines and foods. Who would have believed that the Radio Watch worn by the comic book character Dick Tracy would become so much of our daily lives? Our hand held calculators today have more memory capacity than the computers used by Neil Armstrong to land our first space craft on the moon 40 years ago. In my opinion, the field of science leading to our next greatest technological advancement will be in Biotechnology for clean energy production and green products for green economy of 21st century.

What is Biotechnology? Is there examples existing today in this new field of biotechnology? I would answer with a positive YES. Biotechnology is among the oldest technology invented by humans and has been in use for centuries. The best example is in the making of wine, which I have always had a special interest in with the establishment of the Wolf Creek Winery in Abingdon, Virginia and the Banner Elk Winery in Banner Elk, North Carolina. Microbes from a yeast fungus exist on the grapes or are added to grape juice. These microbes eat the sugar in the grapes and produce ethanol during a process of fermentation. The residual waste contains nutrients that enhance plant growth. Our coal mines and gob piles have been producing methane or natural gas, which many scientists now believe is being produced by microbial activity. This gas today is being recovered as coal bed methane to meet our growing need for clean natural gas. Another example is in the garbage disposal landfills and in the sewage treatment field where microbes breakdown the organic matter producing methane gas. What is happening is that we humans benefit from the hard work of millions of “microscopic worker cells”, not seen by the human eye, but are at work for us.

A Virginia based company, ARCTECH, Inc, located in Chantilly, Virginia headed by Dr. Daman Walia, has been working for the past 15 years developing solutions and technologies related to the bioengineering of coal. During this time, ARCTECH has become a leader in this field of biotechnology with the award of six new patents. A new technology has been developed by adapting microorganisms (derived from wood eating and humus eating termites) to eat coal in the presence of other appropriate nutrient compounds to produce methane gas and high value organic humic products for food production, cleaning waters and recycling wastes even obsolete military bombs and explosives in to fertilizer. This unified approach like oil refinery creates ten times more value from coal than with today's approaches. This has the potential of eliminating any concerns of carbon dioxide emissions from coal use, in fact, coal will become the solution.

The MicGAS™ bioconversion process is accomplished in three major steps. In the first step, the hydrolytic and fermentation process, microbes convert the coal into volatile organic liquids (primarily acetate and CO₂). In the second step, the liquid from the first step, along with the gases produced are contacted with methanogenic (methane producing) microbes which hydrogenate the acetate and CO₂ into Methane Gas. The methane gas is separated and the unconverted residual coal. In the third step, the coal undergoes a biochemical conversion. In this step, the coal residue is converted into humic acid for formulating into agriculture and environmental products. The process flow diagram is shown in Figure 1.

MicGAS™ COAL BIOCONVERSION TECHNOLOGY SCHEMATIC

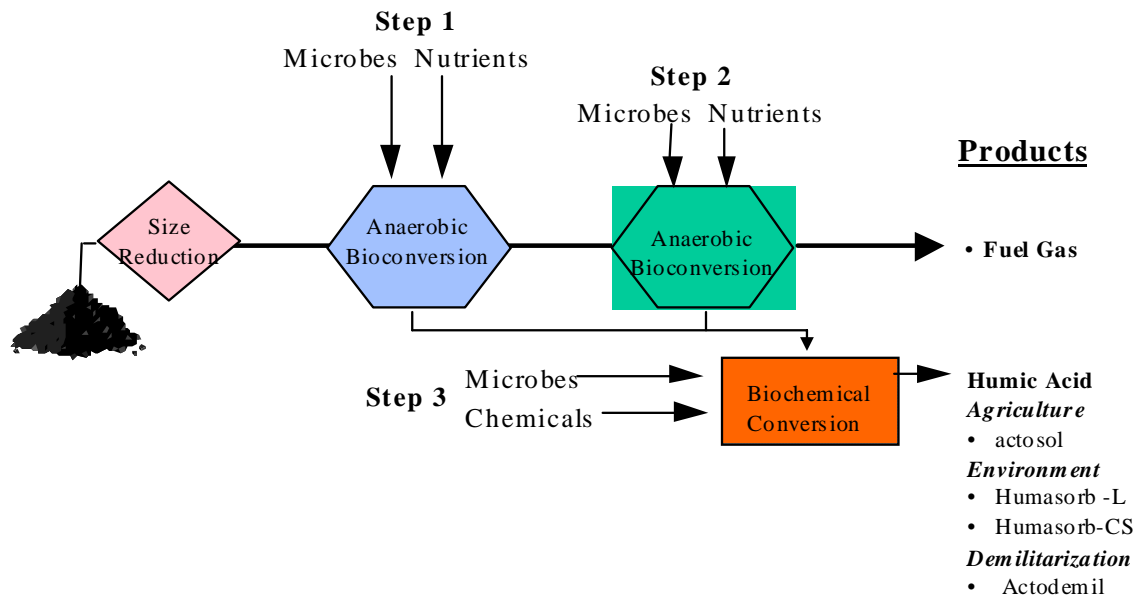


Figure1. Flow Diagram showing the processing steps.

In its simpler version, the MicGAS technology converts carbon in coal into two primary components. The first component is hydrogen rich clean methane gas and the second is carbon rich humic acid products. The use of clean methane gas in higher efficiency advance power generation systems such as gas turbines and fuel cells will keep the costs of electricity production low while reducing the emission of CO₂. The use of humic acid for enhanced vegetation will further remove carbon dioxide from the atmosphere through natural processes. This coal utilization concept is similar to that used in an oil refinery. For example, a barrel of crude oil as a result of cracking and refining provides a multitude of products valued several times higher than the price of gasoline and diesel fuel. The higher value obtained from the sale of these by-products (petrochemicals) enables the oil companies to make more money from these by-products than from the transportation fuels. The utilization of the biotechnologies, such as, those developed at ARCTECH, follows the oil refinery multiple product scenarios by first making a methane gas that can be burn cleanly or converted into liquid fuels and other chemicals such as those produced at the coal gasification plant operated by Tennessee Eastman in nearby Kingsport, and along with a host of different carbon based by-products. These humic acid based by-products can serve large agricultural and environmental markets around the world to produce greater quantities per acre of vegetation growth, clean up wastewaters such as acid mine waters and increase food products such as corn, wheat, grapes, etc. Also, theses coal based fertilizer products will greatly increase vegetation and tree growth during the restoration of surface mined areas while preserving the environment of our coal mining regions and absorbing additional quantities of carbon dioxide from the atmosphere. The US Department of Agriculture states that each acre of land with tree biomass captures 6 tons of carbon dioxide and releases four tons of oxygen per year. To learn about how coal derived humic fertilizer helps in carbon sequestration, please visit: www.ihccs.org

During actual testing of the bioconversion process in a pilot plant at ARCTECH facilities, the attached photograph in Photo 1 shows the actual methane gas being produced and combusted. ARCTECH has also established a feasibility of introducing these microbes in the unmineable coal seams for enhanced production of methane natural gas. Also, the photograph in Photo 2 shows Dr. Wolfe holding a 2.5 gallon sample of the coal based fertilizer called "**actosol®**" that is now being produced and sold in many applications in USA and in many part of the world. **Please visit**

[ARCTECH website; www.arcotech.com](http://www.arcotech.com) for more information on this breakthrough biotechnology and products applications.

PILOT PLANT PRODUCTION FACILITY IN VIRGINIA
Photos 1 and 2

This novel breakthrough MicGAS coal biotechnology has been thoroughly tested in the ARCTECH pilot plant and this technology is now ready for field demonstration. Several sites are being evaluated in the Southwestern Virginia coal fields and certainly among those sites are the Virginia City Hybrid Energy Center located in Wise County.

SUCSESSES OF MicGASTM COAL BIOTECHNOLOGY PRODUCTS
Photos 3,4,5

To learn more about this fascinating new coal bioengineering technology, please contact Dr. Wolfe at rwolfe@skybest.com or Dr. Daman Walia at dwalia@arcotech.com