The Fossil Report

Oak Ridge National Laboratory Fossil Energy Program Spring 2001

Energy Technology for the Future...and for the World

Sikka Named Corporate Fellow

Vinod K. Sikka, leader of the Metals Processing Group in the **Metals and Ceramics Division** and for years a prominent researcher and leader on the Fossil Energy Program, has been named by Oak Ridge National Laboratory Director, Dr. Bill Madia, an ORNL Corporate Fellow.

Designation as a Corporate Fellow is made on a limited basis to recognize exceptionally gifted individuals throughout the organization for their technical achievement in science or engineering. Staff members are honored for excellence and accomplishments in their professional careers.

Vinod Sikka

Corporate fellowships characterize innovation, dedication, and significance of extraordinary contributions to research and development.

These contributions have been acknowledged throughout the United States as well as in other nations.

Sikka has earned a reputation as one of the world's leading scientists in the processing and properties of materials, particularly intermetallic alloys. It is in this area that he has contributed significantly to the success of the Fossil Energy Program.

Madia indicated that Sikka has "made significant contributions" in his field and continues "the tradition of scientific excellence that makes ORNL one of the world's leading research institutions."

Sikka joined ORNL in 1974 and has been leader of the Materials Processing Group in the Metals and Ceramics Division since 1986.

He holds bachelor's degrees in chemistry and in metallurgical engineering, and master and doctorate degrees in metallurgical engineering.

Sikka's work has been featured in more than 150 publications.

He has been granted eight patents and has received five R&D 100 Awards.

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ORNL Technology on the Frontlines of Fuel Cell Development

ZeTek Power Corporation has established a branch of its operations in East Tennessee, using technology licensed from Oak Ridge National Laboratory and developed by **Rod Judkins**, director of the Fossil Energy Program at ORNL and **Tim Burchell**, leader of the **Metals and Ceramics Division** Carbon and Insulation Materials Technology Group.

Rod Judkins

ZeTek Power is the sole European fuel cell manufacturing company and the only company capable of mass-producing fuel cells.

Tim Burchell

Plans are to employ 150 people within two years at the former home of Advance Transformer in Morgan County, Tennessee. Production of fuel cells could begin in early

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Send comments to:

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At the heart of ZeTek's alkaline fuel cell system will be two ORNL technologies.

One removes carbon dioxide from the fuel and from air. This technology avoids the release of carbon dioxide into the environment.

The other technology is a method for manufacturing the carbon elements (used in the electrical swing adsorption) through a slurry molding process.

The Carbon Fiber Composite Molecular Sieve and electrical swing adsorption technologies will enable ZeTek to replace a nonregenerative chemical scrubbing system that made its fuel cell less versatile.

ZeTek will have a nonexclusive license to manufacture Carbon Fiber Composite Molecular Sieve systems and an exclusive license to use them in alkaline fuel cell systems.

This marks the first location of a company in the region, as a direct result of technology developed by ORNL, since UT-Battelle took over management of the Laboratory.

Judkins, himself a native of Morgan County, observes that, "All of this could lead, one day, to an entirely new way of generating and distributing power.

"This could also help reduce greenhouse gas emissions and lessen our dependence on foreign oil.

"This endeavor is a great example of what the private and public sector can do when they work together.

"We have ZeTek bringing the innovation and business spirit, the State of Tennessee is helping with technical and capital assistance, ORNL is providing research and development, while the county brings the work force and facility.

"I am hopeful that this will be a great partnership."

This article was excerpted from articles written by Ron Walli, ORNL Public Relations, and by Cathy Cheverton, Editor, The M&C Pipeline, Volume 10, Issue 1, Winter 2001. Their contributions are gratefully acknowledged.

This work is supported ***DOE Office of Fossil Energy, National Energy Technology Laboratory.***

For more information on this work, contact ***Tim Burchell*** *or* ***Rod Judkins****, Oak Ridge National Laboratory.*

Enzymes Being Used to Upgrade Crude Oil

Two major problems confront the oil industry in the processing of heavy crude oils.

First, the presence of asphaltenes increases the viscosity of the oil, thereby making difficult the design of processing plants and economical processing schemes. The precipitation of asphaltenes aggregates can cause problems such as reservoir plugging and wettability reversal.

Second, the heteroatom content of the oils contributes significantly to corrosion and also results in the need for complex refinery scenarios.

The addition of hydrogen to aromatic and heteroatom molecules through biological means is an attractive method for the upgrading of crude oils.

In nature, hydrogen is added to both simple and complex compounds through the use of hydrogenase enzymes. However, the enzymes which exist in nature have evolved over millions of years to attack compounds which exist in nature. They are not designed to attack hydrocarbons.

Abhijeet Borole is heading an effort in ORNL's **Chemical Technology Division** to resolve this limitation in the use of enzymes to upgrade crude oil.

Biological processing has the dual advantage of low-temperature and low-pressure operation, as well as high specificity.

In order for the biological enzymes to work with the compounds found in crude oils, it is necessary to create favorable binding interactions between the oil substrates and the enzymes.

In addition, the complex nature of crude oil makes necessary the design of biocatalytic binding sites which are sufficiently flexible to accommodate a wide variety of compounds.

This work is supported ***DOE Office of Fossil Energy, National Petroleum Technology Office.***

For more information on this work, contact ***Abhijeet Borole,*** *Oak Ridge National Laboratory.*

New Research to Produce Clean-Fuel Processing

David DePaoli of the Oak Ridge National Laboratory **Chemical Technology Division** is heading a new effort to develop ionic liquids to remove sulfur from gasoline and diesel fuels and for the separation of carbon dioxide from natural gas.

Sulfur removal is needed, as the presence of sulfur is incompatible with petroleum processing technologies and also has detrimental environmental ramifications.

The need to separate carbon dioxide from natural gas is an important objective, in view of global warming concerns.

Other organizations involved in this research are the **University of Alabama**, the **University of Texas**, and **Chevron**.

Additional companies will be invited to form an advisory committee to direct the scope of the research and to assure that the products resulting from this work will be acceptable for industrial use.

Room-temperature liquid salts can act as both solvent and catalyst, making possible certain chemical reactions not possible with other substances.

In addition, the materials can be easily separated and recycled, reducing the amount of wastage and level of energy required by conventional solvent separations during fuel processing operations.

The low vapor pressures of ionic liquids also minimize the human health risk and the risks to the environment usually associated with high-volatility compounds.

This work is supported ***DOE Office of Fossil Energy, National Petroleum Technology Office.***

For more information on this work, contact ***David DePaoli,*** *Oak Ridge National Laboratory.*

Enhanced Photosynthesis: A New Pathway to Carbon Sequestration

Cyanobacteria, the oldest known fossils with descendants which still very much alive day, are being used in new work at Oak Ridge National Laboratory to sequester carbon dioxide.

Cyanobacteria are aquatic, photosynthetic, and they can manufacture their own food. They are the oldest known fossils—more than 3.5-million years old—and are considered to be one of the most important bacteria still on planet earth.

Researchers in recent years have developed photobioreactors that utilize sunlight-induced photosynthesis to sequester carbon, using cyanobacteria. And, photobioreactors are used to produce phototropic algae for use in aquaculture, pharmaceutical, animal feed, and health food industries.

The principal hurdle to the scale-up of photobioreactors to achieve a commercial viability is lighting limitation, both in terms of light delivery and distribution, and energy expenditure.

Natural bioreactors commonly waste 90 to 95% of the incident photosynthetic photon flux, making conventional photobioreactors very difficult to justify from cost and performance perspectives.

Jeff Muhs of the **Engineering Technology Division** is investigating ways in which cyanobacteria can be used to sequester carbon dioxide, through the development of an optimized, enhanced photosynthesis system.

The enhanced system will separate various spectral regions of direct, non-diffuse sunlight to maximize cyanobacteria growth.

The objective of the work will be to demonstrate that low-risk methods of carbon dioxide sequestration, based on optimal use of existing organisms, are capable of significant carbon dioxide uptake and offer a valid, near-term method of carbon dioxide sequestration.

This work is supported ***DOE Office of Fossil Energy, National Energy Technology Laboratory.***

For more information on this work, contact ***Jeff Muhs,*** *Oak Ridge National Laboratory.*

COMING SOON

The Fossil Energy Program Annual Report for the period ending March 2001 is in preparation and will be posted to the Fossil Energy Program Web site in near future.

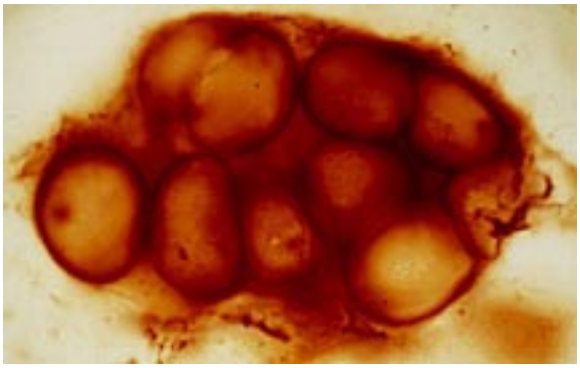
The Oldest Fossils

The oldest known fossils, cyanobacteria, are more than 3.5 billion years old. Perhaps even more remarkable is that cyanobacteria are still an active part of life on earth today, and, in fact, are one of the most important groups of bacteria in our ecosystem.

The oxygen in earth's atmosphere was generated by numerous cyanobacteria during the Archean and Proterozoic Eras. Before that time, the earth's atmosphere was not capable of supporting life as it is know today.

Morphologies of cyanobacteria have remained the same for billions of years and leave chemical products behind as well, in the form of breakdown products from pigments.

Many of the Proterozoic Era oil deposits result from the action of cyanobacteria. Small concentrically-layered structures called pisolites are also due to the action of ancient bacteria. Cyanobacteria have also been found in chert and shale deposits.



Cyanobacteria from a chert deposit in Central Australia, dating from the Late Proterozoic Era, about 850 million years ago.

The image at the left is of layered stromatolite, formed by ancient cyanobacteria.

The layers were produced as calcium carbonate, precipitated over the growing mat of bacterial filaments. Photosynthesis in the bacteria depleted the carbon dioxide in the surrounding water, initiating the precipitation.

The minerals, along with the grains of sediment precipitating from the water, were trapped within the sticky mucilage surrounding the bacterial colonies, which continued to grow upwards to produce a new layer. Layers of sediment were produced as the process was repeated.

This process still occurs today. Stromatolite growths can be found along the beaches of Shark Bay in Western Australia.

This article was excerpted from information provided by the ***University of California, Berkeley, Museum of Paleontology****.*

Langley Leaves Program

Lorie Langley, Manager for Natural Gas and Carbon Sequestration, left the Fossil Energy Program on May 18 to pursue other interests.

Lorie has been a valuable asset to the Program, developing new areas of work in methane hydrate research and natural gas infrastructure, and contributing to the expansion of activities related to carbon sequestration. She, as well as her enthusiasm and contributions, will be missed.

Conference Proceedings Now on Web

The **Proceedings for the 14th Annual Conference on Fossil Energy Materials** is now on the Fossil Energy Program Web site.

This interactive Acrobat document highlights the presentations and posters from the conference, sponsored by the Advanced Research Materiels Program and held in April 2000 in Knoxville, Tennessee.