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MISSISSIPPI GRADUATE TRAINEE PROJECT FOR DOE EPSCoR

SUMMARY REPORT FOR YEAR #2

SUBMITTED FOR THE MISSISSIPPI RESEARCH CONSORTIUM

BY

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PROJECT DIRECTOR

OCTOBER 1993

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I. EXECUTIVE SUMMARY

The Mississippi DOE EPSCoR Project is a program of education and research which is 1) increasing the number of trained professionals in the energy sciences and technology, particularly those from groups traditionally under-represented in the field, 2) interfacing with existing networks of universities, industry, federal, and state institutions involved in energy-related activities.

Key projects that have been accomplished are shown below:

- Statewide Conference on Energy Related Research Held
- HBCU Pipeline Issue Addressed
- Research Preceptors/Problems Selected
- Trainees Screened and Accepted
- Research Initiated
- Practicums Organized

Mississippi's three comprehensive universities -- the University of Mississippi, Mississippi State University, and the University of Southern Mississippi -- and the urban institution, Jackson State University provide a strong foundation for the expansion of energy-related education and research in the state. The activities of the Mississippi DOE EPSCoR Program are being executed under a management strategy developed to establish statewide coordination of research and education programs, i.e., the Mississippi Research Consortium. The Consortium serves as the steering committee for the DOE EPSCoR Program Consortium.

The Project Director of the Mississippi DOE EPSCoR Program is Dr. David Wertz, Professor and Chair of the Chemistry and Biochemistry Department at the University of Southern Mississippi. He is assisted by three cluster leaders, the steering committee, and campus research preceptors. In addition, an Advisory Committee has been formed to provide guidance from representatives of business and industry and federal/state government regarding direction and resources for future energy-related research and education programs.

The following three research clusters were selected for major emphasis in the Mississippi DOE EPSCoR project because of existing expertise at the MRC Universities. At the same time, these three areas allow for active research participation by scientists at historically black Jackson State University.

- FOSSIL FUEL POLLUTANTS CLUSTER addresses the environmentally sensitive concerns caused by the combustion of fossil fuels, particularly coal and coal products, and ways to minimize the environmentally unacceptable species

resulting from use of coal.

ENHANCED OIL RECOVERY CLUSTER has as its goal the availability of a far higher percentage of our older petroleum deposits.

- POWER SYSTEMS AND CONSERVATION CLUSTER is directed towards improved efficiency in energy transport and usage. As the project matures, other research areas may be added to these three clusters.

A schematic of the project and its management plan is presented in Figure One.

From the Fossil Fuel Pollutants Cluster and from the Power Systems Cluster, two multi-investigator projects (which emphasize unusual expertise in the State) have been selected as the principal activities for Mississippi's future DOE EPSCoR activities.

II. PROJECT GOALS, OBJECTIVES AND STRATEGIES

A. GOALS AND OBJECTIVES

The goal of the DOE EPSCoR Graduate Traineeship project is to provide the appropriate research and educational mechanisms to attract quality scientists and engineers who will contribute to advances in energy research and energy issues.

(1) To establish an energy research and education program that compliments the needs of this state and the nation;

(2) To create a critical mass of scientists and engineers by incorporating inter-institutional links built around a commonality of research expertise;

(3) To strengthen the state's scientific community by working with other established programs; and by developing the human resource pool to become involved in energy-related research and education.

(4) To establish technology transfer to appropriate user groups by developing stronger research links with other energy-oriented research communities.

The objectives of this project are being met, with varying degrees of success, in the project's second year. These successes are discussed below.

B. STRATEGY

Existing faculty and facilities, with expertise in energy research, are serving as the research preceptors for the Mississippi DOE EPSCoR Traineeship Program.

To attract the best students by offering competitive stipends of quality educational/research facilities has been the principal strategy employed by the DOE EPSCoR Traineeship preceptors. National advertising by the preceptors has been employed as the principal strategy for bringing the DOE EPSCoR Traineeships to the

attention of prospective trainees. Excellent stipends have helped make the traineeships attractive to such students and several have already initiated their traineeship activities.

A future strategy will be to bring the master of science graduates from JSU into the appropriate doctoral programs at USM, MSU and/or UM.

C. MEETING THE GOALS AND OBJECTIVES -- PROGRESS TO DATE

Sixteen trainees, along with their research preceptors, constitute the resource pool. These trainees would not have been available without the DOE EPSCoR funds to support their research activities. They represent an increase of 40% in energy related research personnel at the graduate level in the State. Since all of the trainees are enrolled in graduate courses and seminars at their MRC universities, curriculum emphasis and particularly seminar topics have been reoriented towards energy-related topics. The latter trend will continue and accelerate in each of the participating departments as the DOE EPSCoR project matures and as other DOE initiatives occur.

Several of the research preceptors have submitted proposals to DOE to obtain additional support for their energy-related projects. Publications and presentations from the Traineeship Program have begun (as noted in Appendix II). It is clear that the caliber of the trainees is consistent with scientific accomplishments and professional recognitions which will continue to produce new science in energy-related fields.

III. PROJECT MANAGEMENT PLAN

The Mississippi DOE EPSCoR Committee has designed a management plan to support the administrative requirements as well as the scientific research being conducted by the individual research groups involved in the clusters. This plan (see Figure 1) is based on the organization of project personnel, the mechanisms for program direction and development, and the methods employed for oversight. Cluster research activities have been grouped around themes of current research, strengths within the state, and high national priority. Within each cluster are several research projects with specific goals and objectives and with a specific trainee (selected by that preceptor) who is employed in a graduate degree program and involved in an energy related research project. Personnel in the management structure of the program include the members of the DOE EPSCoR Committee, the Project Director, and the Cluster Leaders.

The MRC Steering Committee is responsible for formulating, implementing and monitoring appropriate strategies and mechanisms to ensure that the chief goal of the DOE EPSCoR Program, enhancement of the quality and competitiveness of science in the state, is met. The MRC Steering Committee has managed, coordinated, and established policy for this program. It will continue to do so.

FIGURE TWO

A. PROJECT DIRECTOR. The Project Director for the Mississippi DOE EPSCoR Graduate Traineeship Project (Dr. David L. Wertz) has represented the committee in all communications with DOE. The Project Director maintains an effective interface with the Cluster Leaders to ensure rapid, effective communication. Wertz has been responsible for overseeing the three clusters in the program. He has chaired the first quarterly meeting of the committee conducted to receive briefings regarding progress and/or problems encountered and to discuss possible modifications of strategy or allocations of resources. As Project Director, he provides regular briefings to DOE. As Project Director, he maintains overall budget control. He has devoted approximately 15% of his time to managing the Mississippi Graduate Trainee DOE EPSCoR Project.

B. CLUSTER LEADERS. The Cluster Leaders have assisted the Project Director in organizing and managing the Mississippi Graduate Traineeship DOE EPSCoR Project.

The Cluster Leaders have conducted the routine administrative functions of each of their respective programs. The Cluster Leaders have been responsible for collecting and maintaining the data concerning relevant scientific activities of individual scientists and engineers participating in the clusters, for organization of meetings, for development of appropriate materials necessary for the management of the program, as well as insuring the inter-institutional links are solidified. Each made a presentation at the recent on-site visit by DOE staff and consultants (January, 1992).

C. EXTERNAL ADVISORY BOARD. To provide guidance to the MRC and the cluster leaders, an external advisory board has been formed. Asked to serve on the Board are:

1. Larry Hartness
Vice President for Engineering
ERGON, Inc.
Jackson, MS
2. Mr. William K. Newman
Vice President for Power Generation
Mississippi Power Company
Gulfport, MS
3. Mr. Joseph Sims
Mid Continent Oil and Gas Association
Jackson, MS
4. Mr. Wes Miller
Department of Energy & Transportation
State of Mississippi
Jackson, MS
5. Dr. Mildred B. Perry
U. S. DOE
Pittsburgh Energy Technology Center
Pittsburgh, PA
6. Dr. Riitta Ollendorff
Amoco Research
Naperville, IL

Additional members will be included as the project matures. Each preceptor is continuing to contact potential advisory board members in the areas of his/her expertise.

D. FISCAL CONTROL. The University of Southern Mississippi serves as Project Fiscal Agent for the Mississippi DOE EPSCoR Project on behalf of the DOE EPSCoR

Committee. The University of Southern Mississippi is the home institution of the designated Project Director, thus selection of this institution as the project fiscal agent facilitates rapid and efficient communication during the course of the program and ensures effective coordination of fiscal matters relating to those components at other institutions in the state.

E. PROJECT REPORTING. The members of the DOE EPSCoR Committee will review brief progress reports submitted by the cluster leaders to the Project Director at the quarterly meeting of the committee. The Project Director will prepare an annual progress report for use by the committee and the DOE Program Officer. This reporting process ensures that data on which to base evaluation of the overall progress of the Mississippi DOE EPSCoR Project and of the various clusters is readily available. The data will also provide a guide concerning future actions and any changes in strategy required. The Project Director will, at the conclusion of the Mississippi DOE EPSCoR Project and, at appropriate times, prepare a report describing and evaluating the management techniques and processes used during the Mississippi DOE EPSCoR Graduate Traineeship project. The report will be submitted to the Department of Energy and will be made available to other interested parties.

F. MRC UNIVERSITY SUPPORT. Each of the universities is providing tuition and fee support for each of the trainees and released time support for most of the preceptors. USM is providing additional research support and extensive travel support to the project manager. Each of the universities is also providing travel for the preceptors to attend the statewide DOE EPSCoR meetings.

G. PARTICIPATING DEPARTMENTS AND PROGRAMS

- (1) JACKSON STATE UNIVERSITY (JSU)
Biology, Chemistry, and Computer Science
- (2) MISSISSIPPI STATE UNIVERSITY
Electrical and Computer Engineering, Mechanical and Nuclear
Engineering, Petroleum Engineering and Diagnostic Instrumentation
- (3) UNIVERSITY OF MISSISSIPPI
Biological Sciences, Chemical Engineering, Geological Engineering
and Mechanical Engineering
- (4) UNIVERSITY OF SOUTHERN MISSISSIPPI
Chemistry and Biochemistry, Polymer Science and Coal Products
Research

IV. NARRATIVE SUMMARY OF PROGRESS

A. PROJECT DIRECTOR TRAVEL FOR THE EPSCoR TRAINEESHIP PROGRAM

(1) In November, 1991, Dr. Wertz attended the national EPSCoR meeting in Portland, Maine to represent the Mississippi DOE EPSCoR traineeship program and to better familiarize himself with the national goals and objectives of the various EPSCoR activities.

(2) In late November, Wertz visited each of the four MRC campuses to discuss the one-year grant activities with each preceptor and to facilitate the various start-up procedures. During these visits, Wertz toured several of the laboratories of the faculty preceptors.

(3) In January, Wertz and the cluster leaders from the DOE EPSCoR Planning Grant participated in a two-day site visit with DOE personnel and a DOE review team to critique and strengthen the Mississippi DOE EPSCoR Planning Grant.

(4) In April, 1992, the three cluster leaders and others who will likely be involved in future DOE EPSCoR activities visit each of the four MRC campuses. During each visit, two principal activities will occur: (a) presentations from the cluster leaders concerning future activities will be made, and (b) current and potential preceptors will provide laboratory tours to illustrate their facilities and capabilities for energy research.

(5) Wertz and other MRC personnel attended the May 5, meeting titled "DOE Research Program Priorities and Initiatives" to be held in Washington, DC.

(6) Wertz met nine times during the Fall and Winter, 1992, and Spring 1993, with the MRC Committee that developed the Mississippi DOE EPSCoR proposal. A continuation of these meetings has occurred in September, 1993.

B. THE PIPELINE ISSUE. An excellent opportunity for the Mississippi DOE EPSCoR Project is to attract students from the historically black colleges and universities in this area into energy research related graduate programs at the MRC Universities. To accomplish this, at least fifteen seminars have been given by the various project preceptors to the HBCU's, not only in Mississippi but in several neighboring states as well. During each seminar, the DOE EPSCoR Graduate Traineeship Program and its excellent support for graduate energy researchers have been well advertised. Attempts to select female graduate students into the DOE EPSCoR Program have also been successful.

V. RECRUITING METHODS UTILIZED TO ATTRACT POTENTIAL TRAINEES

A. SEMINARS AND CAMPUS VISITS. Every predominantly minority college and university in Mississippi and most in the surrounding states have been visited by an EPSCoR preceptor in attempts to recruit minorities into the program. The DOE EPSCoR Traineeship Program has been discussed with faculty and potential graduate students during these visits.

B. DISCUSSIONS WITH PREVIOUS RESEARCH COLLABORATORS. Several of the preceptors have had long established relationships with faculty at the Bachelors granting colleges and universities around the country. Informal one-on-one discussions about the DOE EPSCoR traineeships have occurred, with good results!

C. ADVERTISEMENTS IN PROFESSIONAL JOURNALS. Advertisements in the appropriate national journals were submitted in the first annual report.

VI. INFORMATION ABOUT THE TRAINEES CURRENTLY INVOLVED IN THE PROJECT

The credentials of more than fifty candidates were considered for the traineeships of the Mississippi DOE EPSCoR Project.

At the present time, fifteen trainees are in place. A brief academic profile of the trainees is provided in Table One. Twenty-five percent of the current trainees are women, and 35% are black, evidencing a strong interest in energy research and the Mississippi DOE EPSCoR activity from underrepresented segments of the scientific higher education population. These high percentages also indicate the success with which the Mississippi DOE EPSCoR Traineeship Program is reaching these underrepresented populations. Progress reports from the trainees are provided in Appendix I.

VII. FAVORABLE DEVELOPMENTS DUE TO THE TRAINEESHIP PROJECT

A. VISITING THE CAMPUSES OF THE PARTICIPATING FACULTY PRECEPTORS. The project director, in November, 1992, visited each of the participating MRC campuses to discuss the objectives and the specific goals of the project with each of the faculty preceptors. Many of the individual preceptors used the visit to review their facilities and their research projects with the project director and to discuss specific problems related to the initiation of each traineeship project.

B. SYMBIOSIS IN FOSSIL FUEL BENEFICIATIONS. During each campus visit, the Fossil Fuel participants met together to develop a symbiotic major theme project while utilizing the characterization expertise of some and the fuel beneficiation

expertise of others. Emerging from these discussions was a nationally competitive project involving at least six experts -- Cannon, Hussein, Ward, Chen, Cook and Wertz -- all of whom were in Mississippi and none of whom were professionally acquainted with their colleagues at the other MRC campuses. This group plans to submit a major proposal soon!

C. TRAINEE PRACTICUMS. During this second year, practicums were taken at National Wetlands Research Center, American Congress of Surveying and Mapping, Pittsburgh Energy Technology Center, Kentucky Center for Applied Energy Research, Mississippi Power Company, Argonne National Laboratory, and Exxon Energy Research Laboratory, Cyanobacteria Workshop, and the National Institutes of Health.

D. SOME FORTUNATE OCCURRENCES. 1. One preceptor has been able to make a "double use" of the trainee stipend. In this situation, a terminal year doctoral candidate is being supported at a time when it is critical that he have maximum laboratory time (which the traineeship provides). The preceptor has, however, used the availability of the traineeship in the "near future" to attract an excellent student to his university who will be joining this research group in Fall, 1992. 2. Quotes from Preceptors. (a) "Without the DOE EPSCoR funds, it would have been impossible to attract a student of *****'s caliber to our program. (b) The project is off and running with a very positive start -- the organisms now in hand show great potential. Already publications and presentations to internationally important audiences have begun. Shown in Appendix I are those which have been accepted to date (including some galley proofs, etc.)

The first graduation has occurred. Mr. Robert F. Tavlin has completed the M.S. program in chemical engineering at the University of Mississippi.

VIII. CURRENT PROBLEMS AND/OR UNUSUAL DEVELOPMENTS

Timing was a problem for some of the preceptors during the first year of the project. Availability of stipend support on October 1, precluded project involvement of trainees on a full-time basis during the Fall, 1991, semester because the potential trainees were committed to other activities. Several of the preceptors (see below) were fortunate enough to be able to recruit a trainee for the start of the Spring, 1992, semester. The problem mentioned above has no effect during our second year of operation.

During the initial period of the project, two of the faculty preceptors -- Dr. Cass Parker and Dr. William Lupton -- resigned their positions and left this

project. Dr. Wedad Hussein replaced Parker, and Dr. G. S. Jung replaced Lupton. Dr. Hussein, in the Fossil Fuel Pollutants cluster, has introduced the technique of bio-remediation of coal into the overall project theme and has already selected a trainee. Dr. Jung has also selected a trainee and developed a project which compliments other activities in the area of computer pattern recognition applied to energy research.

Dr. David Miller, a preceptor (jointly with Dr. King) and the cluster leader for the Power Systems and Conservation cluster, has retired. Dr. King has assumed his role as cluster leader.

One serious problem deals with insufficient funds for travel and housing for the trainee during the practicum experience.

The Mississippi DOE EPSCoR award was split into sixteen traineeships, here has been minimal implementation funding for most of the projects. However, because each of the trainees has entered a functioning research environment, and the minimal start-up funds (ca. \$4,000 per trainee per year) has not presented an insurmountable problem.

APPENDIX I

PROGRESS REPORTS FOR THE SECOND YEAR OF THE DOE EPSCoR MISSISSIPPI GRADUATE TRAINEESHIP PROJECT

OCTOBER 1, 1992 - SEPTEMBER 30, 1993

I. 1. FOSSIL FUEL POLLUTANTS

QUANTITATIVE ANALYSIS OF SULFUR IN COALS BY WAVELENGTH DISPERSIVE X-RAY FLUORESCENCE SPECTROMETER

Progress Report for Charles Smithhart
(D. L. Wertz, Preceptor)

Efforts continue in achieving the project's goal of developing methods for quantitative elemental and oxidation state analysis of sulfur in coals and coal products by wavelength-dispersive X-ray fluorescence spectrometry. A new transmission-fluorescence technique which compensates for matrix-absorption effects using sub-critically thick briquettes of both raw coal and coal suspended in various binders is currently under investigation. An experimental protocol for minimizing the anomalous interference effect of calcium x-ray emissions on phosphorus has been employed which uses a combination of electronic pulse-height rejection and monochromator optimization. The spectrometer's stability and precision have been verified for empirical quantitative sulfur analysis by the standard addition method, using NIST reference coal 1632b; the relative average deviation percentage for the sulfur response was found to be in the range %0.5 - %0.8. Absolute accuracy by this method is within the quoted deviation provided by NIST. Much of the work was done in collaboration with scientists involved in the Mississippi project or with scientists from other DOE laboratories.

Future work will involve refining the transmission-fluorescence technique using coals from the Argonne Coal Sample Program. This data will be ultimately used in the doctoral dissertation.

One publication and three presentations at National meetings have resulted so far from this work. Three more manuscripts have been submitted for publication.

The practicum was split between the Pittsburgh Energy Technology Center and the Kentucky Center for Applied Energy Research.

DOE-EPSCoR Traineeship Program, Robert L. Cook

"On-Line Analysis of Pollutants from Combustion Driven Facilities by
Fourier Transform Infrared Spectroscopy"

Trainee: L. Meschelle Jacobs

Fourier transform infrared (FTIR) spectroscopy is becoming recognized as a reliable tool for measuring trace-level gas concentrations. The purpose of this work is the development of an on-line FTIR system for the accurate monitoring of chlorinated hydrocarbons resulting from combustion. Quantitative spectroscopy studies have been performed at a path length of 19m.

The vacuum system was altered to accommodate introduction of liquid samples, under vacuum, into the multi-path absorption cell (white cell). The vacuum system now has four ports equipped with test tubes, and one port for gas cylinders.

At this point, absorption coefficients and detection limits have been determined for carbon tetrachloride, chloroform, methylene chloride, 1,2- - dichloroethane, freon-22 (chlorodifluoromethane), chlorobenzene, benzene, and carbon monoxide. Determination of absorption coefficients of other compounds is on-going. A library of spectral data is also being compiled.

Search routines for qualitative analysis of unknown mixtures have been evaluated using a five-component mixture. The reverse-peak search has repeatedly proven to be the most reliable assignment routine. A software routine that quantifies multicomponent samples via principle component analysis or partial least squares is currently being studied for applicability in the determination of chlorinated-gas pollutants.

A number of relevant journal articles have been found and organized into an accessible form.

A STUDY OF RECOMBINANTLY MODIFIED ORGANISMS
FOR HEAVY METAL DETOXIFICATION
(Patricia McCormick, graduate student for Gordon Cannon)

Increasing levels of heavy metal contamination within the environment have led researchers to search for economical and feasible methods to reduce toxic buildup of these materials. Genetic manipulation of cyanobacteria, organisms that require only sunlight and CO₂ as their basic energy source, may lead to a greatly enhanced ability to produce metallothionein. These low molecular weight, cysteine-rich proteins bind excess metals as a natural detoxification defense in biological systems. The suitability of this system for ecological cleanup is readily apparent.

A naturally competent, unicellular cyanobacterium, *Anacystis*, and the multicellular, filamentous *Spirulina* have been chosen for this work. Vector constructs will be developed in *Anacystis* and used as models for development of a transformation system in *Spirulina*, a cyanobacterium for which the genetics are currently unavailable but eagerly sought. Initial studies assessed natural tolerance levels to zinc, cadmium, and copper. A greater tolerance for zinc (75 μ M for *Anacystis* and 25 μ M for *Spirulina*) was noted, less tolerance for cadmium (4 μ M for both), and greatest sensitivity to copper (2 μ M for both) was determined.

We have obtained cloned copies of the *cupI* gene (for the copper metallothionein) from the yeast, *Saccharomyces cerevisiae*, and the *smtA* gene (a more general metallothionein) from *Anacystis*. These genes have been cloned into cyanobacterial shuttle vectors and transformation studies are currently underway. We are also experimenting with cloning of tandem repeats of the genes, mimicking a natural construct found in yeast that leads to increased production of metallothionein and, therefore, increased metal sequestration.

On-going and future studies therefore include:

a) screening for increased heavy metal tolerance and sequestration following transformation with the metallothionein gene or genes

b) measurement of the levels of metallothionein expression via PAGE electrophoresis

c) examination of codon usage by cyanobacteria to possibly improve expression levels

d) determination of the degree of heavy metal sequestration by the recombinant cyanobacterium through measurement of metal concentration in media before and after growth, as well as measurement of the level of metal in the recovered organism.

Annual Report - July 23, 1993

Nitrous Oxide Formation and Destruction in Fluidized Coal Combustion

Dr. Wei-Yin Chen, Associate Professor
Department of Chemical Engineering, Anderson Hall
University of Mississippi, University, MS 38677
(601)232-5651

Our previous study indicated that coal nitrogen had very similar evolution rate as the carbon oxidation rate under combustion conditions. The delayed nitrogen evolution to HCN is generally considered the major cause of N_2O formation in a circulating fluidized bed. Therefore, knowledge concerning the dynamics of particle size distribution in a fluidized bed is significant to pollutant emissions. In addition, coal fragmentation also profoundly influences combustion efficiency. Our first phase of the program was devoted to the experimental investigation and theoretical analysis of coal fragmentation.

This fragmentation research addresses the experimental screening of potentially important variables and the correlation of the dynamic particle size distribution data with a previously established stochastic model. Parametric examinations were made of the dynamic and final-state size distributions of coal particles in a basket suspended in a 3"-fluidized-sand bed. This fluidized bed provided both rapid heating and quenching. It was accomplished by lowering the basket from and raising the basket into a water-cooled, reversed-gas flow section. The parameters investigated included coal type, temperature, initial size, and oxygen content for the final state; residence time was an additional parameter for the dynamics. Two-level factorial design was adopted in analyzing the final-state distributions. It has revealed that the coal type, oxygen content, and initial particle size affect appreciably the particle multiplication; specifically, higher rank coal, higher oxygen content and larger particles favor the particle multiplication. Nevertheless, it has also been observed that lignite structure is fragile after drying; for example, it breaks up easily along the geological bedding planes after drying at room temperature. Factorial design has indicated some interactions take place among the variables. The interactions between the initial particle size and temperature imply the potential significance of temperature gradient in the particle.

The dynamic data have been analyzed by resorting to the master-equation approach based on the stochastic population balance. The particles have been lumped into a limited number of states representing the different sizes (volumes) of particles. Each particle at state i undergoes fragmentation into two particles at states j and k , where $i=j+k$. The governing equations have been derived from the master equation for means, variances, and covariances of the random variables, each representing the number of particles in an individual state in the system. The transition intensities in the governing equations or model have been recovered by fitting the model to the experimental data. A good agreement has been obtained between the model and data.

An on-line N_2O analyzer (Horiba VIA510) has been ordered through the Associates' Fund of the University of Mississippi. This instrument will be delivered in October, and linked to the reactor for the measurements of rate of N_2O emissions from various coals during the next phase of the program.

Biodegradation of Sulfur in Coal

Dr. Wedad R. Hussein, Preceptor

Second Year Progress Report

<u>Students:</u>	Juanita McDonald	Female, African American February-March, 1992
	Burnell St.Cyr	Male, African American September-December, 1993
	Kenneth Collins	Male, African American June, 1993-present Graduated from JSU, B.S. Chemistry, May, 1993

Strategy Research:

Substituted dibenzothiophene (DBT) is one of the constituents of organic sulfur in coal-network. To start with, two bacterial species, namely, *Thiobacillus thiooxidans* and *Escherichia coli*, strain B will be grown on culture media containing DBT. *E. coli* strain B is a wild strain that can mutate easily with luxurious growth. Hopefully, under the appropriate growth conditions we will be able to induce enzyme systems that are capable of cleaving C-S bonds making sulfur available to S-utilizing bacteria. The final goal is to convert organic sulfur to soluble sulfates that can be easily removed.

Chemicals and bacterial cultures have been ordered. Perhaps, in a month or two they will be here, then we can start experimental work.

Practicum Arrangement:

By the summer of 1994, Kenneth would have gained experience in the area of biodesulfurization of coal, collected some data and have clear direction for his research. Arrangements, then, will be made with the Oak Ridge National Laboratory where this area of research is active.

I. 2. ENHANCED OIL RECOVERY

U.S. DoE EPSCoR

PROGRESS REPORT

JULY 22, 1993

MICROBIAL ENHANCED OIL RECOVERY

Department of Biology
The University of Mississippi
University, MS 38677

EPSCoR Trainee: Mr. Scott Bailey

Preceptor: Dr. Bailey Ward, Professor of Biology

Progress Summary: Mr. Scott Bailey joined the project in August, 1992, and began work on several microbial cultures that already had shown promise for MEOR applications (see September, 1992 Progress Report). Upon close examination, we discovered that several of our potentially superior cultures were mixed cultures. Scott then spent the next few months separating and characterizing the individual cultures for MEOR activity, with emphasis on oil emulsification and ability to grow on oil as a sole carbon and energy source. During this period we also replumbed our gas chromatograph (FID) in preparation for analysis of microbially treated crude oil. The GC analyses give us information on microbial degradation of alkanes (up to about C35). We also are using a gravimetric method for measuring total loss of crude oil resulting from microbial treatment. The method is a modification of the methods developed by the U.S. EPA laboratory, Gulf Breeze, Florida. Total crude-oil loss minus light-fraction loss (GC/FID) will give information on degree of heavy fraction degradation. For possible EOR applications using active cultures, it might be desirable for the microbes to grow on some oil fractions, thereby increasing in number in situ and effecting mobilization of the residual oil for water-flood recovery.

After collecting data on several microbial cultures that appeared to exhibit superior properties, Scott began focussing on a single organism, identified by Biolog® as a Rhodococcus sp. (several of the active cultures appear to be different Rhodococcus sp.), tentatively designated as UMST. The UMST organism is a superior emulsifier of crude oil and also will grow on the oil as a sole carbon source. Scott has characterized the emulsification kinetics, has managed to separate the active component, and now is focussing on characterizing and identifying the chemical nature of the active biosurfactant of UMST, which appears to be a unique kind of water-soluble biopolymer that has high activity on oil emulsification. For some EOR applications, it might be desirable to pre-grow the cultures on an inexpensive organic substrate, then isolate, concentrate, and add the active oil-emulsifying polymer directly to water-flood.

From May 24 to mid-August, Scott was on a student summer internship at the National Institute for Petroleum and Energy Research (NIPER), Bartlesville, Oklahoma, where he worked with Dr. Rebecca Bryant on NIPER MEOR projects. Scott also carried our UMST to Bartlesville, where he was able to make analyses using NIPER instrumentation and facilities not available in our labs.

- a. Presentations by Scott Bailey, Trainee: Seminar entitled "Biosurfactants" presented at NIPER (see b. below), August, 1993
- b. National Laboratory Experience: Scott Bailey was awarded a Summer Internship from May 24 - August 13, 1993, at the National Institute for Petroleum and Energy Research, Bartlesville, OK. At NIPER, Scott worked with Dr. Rebecca Bryant on MEOR projects.
- c. Scott also attended the American Society for Microbiology General Meeting, Atlanta, GA, May 15-20, 1993, where he gathered valuable information on biopolymers of microorganisms, analytical techniques, and research progress by colleagues at national labs.
- d. Trainee: Scott Bailey Gender: male Race: caucasian

TO: Dave Wertz, PI, Univ. of Southern Mississippi
FROM: Al Van Besien, Assoc. Professor, Univ. of Mississippi *AVB*
SUBJECT: DOE/EPSCoR Grant, Progress Report September 1993

Summary of Progress to Date

Due to the late award of the EPSCoR grant, difficulty was experienced in selecting the trainee for the EPSCoR program; selection of Ms Jane Sessions was accomplished in June, 1992. During the period June 1992 to December, 1993, Ms Sessions was given instructions in operation of the geographic information management system (both software and hardware). Since December, various software and hardware problems, primarily in the digitizing tablet but also in the hard drive, have effectively precluded operation of the system. Necessary revisions to the software and purchases of some new items of equipment are expected to have the system fully operational in September.

The trainee has been involved in literature search for selection of the study area and for data sources relative to the GIS development. At the present time, the areas most likely to be selected as the study site are in the northeast quadrant of Mississippi, in the Black Warrior basin, and in the west central portion of the state, where numerous linear features may be interpreted as faults and possible structural traps for hydrocarbon accumulation. Because of the delay in training occasioned by the technical problems in software and hardware, the practicum has been delayed.

DOE Graduate Traineeship
Trainee: Mr. Gary Reid
Preceptor: Dr. David N. Sawyer

Summary Progress Report

To insure a project of high quality, yet able to be completed by the time set for the closing of the Petroleum Engineering Dept. (June 30, 1995), we formed a committee of 4 professors, in addition to Dr. Sawyer, who served as Chairman. Three were from Petroleum and one was from the Geology Department. By meeting frequently with Mr. Reid, we were able to determine:

- 1) Where his skills and knowledge lay
- 2) Which types of projects were the most valuable to (a) CO₂ miscible flooding in Mississippi (b) the increase in Mr. Reid's proficiency as a research engineer
- 3) What additional materials, supplies, parts, etc. would be necessary for the duration of the project.

Since Mississippi has a large natural supply of CO₂ bordering the oil fields, we decided to characterize which oils would be miscible with the Jackson Dome CO₂ and whether or not a valid correlation exists between miscibility and reservoir rock and/or fluid properties. Mr. Reid then reviewed known properties of various reservoirs and made a determination of how many fluid samples would be necessary and chose the reservoirs from which to take these samples. Many were already in our possession. He also ordered (and we have received) all spare parts, supplies, chemicals, etc. necessary to run the experiments.

Mr. Reid has visited the CO₂ production facilities of a major oil company and also two fields where CO₂ is being injected. Since our laboratory has the most modern equipment, I saw very little value in having him visit an out-dated laboratory; however, for purposes of safety, I instructed him to meet with the manufacturer of the equipment and to discuss its operation with technicians and engineers who have run very similar equipment.

Most recently, Mr. Reid has been leak testing individual components of the system. He has also completed an exhaustive literature survey on both laboratory and field operation of CO₂ miscible equipment.

JACKSON STATE UNIVERSITY

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CENTER FOR SPATIAL DATA RESEARCH
AND APPLICATIONS
P. O. Box 18739
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Date: 9/10/93

To: Mr. Dave Wertz
From: Brent Johnson, EPSCoR trainee, Jackson State University
Re : Annual Report, GIS-Based Oil Spill Response Enhancement
System

Recapitulation: The objective of this project is to develop a computerized system to enhance the operations of an oil spill response effort, primarily the land operations, utilizing geographical information system (GIS) technology. The project has been broken into four modules 1. Acquire model of roads systems network 2) Develop scheme for optimum vehicular routing 3) Provide graphical user interface (GUI) to system 4) Output results of analysis both textually and pictorially

ACQUIRE MODEL OF ROADS SYSTEMS NETWORK

Road modelling is being accomplished via nine data sets representing the roads systems across the three contiguous Mississippi Gulf Coast counties--Hancock, Harrison, and Jackson Counties. The road systems being modelled are the primary, secondary, and county roads. In addition to the roads representation, the system of Gulf Coast shipping lanes has been acquired and appended to the overall routing system network.

DEVELOP SCHEME FOR OPTIMUM VEHICULAR ROUTING

In the routing of emergency response vehicles, the "best" path (road sequence) is selected to ensure a timely response to an oil spill occurrence. The "best" travel path is designated as that path meeting certain prescribed criteria, such as that path which allows a travel speed of at least 50 mph, has a weight capacity of at least 50,000 lbs and that doesn't exceed 1.5 hours in travel time. A complete list of attributes has not yet been determined, but a subset of this list has been implemented in the GIS database and some tests have been run against them. Once road characteristics have been assigned, the GIS optimum routing

strategy is able to select an optimum path. With the incorporation of the shipping lanes (which are essentially "roads" in the water) into the routing network, paths may now extend from some point inland, to the coast (presumably to some shipping port) and then offshore.

PROVIDE GUI TO SYSTEM

To maximize system interaction through graphical means, an ARC/INFO module made specifically to facilitate menu-building is being employed. It provides several graphical alternatives to entering commands and options from a command line.

OUTPUT RESULTS OF ANALYSIS BOTH TEXTUALLY AND PICTORIALLY

The GIS provides a procedure for displaying the directions along a path giving source, destination, east-west-north-south variations. There has been an enhancement to the previous ARC/INFO release which gave variations in the direction of a path in terms of left and right. Now, direction variations are given in terms of east-west-north-south.

Progress is being made toward the synthesis of these modules into a single functional unit.

Design and Recombinant Synthesis of a Hydrophobically Associating Polypeptide

Project Summary

Recombinant DNA techniques represent a novel method of producing polypeptide-based polymers with a predetermined primary sequence. The precise control over polymer architecture enables the tailoring of material properties for specific applications including water remediation. Current research goals involve the production of a polypeptide-based polymeric micelle capable of sequestering apolar molecules in an aqueous environment. Additionally, the sequestration properties of these polymeric micelle should be triggerable in response to some environmental stimulus such as pH. Naturally occurring insect apolipoproteins or lipid transport molecules have been chosen as model proteins for the design of a hydrophobically associating polypeptide. Apolipoproteins serve to solubilize and transport apolar diacylglycerols and other lipids in aqueous environments. The apolipoprotein, ApoLp-III from the insects *Manduca sexta* and *Locusta migratoria*, exist as multi-helical structures. These proteins are believed to function by means of a secondary structure rearrangement to interact hydrophobically and electrostatically with apolar lipid particles. A polypeptide, DN3, has been designed to possess multiple amphipathic helices interrupted by highly acidic "turn" regions. Secondary structure rearrangements, in DN3, analogous to those of ApoLp-III should be facilitated by these acidic turn regions in response to pH. The gene synthesized to encode DN3 has been designed such that concatemers consisting of multiple helix-turn regions may be isolated and expressed. Thus polypeptides of various "degrees of polymerization" may be produced.

In the course of the last year, the synthetic gene encoding for DN3 has been synthesized and concatemers ranging from one repeat (87 nucleotides, one helix-one turn) to 115 repeats (approximately 10,000 bp, 115 helix-turns) have been isolated. A segment of DNA encoding for two helix-turn repeats has been successfully ligated into the expression plasmid pT7-7. The sequence of this insert has been confirmed using dideoxy sequencing methods. Whole cell lysates of those cells containing the synthetic gene, when run on an SDS-polyacrylamide gel (SDS-PAGE), possess a unique protein band only after induction. The resulting protein does not migrate at the anticipated molecular weight relative to the protein standard aprotinin (6500 Dal). The anomalous migration of low molecular weight proteins is a well documented phenomenon in SDS-PAGE. This polypeptide resides in the soluble fraction of whole cell lysates, purification of this polypeptide is underway.

Higher molecular weight concatemers of DN3, consisting of 6-7 repeats, have been cloned into the expression plasmid T7-7. Upon dideoxy sequencing, deletions and rearrangements have occurred in all of those clone isolated from the ligation of the higher molecular concatemers. At the present time bacterial strains that contain genetic alterations to minimize genetic recombination and deletions are being employed in an effort to produce clones containing intact concatemers larger than 174 bp.

I. 3. POWER SYSTEMS AND CONSERVATION

ANNUAL REPORT
October 1992 - September 1993

Application of Solid-State Control Components and Neural Networks
for Rapid, Intelligent Series Capacitance Control of Transmission Lines
for Improvement of Power System Stability and Efficiency

Preceptors: Drs. Roger L. King and David B. Miller
Department of Electrical and Computer Engineering
Mississippi State University

Trainee: William C. Grantham, BSEE

The research is focusing on a new system for control of power flow on an electric power transmission system. This year the research emphasis has been on the use of controllers based on Fuzzy Set Theory. The advantage of these new controllers is that they depart from the idea of hard or crisp setpoints and tend to be more flexible controllers. Also, it is possible to develop a fuzzy controller without having a precise mathematical model of the system.

The electric utility industry in the United States is divided into many interconnected areas for the purpose of improved reliability. Each of these areas is responsible for generating enough power to supply its own customers or "native load." By maintaining the generated power equal to the power consumed by the load, the utilities will maintain system frequency at 60 Hz. Under-generation will cause the system frequency to fall while over generation will cause it to rise. Since the loads are constantly changing, the generation level in each area must also be changing to maintain the scheduled frequency. Since the different areas are interconnected, changes in one area will be "felt" by all the other areas that are connected. Therefore, the power flow on the tie-lines used to connect areas are also essential to the control of the generation within an area.

The goal of this year's research was to design a fuzzy controller that would measure the tie-line power flow of the system and the frequency and determine the correct generation response. The design of this controller was accomplished using the Fuzzie PC Based Logic Shell (Version 1.8) by MODICO. The fuzzy controller was tested using a simplified model of an interconnected power system. The results of the test indicate that it is possible to design a fuzzy controller to regulate generation of a power system. Further research in this area should include a more complex real time dynamic model of the system and the controller. A report documenting this research was prepared.

DOE/EPSCoR Traineeship Grant Annual Report: 1992-1993
B. K. Hodge, Professor, Mechanical Engineering, MSU
Carl A. James, DOE EPSCoR Trainee, Mechanical Engineering, MSU

During the Fall 1992 and Spring 1993 Semesters, Mr. Carl James, the Mississippi State University (MSU) Mechanical Engineering Department (ME) EPSCoR Trainee, completed requirements for the Master of Science degree. As planned, on completion of the MS, he started on his PhD program. Without the funds available from this grant, it is doubtful that Mr. James would have attended MSU.

The MSU ME Department DOE/EPSCoR research thrust area is centered around experimental and computational aspects of advanced heat exchanger design and application. The MSU ME DOE/EPSCoR team continued interaction with both industrial and national laboratory contacts in this area. Two members of the team, Taylor and Hodge, have completed two research contracts and are awaiting award of a third from the Energy Systems Division of Argonne National Laboratory.

The MS thesis of Carl James, the DOE/EPSCoR trainee, was based on the second research contract with Argonne. His progress to date in both academic and research endeavors has been outstanding, and he received his MS degree in May 1993. In addition to his thesis, he has co-authored two peer-reviewed technical papers presented at national conferences. Additionally, a slightly revised version of his thesis will be an Argonne National Laboratory technical report, and the two conference papers have been submitted to the peer-reviewed *Journal of Enhanced Heat Transfer*, the premier journal in the subject area.

(a) Publications

1. James, C. A., Hodge, B. K., and Taylor, Robert P., 1993, "A Discrete Element Predictive Method for Two-Dimensional Rib Roughness in Fully-Developed Pipe Flow," presented at the ASME Fluids Engineering Meeting, Washington, DC, 21-24 June, ASME FED-Vol. 150, pp. 83-91.
2. James, C. A., Hodge, B. K., and Taylor, Robert P., 1993, "A Discrete Element Method for the Prediction of Friction and Heat Transfer Characteristics of Two-Dimensional Rib Roughness in Fully-Developed Turbulent Pipe Flow," to be presented at the 1993 National Heat Transfer Conference, Atlanta, GA, 7-10 August.
3. James, C. A., 1993, "Prediction of Friction Factors and Heat Transfer in Rib-Roughened Pipes," MS thesis, Mechanical Engineering Dept., Mississippi State University, Miss. State, MS, May.
4. James, C. A., Hodge, B. K., and Taylor, Robert P., 1993, "Validated Heat Transfer and Pressure Drop Predictions Based on the Discrete Element Method: Phase 2--2-Dimensional Rib Roughness," Energy Systems Division, Argonne National Laboratory, report in press.
5. James, C. A., Hodge, B. K., and Taylor, Robert P., 1993, "A Validated Procedure for the Prediction of Fully-Developed Nusselt Numbers and Friction Factors in Pipe with 2-Dimensional Rib Roughness," submitted for publication in *J. Enhanced Heat Transfer*.

(b) Trainee practicums

Mr. James practicums this year consisted of a visit to Argonne National Laboratory and attendance and participation in the ASME Fluid Engineering Meeting (Washington, DC, June) and the 1993 National Heat Transfer Conference (Atlanta, August). At this stage of his research education process, Mr. James needs to be making national-level contacts and getting acclimated to national-level technical presentations and interactions. His three practicums provided good opportunities for him to initiate this important phase of his technical education.

(c) Mr. Carl James is a Caucasian male.

The MSU ME EPSCoR traineeship program was quite successful during the 1992-93 School Year. The trainee has made excellent academic and research progress. Additionally, his research topic and area of interest complemented the research thrust of the MSU ME DOE/EPSCoR team.

Conservation of Thermal Energy Via Coupled
Conduction, Radiation, and Mass Transfer in Fibrous Insulation

At the completion of the second year of this DOE EPSCoR Traineeship Project the progress has been very good. Dr. J.A. Roux is the preceptor for this project and Mr. Kendall T. Harris is the trainee. Mr. Harris has a B.S. degree from the University of Kansas and is a retired F-14 Navy pilot. Mr. Harris is an African American graduate student from East St. Louis, IL and he brings a record of hard work, commitment to quality, and a sincere scientific interest to this project.

During this second year, experimental data have been recorded for the heat flux through the ceiling of an occupied residence in Northern Mississippi (Oxford, MS). Also relative humidity and temperature measurements were recorded at the top and bottom of the fiberglass insulation batt for R-11, R-19, and R-30 insulation batts. These temperature, relative humidity, and heat flux measurements have shown that the presence of moisture gradients across the insulation for summer conditions have a significant increase on the heat transfer (gain) into a residence during the summer. It is clear that the presence of moisture is hurting energy conservation for both summer and winter conditions.

In addition to the experimental measurements mentioned above, the numerical modeling has also shown good progress. The experimental data measured above were used to begin the validation process of the numerical model. The results of the modeling have been documented two papers [1] and [2].

REFERENCE

1. "Transient Model to Predict Conductive, Radiative Heat Transfer Coupled with Moisture Transport in Attic Insulations," Gorthala, R., Harris, K.T., Roux, J.A., and McCarty, T.A., accepted for publication in the AIAA Journal of Thermophysics and Heat Transfer. (Tentative publications date ---- Vol. 7, No. 4, Oct.-Dec. 1993).
2. "Total Heat Transfer Due to Variation in Fiberglass Insulation Thickness in Attics," Harris, K.T., McCarty, T.A., Roux, J.A., and Gorthala, R., accepted for publication and presentation at the ASME 1993 National Heat Transfer Conference, Atlanta, GA, 8/8/93-8/11/93.

Characterization of Metal Ion Exchanged SiO₂-Filled Perfluorosulfonate Ionomer (*Nanocomposite*) Membranes

Stephen V. Davis and K. A. Mauritz
Department of Polymer Science
University of Southern Mississippi

Organic/inorganic nanocomposite membranes were formulated by means of an acid catalyzed *in situ* sol-gel reaction for tetraethylorthosilicate (TEOS) in perfluorosulfonate (Nafion) ionomer (PFSI) membranes. SiO₂ nanoparticles were grown within the polar ionic clusters of these ionomers. The initial premise of this activity is that the dual phase morphology of Nafion serves as a template to direct the geometrical growth of SiO₂. Initially, membranes were in the SO₃H form prior to the sol-gel reaction. Later, we ion-exchanged the H⁺ form using aqueous metal salts (*e.g.* of Ag⁺, Pt⁺⁺, Cu⁺⁺, and K⁺). These nanocomposites are currently being studied for their gas separation abilities and their possible use as heterogeneous catalysts. Steady state *permeances* which, (assuming uniform SiO₂ distribution throughout the membrane, is equal to permeability) were determined after modifications to our standard gas permeation cells to compensate for swelling of the membranes. Permeation studies indicated a dual mode sorption of gases that diminishes as the SiO₂ content increases. In view of available SAXS data for Nafion, which reveals a microphase separation, the assumption of dual mode sorption is reasonable. Permselectivity of CO₂, Ar, N₂, and He gases was investigated to varying extents for unfilled and composite membranes. Scanning Electron Microscopy (SEM) and Light Microscopy (LM) were used to monitor surface phenomena and to serve as a quality control of prepared membranes. LM revealed surface-attached silica layers whose extent and existence are functions of incorporated counterion. Thermal analyses monitored reaction progress by weight loss (TGA) and fractional change in heat capacity, C_p (DSC). Tensile studies performed on an upgraded Instron 1130 indicated a decrease in strain-at-break, increased strength, and increased initial modulus.

The structure-property characterization studies performed to date suggest the following pattern of silicon oxide incorporation within the membranes. From the increase in permeability at low solids uptake, as well as the increase in tensile elongation-at-break, the silicon oxide phase, existing as independently nucleated particles, increases the free volume available for penetrant flow or molecular reorganization. One might think that the invasive nanoparticles act as structural defects that disturb their local environments with regard to molecular packing efficiency. As the solids uptake increases, both properties tend to decrease, which is believed to be due to the filling up of the free volume created previously. As more SiO₂ is incorporated, interpenetration of the PFSI matrix occurs, causing a drastic change in mechanical properties, *i.e.*, ductile to brittle transition, and a less profound effect on gas permeation. From solid state ²⁹Si NMR spectroscopy, an increase in less connected SiO₄ tetrahedra is suggested as the SiO₂ content increases. This corroborates our earlier assertion that eventually, with increasing SiO₂ content, more linear Si-O-Si-O- chains penetrate the semicrystalline region to link the ionic clusters together.

DOE Graduate Traineeship Preceptors
Progress Report
1992-93

1. Synopsis of project and progress made

In September 1992 a new student came aboard, Mr. Roger Van Carpenter. Van was interested in determining the nitrogen content of various soils in Mississippi. Van wanted to determine if there was a correlation between initial soil nitrogen content and the efficacy of three freshwater microalgae in providing nitrogen (as their biomass decays in soil) to an economic crop such as soybean. This new venture required that we purchase supplies to enable us to collect and assay various soils for their nitrogen content. We also acquired an automated microkjeldal nitrogen analysis system. We were not able to use it because we haven't gotten the digestion unit to prepare samples for the microkjeldal system. My expectation is that we will receive the digestion unit during the Fall 1993.

Van learned the basic microbiological techniques of culturing microalgae and bacteria. This included mastering axenic transferring techniques, cell counting procedures, oxygen determinations, and microalgal nitrogen analysis using wet chemistry techniques. Van worked with *Chlamydomonas* and *Chlorella* as he investigated the natural quantity of nitrogen in these species. Preliminary data suggest that *Chlorella* naturally contains more nitrogen than *Chlamydomonas*. This information helped us design NaCl tolerance experiments to determine which of these species, if any, accumulates more nitrogenous compounds in varying NaCl concentrations. He also assisted in rearranging the laboratory to make it more conducive for microbiological research methodology.

Additionally, we were able to leverage the supply funds to purchase enough research materials for the lab to partially support one additional graduate student, Ms. Kimberly Reed. These materials allowed Ms. Reed to learn and develop the microbiological techniques mentioned above to investigate a problem related to the biofertilizer project to which Van was assigned. She is now looking at the effects of high saline environments on nitrogen and carbohydrate accumulation in *Chlamydomonas*, *Chlorella*, and *Chlorococcum*.

The work performed by Mr. Carpenter was accomplished from September 1992 to December 1992. Early in January 1993 Van left the university and was unable to complete his work. We were not able to replace Van until late spring. At that time we employed Mr. Eric Beasley to work on the project. He continued the experiments started by Van with marginal success. However, Eric was able to attend a Recombinant DNA Methodology & Special Topics in Biotechnology Workshop sponsored by the National Institutes of Health from May 30 - June 5, 1993. This experience helped us consider experiments investigating whether microalgae can be genetically altered to produce more nitrogen in response to NaCl shock. Preliminary experiments are being developed at this time.

We have now employed Mr. Christopher Furdge, a recent graduate from Alcorn State University. Chris began his work mid August, the beginning of the academic year. He has restarted the experiments and we are progressing successfully.

**DATE
FILMED**

12 / 3 / 93

END