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Abstracts of Phase I and Phase II Awards

Small Business Innovation Research Program 1991

SBIR

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ABSTRACTS OF PHASE I AND PHASE II AWARDS

Small Business Innovation Research (SBIR) Program
1991

Office of Research and Development
Office of Exploratory Research
U.S. Environmental Protection Agency

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Introduction

U.S. Environmental Protection Agency
Small Business Innovation Research Program

This brochure contains abstracts of the Phase I awards made in 1991 by the Environmental Protection Agency's (EPA's) Small Business Innovation Research (SBIR) Program. The SBIR Program funds high-risk research in EPA program areas that could lead to significant opportunities and public benefits if the research is successful.

The EPA SBIR Program encourages proposals in advanced application areas in the field of environmental engineering and environmental monitoring instrumentation directly connected to pollution control processes. Objectives of the three-phase program, in addition to supporting high-quality research, include stimulating technological innovation, increasing the commercial applications of EPA supported research, and improving the return on investment from federally funded research for its economic and social benefits to the nation.

The SBIR Program is highly competitive. In 1991, the SBIR Program received 367 Phase I proposals which resulted in 31 awards. Phase I provides up to $50,000 for six months to determine, as much as possible within these limitations, whether their research idea appears technically feasible, and whether the small firm can do high-quality research. If the project achieves these goals sufficiently, and excels competitively, this then justifies greater government support in Phase II. The Phase I final report serves as a base for follow-on funding commitment discussions assisting in ascertaining success.

Phase II is the principal research effort for those projects that appear most promising after the first Phase and averages $150,000 for a period of one to two years.

In 1991, the 14 Phase II awards were selected from 30 Phase II proposals resulting from the 32 Phase I awards made in 1990.

Phase III is the product (or process) development phase and involves follow-on nonfederal funding, such as from venture capital or large industrial firms, to pursue potential commercial applications of the government-funded research. No SBIR funds are provided in Phase III.

Donald F. Carey, SBIR Program Manager
U.S. Environmental Protection Agency
Office of Exploratory Research (RD-675)
401 M Street, SW
Washington, DC 20460
(202) 260-7473

1991 PHASE I ABSTRACTS

Topic A:

Drinking Water Treatment

1. *A New Control/Optimization Instrument for Coagulation Management*

Clear Corporation Enterprises, Inc.
1750 30th Street, #605
Boulder, CO 80301
(303) 530-5686
Roger M. Jorden, Principal Investigator
EPA Region 8 Amount: $50,000

Safe Drinking Water Act requirements will soon mandate improved performance in drinking water purification plants nationally for both turbidity (potential disease transmitting particles) and for disinfection byproducts control (potential carcinogens). Improved chemical coagulation dose and optimization are the first line of defense for achieving both of these objectives simultaneously in existing filtration plants. Present day instrumentation and procedures are woefully inadequate. Streaming current detectors cannot be calibrated to a known reference and require highly skilled technicians to set and maintain control on course. Optimization with the jar test, a trusted standard, is skill and labor intensive, and is too insensitive for many modern water treatment plants.

A fiber optical particle analyzer (FOPA) is a new sensor that is used to measure two independent coagulation responses; colloid charge and floc rate. A dual-sensor instrument, interfaced to a computer, is potentially capable of performing both the needed functions of control and optimization in an automated fashion. The device is potentially rapid, and "smart" because it is based upon unique properties of the coagulation process. Clear Corporation Enterprises, Inc.'s, objective is to evaluate the feasibility of this new control/optimization concept using dual probes. Major questions addressed are: (1) how is the probe best configured to achieve automated, dedicated, closed-loop, on-line control, (2) how is a second version of the probe best configured to achieve automated optimization analysis, (3) can these dual probes truly be used to "help" each other, and (4) can this device address the pressing new regulatory drinking water requirements to both reduce particles (turbidity) and a portion of organic precursors leading to disinfection byproducts.

The proposed new intelligent, control/optimization instrument is attractive because it could potentially reduce operator training demands and work load for this uniquely most critical water treatment plant operating variable—coagulation chemistry. Unlike streaming current, this device is based on chemical equivalents and as such should provide a common reference and thread to greatly simplify coagulation so that it can be more effectively manipulated at existing and new facilities.

2. *New Sorbents for Trace Heavy Metal Removal from Drinking Water*

ICET, Inc.
916 Pleasant Street, #12
Norwood, MA 02062
(617) 769-6064
Shantha Sarangapani, Principal Investigator
EPA Region 1 Amount: $50,000

New ideas are presented on the covalent attachment of chelating functionalities to a common, inexpensive sorbent material, which can then complex heavy metal ions irreversibly. The efficient removal of lead, cadmium, chromium, mercury, zinc, nickel, cobalt, iron, and copper is anticipated. The covalently attached ligands are expected to be stable towards hydrolysis and pH variations. The capacity of the chemically modified sorbent materials will be evaluated for the above-mentioned heavy metal ions in the presence of calcium and magnesium ions and for simulated water samples. The sorbent material before and after sorption will be examined by neutron activation analysis, and the eluted water will be analyzed by Inductively Coupled Plasma Mass Spectrometry.

Topic B:

Municipal and Industrial Waste Water Treatment and Pollution Control

3. *Automated ORP Process Control for an Oxidation Ditch Internal Anoxic Mixing System*

Gray & Osborne Consulting Engineers, Inc.
P.O. Box 2069
Yakima, WA 98907
(509) 453-4833
Thomas E. Coleman, Principal Investigator
EPA Region 10 Amount: $50,000

In September of 1990, a submersible mixer was installed in the oxidation ditch at the Grand Coulee, Washington, wastewater treatment facilities. This mixer makes it possible to maintain mixing with the brush rotor aerators off, thereby creating anoxic conditions in the ditch. The potential advantages of this process modification include enhanced nutrient removal, filamentous sludge bulking control, and energy savings. The process is based on a strategy that maximizes the use of influent soluble BOD (SBOD) under anoxic conditions. Under anoxic conditions, only non-filamentous bacteria use nitrate in place of oxygen, and thus the process "selects" against filamentous organisms, while at the same time reducing total nitrogen and reducing aeration energy requirements. Preliminary empirical observations at Grand Coulee have been encouraging; however, the key to realizing the full potential of this process and making widespread application practical and cost-effective is the development of an automatic control system.

The focus of this proposal will be to conduct the basic research necessary to investigate the feasibility of using oxidation-reduction potential (ORP) as an on-line process variable in the automated control of the anoxic mixing system. The automated control system would make the application of this relatively simple technology feasible for a large number of existing oxidation ditch plants. This would be of particular benefit to small municipalities that may lack highly skilled operating personnel and the technical support from vendors and service technicians that are available in larger communities.

4. *Offgas Recycle for Enhanced VOC Biodegradation—An Innovative VOC Control Strategy*

Eckenfelder, Inc.
227 French Landing Drive
Nashville, TN 37228
(615) 255-2288
W. W. Eckenfelder, Principal Investigator
EPA Region 4 Amount: $49,800

The Phase I research will complete development of a mathematical model and conduct continuous flow bench-scale studies to evaluate the feasibility and applicability of a proposed alternative offgas VOC control strategy. The proposed system utilized offgas capture from wastewater treatment and storage units for recycle to an aerobic biological treatment process. The recycled gas phase will increase the biomass-VOC contact time and the mass of VOC removed by the biodegradation mechanism. This will reduce the net VOC mass that is volatilized and ultimately discharged in the waste gas. The proposed treatment scheme will thereby reduce the offgas volume and VOC load that requires treatment and will result in potentially significant savings in capital and operating costs. The offgas recycle system may be applied as either a stand-alone or supplemental VOC control strategy. It requires a wastestream that contains VOCs and sufficient organic substrate to support a biological treatment process. These conditions typically exist for the above regulated industries which have also installed conventional biological treatment facilities for wastewater management.

Topic C:

Biological Sludge Treatment for Improved Handling and Disposal

5. *Improved Anaerobic Digestion Through Biological Enhancement*

Western Environmental Engineers
1235 East Fourth Avenue
Olympia, WA 98506
(206) 357-9000
Dennis Burke, Principal Investigator
EPA Region 10 Amount: $48,837

The proposed anaerobic digestion process improvement will provide a means to separate anaerobic bacteria from the digester supernatant and recycle those bacteria to the anaerobic reactor. The process improvement will thus allow for the maintenance of high concentrations of anaerobic bacteria within the reactor. Solids retention times are expected to be increased substantially. As a result, the hydraulic retention time is expected to be considerably reduced. This research will investigate alternative methods of separating anaerobic bacteria from digester supernatant.

Topic D:

Solid and Hazardous Waste Disposal

6. *Safe, Environmentally Acceptable Resources Recovery from Oil Refinery Sludge*

Calderon Energy Company of Bowling Green, Inc.
P.O. Box 126
Bowling Green, OH 43402
(419) 354-4632
Albert Calderon, Principal Investigator
EPA Region 5 Amount: $49,724

Petroleum refineries are unavoidably generating waste streams of oil sludge in the amount of approximately 30,000 tons per year per refinery. The waste stream com-

prises sediment from storage tanks, bottoms from distillation units, spent catalyst, and waste water. Disposal of this refinery sludge is a challenge to the petroleum industry.

Calderon Energy Company of Bowling Green, Inc., believes it will be possible to confirm the feasibility of recovering clean energy from refinery sludge in an environmentally acceptable manner by mixing it with the bituminous coal being processed through the Calderon Coal Conversion System Process Development Unit (PDU) now in operation in Alliance, Ohio. By measuring and analyzing the coal and sludge entering, and products, byproducts, and emissions leaving the PDU, it will be possible to confirm the following objectives: (1) conversion of refinery sludge to a valuable byproduct, (2) meeting EPA regulations for solid, liquid, and gaseous emissions, and (3) optimization of the process for Phase II and collection of accurate capital and operating cost data.

7. Color Sorting of Post-Consumer Glass and Plastic Containers to Improve Their Recyclability

National Recovery Technologies, Inc.
566 Mainstream Drive
Nashville, TN 37209-1223
(615) 329-9088
Edward J. Sommer, Jr., Principal Investigator
EPA Region 4 Amount: $50,000

Many U.S. municipalities and communities are integrating recycling programs in the management of their solid waste in order to minimize landfill requirements. The success of these recycling programs is strongly dependent upon the marketability of the materials set aside from the waste stream for recycling. The requirements for marketing recycled glass are well established and are highly dependent upon color sorting of the glass. Post-consumer plastics recycling is in its infancy and is experiencing rapid growth. Plastics container manufacturers and other users of recycled resins have stated that color sorting of post-consumer plastic containers can significantly expand the marketability of resins derived from these containers. Color sorting of glass and plastics containers for recycling is currently done by manual handsorting. The objective of the proposed Phase I research is to determine the feasibility for developing an automated color sorting process for post-consumer glass and plastic containers.

8. Recycling of Polypropylene Carpet Waste into Polyester Carpet Backcoating

Hoyle Associates
631 Stevens Street
Lowell, MA 01851
(508) 459-3200
Albert G. Hoyle, Principal Investigator
EPA Region 1 Amount: $49,600

In the manufacture of cross-lapped, needlepunched, polypropylene, pile-surfaced carpeting, there is unavoidable edge trim waste due to the inherent nature of the cross-lapping and needlepunching processes. This waste in its present form is useless to anyone and is presently being disposed of by dumping into a landfill site by a disposal company. Typical small businesses have to pay to have this waste removed and lose monthly at least $12,500 in fiber and backcoating as a result of this waste disposal. The disposal material decreases available landfill capacity by about 10,000 pounds per month (the amount of waste generated). In this project, Hoyle Associates propose to find the means to convert this waste into granular or fibrillar material which could be used as a heat-reactive backcoating binder for polyester needlepunched carpeting also manufactured by a typical small business in this market.

The waste carpeting, when converted into granular or fibrillar form, could be utilized in backcoating as follows: (1) applying it to the back of polyester carpeting, heating to melt the polypropylene, then smoothing and resolidifying the molten material as it leaves the heat source, and (2) melting it and applying to the back of polyester carpeting while in a molten state.

Topic E:

In Situ Treatment Technologies for Hazardous and Toxic Waste at Superfund Sites

9. Degradation of Organopollutants by Phanerochaete chrysosporium

Tienzyme, Inc.
123 Coal Alley
State College, PA 16801
(814) 238-6028
Susan Myer, Principal Investigator
EPA Region 3 Amount: $49,762

There is presently widespread interest in using the lignin-degrading fungus *Phanerochaete chrysosporium* and its enzymes (ligninases) for degradation of environmental pollutants. This fungus possesses a very nonspecific oxidation system capable of degrading a large number of compounds to the level of carbon dioxide. The synthesis of this degradation system is triggered by starvation of the fungus for nutrient nitrogen and carbon. Herein lies the major limitation in practical utilization of this fungus. The rate of biodegradation is very low and the production of degradative enzymes such as the ligninases is very low. Tienzyme, Inc., has developed a selection procedure for isolation of mutants which overproduce the ligninases in addition to being able to degrade organopollutants under conditions of nutrient supplementation. The present proposal is aimed at characterizing these mutants for their biodegrading activity and to further isolate other mutants with superior phenotypes.

10. Effects of Cosolvent Additions on the Biodegradability of High Molecular Weight PAH Compounds in Soil

BioTrol, Inc.
11 Peavey Road
Chaska, MN 55318
(612) 448-2515
Durell C. Dobbins, Principal Investigator
EPA Region 5 Amount: $49,550

Addition of cosolvents to water increases the solubility of hydrophobic contaminants by shifting the adsorption equilibrium to favor higher aqueous phase concentrations. Increasing their water solubility makes contaminants more accessible for biodegradation. While it is often speculated that low rates or lack of biodegradation is caused by low aqueous solubility, no studies have been performed to date to determine whether cosolvents can elicit a biodegradation response in samples that were presumably sorption limited. The proposed study will determine the effects of cosolvents on biodegradation of high molecular weight polynuclear aromatic hydrocarbons in samples where no biodegradation was previously observable, presumably due to organic-phase partitioning. The results of the study will theoretically provide a new cosolvent-enhanced bioremediation procedure that is economically advantageous over alternative technologies where bioremediation alone is inadequate to achieve assigned cleanup criteria.

Topic F:

Innovative Restoration Technologies Removing Heavy Metals at Superfund Sites

11. Heavy Metal Removal and Recovery with a Natural Zeolite Continuous Ion Exchange Thermal Multicomponent Fractionator

Boulder Innovative Technologies
1930 Central Avenue, Suite B-1
Boulder, CO 80301
(303) 440-8722
Richard D. Andrews, Principal Investigator
EPA Region 8 Amount: $32,628

Ion exchange is an attractive technology for removal of heavy metals from water and wastewaters, but it is commonly found to be uneconomical due to the high cost of chemicals and disposal of the brines or secondary wastes generated. Several improvements to this technology are proposed to allow ion exchange to be more widely applied to the removal of toxic heavy metals at Superfund sites and in other situations involving heavy metal contamination of water and ground water such as mine drainages and industrial wastewaters.

The proposed technology will use an inexpensive naturally occurring ion exchange mineral which costs 10 to 30 times less than conventional ion exchange resins. In addition, a continuous treatment system will be investigated which uses no chemicals for eluting the metals from the exchanger as do virtually all current ion exchange systems. It will use low level thermal driving force. Other innovations will be involved which will allow the separate recovery of concentrated single metal products.

12. Detoxification of Acid Mine Drainage Using High Performance Chelation Technology

ChromatoChem, Inc.
2837 Fort Missoula Road
Missoula, MT 59801
(406) 721-5897
Richard F. Hammen, Principal Investigator
EPA Region 8 Amount: $50,000

The abandoned Berkeley Pit Copper mine site in Butte, Montana, is a major component of the Butte Silverbow Creek Superfund site. It consists of several billion gallons of acid (pH 2-3) mine drainage that is contaminated with toxic levels of a variety of heavy metals, arsenic, and sulfuric acid. The flow of contaminated water into the pit is about 7 million gallons per day. ChromatoChem, Inc., and its collaborators at the University of Montana, have developed a High Performance Chelation Chromatography (HPCC) system that effectively removes the heavy metals and arsenic while increasing the pH of the drainage by 2-3 logs. The system produces water that has less than 1 part/million of toxic metals and affords at least a 20-fold concentration of the metals, making recovery and sale of metals possible. In addition, the differing binding constants of the various metal species for the affinity support allow for differential elution of the metals from the affinity support, increasing their value. This proposal will demonstrate that the process can be "scaled up " by using a HPCC column that can process 4 gallons of acid mine water/minute. Studies will be performed to determine the capacity and durability of the column and to maximize the differential elution of various metal species from the column. The HPCC system offers a method to economically "detoxify" vast quantities of acid mine drainage while recovering valuable metals to help defray the expense of operation.

13. Emulsion Liquid Membrane Extraction of Chromium(VI) from Superfund Sites

TDA Research, Inc.
12421 West T Avenue, #6
Wheat Ridge, CO 80033
(303) 422-7953
John Wright, Principal Investigator
EPA Region 8 Amount: $50,000

Chromium contamination is present at over one-half of the Superfund Sites. Chromium(VI) is a strong oxidizer, toxic, carcinogenic, and is particularly difficult to manage because chromium is usually present as an anion. It has

little interaction with the soil, resulting in widespread ground-water contamination, and it cannot be treated by conventional processes which are designed to remove cations. Conventional processes for chromium removal (reduction followed by precipitation) are very expensive for the dilute streams typical of ground-water contamination. Therefore, TDA Research proposes the use of Emulsion Liquid Membranes (ELM) to preconcentrate chromium contaminated water, which could result from pump-and-treat, *in situ* soil washing, for on-site extraction. By combining both a complexing and stripping agent in a single unit operation, ELM is capable of concentrating chromium by a factor of greater than 1000. In Phase I, TDA Research would develop a suitable emulsion (solvent, complexing agent, surfactant, and stripping agent), conduct experiments to demonstrate process feasibility, and carry out economic analyses to compare TDA Research's ELM process with other competing chromium concentration and/or removal processes.

Topic G:

Control of Acid Rain Precursors

14. Reduction of Sulfur Dioxide Emissions from Smelter Ovens

Membrane Technology and Research, Inc.
1360 Willow Road, Suite 103
Menlo Park, CA 94025
(415) 328-2228
J. G. Wijmans, Principal Investigator
EPA Region 9 Amount: $50,000

Sulfur dioxide and nitrogen oxides are the chief precursors of acid rain, and their continued emission into the atmosphere has become a global concern. It is estimated that 23.4 million tons are emitted from industrial processes yearly, mainly from nonferrous metal smelting operations. Nonferrous metals, including copper, nickel, zinc, lead, and molybdenum, are mined as metal sulfides, and the metal is liberated by roasting the sulfides in a smelter oven. The smelter oven is fed with air or oxygen-enriched air and produces an offgas containing large amounts of sulfur dioxide.

Membrane Technology and Research, Inc., has developed a class of membranes that is extremely selective for sulfur dioxide over other gases. In the Phase I program, a laboratory system that includes a spiral-wound module containing the new membrane will be tested for its sulfur dioxide removal capability. An application study will be performed to identify the most efficient methods to improve sulfur dioxide capture.

15. Development of Regenerable Hot-Gas Desulfurization Sorbents with Improved Pollutant Capture Properties

REMSA, Inc.
P.O. Box 189
Hampton, VA 23669
(804) 723-0008
Babafemi A. Adesanya, Principal Investigator
EPA Region 3 Amount: $49,919

Currently, coal and residual oil-fired, steam-electric stations are the largest source of atmospheric sulfur dioxide pollutants. The fractional contribution of sulfur oxide emissions from coal is greater than its fraction from oil used in power generation since the sulfur content of most of the coal is higher. Among the various alternatives that may be used to reduce the sulfur oxide pollution caused by coal-fired power generation plants, the advanced power generation systems based on the integrated combined cycle generators and the molten carbonate fuel cells appear to have great potential. Currently the most advanced hot gas desulfurization process is based on the zinc ferrite sorbent. Recent studies with the zinc titanate sorbent have indicated that it has a higher operating temperature and limits the sulfate formation.

It is believed that the performance of zinc titanate sorbents can be improved by the addition of some promoters to (1) decrease the effluent sulfur levels below 1 ppm, (2) increase elemental sulfur formation during regeneration, (3) facilitate the removal of other contaminants such as organic sulfur compounds and ammonia, and (4) increase the sulfur capture capacity.

The main objective of the proposed research is to study in detail the effect of promoters such as cobalt on zinc-titanium oxide sorbents, namely on their reactivity, stability, and regenerability over the temperature range of 538-870°C. Another factor that will be investigated is the ability of promoters to enhance elemental sulfur formation during regeneration. The results of the proposed investigation will contribute to the commercialization of advanced power generation systems based on the integrated combined cycle generators and the molten carbonate fuel cells which are shown to have thermal efficiencies 15-30% higher than those of current coal-fired power generators.

16. Catalytic Reduction of Nitric Oxide in Net Oxidizing Environments

TDA Research, Inc.
12421 West 49th Avenue, #6
Wheat Ridge, CO 80033
(303) 422-7918
John D. Wright, Principal Investigator
EPA Region 8 Amount: $50,000

Nitrogen oxides (NO and NO_2 or NO_x) are among the most pervasive and difficult emissions to control. Although the decomposition of the major species (NO) is thermody-

namically favored, there are no catalytic processes capable of decomposing NO_x without the addition of a reducing gas. This is because the oxygen produced during the decomposition remains strongly chemisorbed on the catalyst, blocking access of the NO to the catalytic sites and reversibly poisoning the catalyst. Because the reducing gas contributes roughly one-half of the total cleanup cost, a direct catalytic decomposition process which did not require the use of a reducing gas would be a major advance.

TDA Research, Inc., (TDA) proposes to develop substitute zeolites capable of carrying out this reaction. These materials desorb the oxygen at a lower temperature than do other materials, allowing the reaction to proceed. TDA will synthesize substitute zeolites and evaluate the performance of these materials under conditions representative of the exhaust of a gas turbine. Then TDA will develop improved catalysts through manipulation of both the structure and composition of the zeolite, as well as the catalytically active cations.

17. Development of a Novel Duct Injection Process for Simultaneous Removal of SO_2 and NO_x from Power Plant Flue Gases

Fossil Energy Research Corp.
23342 C South Pointe
Laguna Hills, CA 92653
(714) 859-4466
Shaik Qader, Principal Investigator
EPA Region 9 Amount: $49,996

Fossil Energy Research Corporation proposes the development of a novel duct injection process for simultaneous removal of SO_2 and NO_x from coal-fired power plant flue gases. In this process, a mixture of lime and a proprietary sorbent is injected either dry or in the form of a slurry into the flue gas duct between the air preheater and particulate collection device. Lime removes SO_2 and the proprietary sorbent removes NO_x from the flue gas. The NO_x separated from the flue gas is fed back to the boiler where it is reduced to N_2 and H_2O. The unused lime and most of the NO_x sorbent are recovered and recycled. The waste product of the process is a solid residue which contains fly ash and sulfates of calcium. A rough cost estimate showed that the proposed duct injection process has a potential cost advantage of 60% - 70% when compared to other combined SO_2 and NO_x removal processes.

18. An Improved Thermal Selective Noncatalytic NO_x Reduction Technique for Stationary Sources

Reaction Engineering International
44 West 300 South, #21075
Salt Lake City, UT 84101
(801) 328-2002
Michael Heap, Principal Investigator
EPA Region 8 Amount: $49,612

Selective NO reduction techniques involving the injection of nitrogen-containing compounds, such as ammonia, to combustion products over a relatively narrow temperature range have been used for some time. Systems have been installed on gas-, oil-, and coal-fired boilers, on process heaters, and on municipal waste incinerators. However, these systems are limited in their control effectiveness. Thermal selective reduction techniques are effective only in a narrow temperature window. In large systems, this window may shift as the combustor operation changes, reducing effectiveness and assuring ammonia slip. Reaction Engineering International's previous research studies suggest that there are ways to increase the effectiveness of selective thermal reduction techniques.

The objective of the Phase I research program is to extend the understanding of the influence of $CO/H_2/O_2$ concentrations on the reduction of NO_x by selective reducing reagents in order to define the process requirements for the improved control technique.

The specific goals of Phase I are to: (1) conduct a series of parametric experiments under well defined conditions to establish the parameters controlling NO_x reduction when using various nitrogen-reducing reagents in the presence of carbon monoxide, hydrogen, and oxygen; (2) determine the concentrations of CO, N_2O, NO, and reduced nitrogen species in the effluent gases; (3) determine why solid reagents are more effective than gaseous reagents; and (4) modify an existing model to describe the results of the experiments.

19. Catalytic Lean Burn Gasoline Engine

Precision Combustion, Inc.
25 Science Park
New Haven, CT 06511
(203) 786-5215
William C. Pfefferle, Principal Investigator
EPA Region 1 Amount: $49,922

Precision Combustion, Inc., proposes to explore catalytic coatings on the combustion chamber walls of small utility engines in a continuing modification of small gasoline engines so that ultimately they will be able to operate at truly lean fuel/air ratios favoring low HC, CO, and NO_x emissions. The current simplicity of these engines offers some good opportunities for this approach to succeed. A spinoff benefit would likely be technology to similarly modify the more-complex automotive Otto-cycle engine by compiling research data on the effect of catalytic surfaces on engine performance and emissions.

In Phase I, small engine testing in a well-instrumented engine test cell will explore this catalytic lean burn concept on a four-stroke engine. In Phase II, the concept would be carried forward to engine optimization.

Topic I:

Air Pollution Control

20. Advanced Scrubbing Systems for Removing VOCs from Air

Membrane Technology and Research, Inc.
1360 Willow Road, Suite 103
Menlo Park, CA 94025
(415) 328-2228
Amulya Athayde, Principal Investigator
EPA Region 9 Amount: $50,000

A new scrubbing process to remove low concentrations of VOC's from air streams has been conceived. The process uses liquid scrubbing media in which VOCs have high solubilities. The VOC-laden scrubbing liquid is regenerated by a membrane pervaporation system producing a clean stream of scrubbing liquid suitable for immediate recycling. The new scrubbing medium would enable a compact, small-volume flow scrubber to be used for many applications where this was not possible previously. The combined scrubbing/pervaporation process would produce a concentrated VOC-containing product stream and a solvent-free air stream; no secondary waste streams are produced. Based on preliminary cost calculations, the process appears likely to be competitive with alternative technologies.

21. Catalytic Adsorbents for the Abatement of Chlorinated Hydrocarbons

Aircor, Inc.
120 B Bloomingdale Avenue
P.O. Box 159
Wayne, PA 19087
(215) 975-9792
E. Robert Becker, Principal Investigator
EPA Region 3 Amount: $50,000

A novel emission control process for chlorinated hydrocarbons produces no toxic or corrosive secondary gases. Catalytic adsorbent materials will be developed to destroy low concentrations of chlorinated hydrocarbon in gaseous effluents without the release of hydrochloric acid and chlorine gas. Instead the adsorbent will fix the chlorine atoms as harmless nonvolatile chloride salt at temperatures well below conventional catalytic incineration. Low temperature operation and nontoxic secondary waste will make this an attractive economical abatement process for chlorinated hydrocarbons.

Chlorinated organics are among the most difficult wastes to destroy, and they constitute a large portion of the VOCs associated with ozone nonabatement. When they are oxidized, hydrochloric acid (HCl) is formed, which retards the catalytic activity of metal catalysts, and it undergoes further oxidation to form chlorine gas (Cl_2). The HCl also attacks incineration equipment. Chlorine and acid resistant catalysts currently used operate at high temperatures and require large amounts of fuel.

The catalytic adsorbent will be produced by forming an active metal oxide in intimate contact with an active limestone surface. The limestone will act as a dispersing medium for the catalyst. Any HCl formed on the catalyst will immediately react with the calcium carbonate (limestone) to regenerate the metal oxides. This stops the HCl from oxidizing to chlorine and results in no free HCl. This is the important novel feature of the process which distinguishes it from conventional catalytic oxidation. The effluent gas from the process contains only water and carbon dioxide.

22. Multi-Vortex System for Recovering Volatile Organic Contaminants from Industrial Gas

Energy Innovations, Inc.
8709 Knight Road
Houston, TX 77054
(713) 790-9892
Meredith C. Gourdine, Principal Investigator
EPA Region 6 Amount: $49,500

More cost effective systems are needed for recovering volatile organic contaminants (VOCs) from industrial exhaust gas. The proposed approach is to cool the gas well below the dew point of the VOCs. Normally, ice and dirt form on the condensing surface, reducing the heat transfer rate, requiring shut-down and preventive maintenance. Energy Innovation, Inc.'s, innovation will eliminate these requirements. Mathematical models will be generated and experiments conducted for verification of the proposed theory.

The object of this research is to demonstrate the feasibility of building a reliable, compact VOC recovery system with a substantial reduction of energy requirements.

23. Advanced Particulate Control Device for High Temperature Flue Gases

LSR Environmental Systems Co.
2352 Main Street (2-A3)
Concord, MA 01742
(508) 897-4345
Leo A. Smolensky, Principal Investigator
EPA Region 1 Amount: $50,000

The removal of fine particulates from flue gas at elevated temperature is a difficult challenge. Solid waste incinerators, for example, can emit more than 0.2 lb/M-BTU of fuel fired. Many of these incinerators have little or no heat recovery and discharge high temperature flue gas to the atmosphere. Collection of the so-called respirable dusts, consisting of particles below about 10 microns is quite difficult in these applications.

The core separator is an innovative, high-efficiency dust collector, which can separate very fine particles. It has the ability to overcome some major limitations inherent in conventional mechanical collectors, namely turbulence and particle reentrainment. It provides high collection effi-

ciency with simple and reliable operation. Proof-of-principle of the core separator has been demonstrated with flow models at ambient temperature. However, a broader Phase I feasibility analysis is needed to demonstrate that the same performance is attainable at high temperature. The feasibility analysis is divided into two areas: (1) construction of a hot model, and (2) experimental testing and data analysis. A prototypical unit is envisioned for Phase II.

24. A Dry Scrubber for Pre-NSPS Boilers

LSR Environmental Systems Co.
2352 Main Street (2-A3)
Concord, MA 01742
(508) 897-4345
Leo A. Smolensky, Principal Investigator
EPA Region 1 Amount: $50,000

A new method for removing acid rain precursors from coal-fired boilers has been conceived. The concept involves a tail-end scrubber retrofit for installation in plants which pre-date the 1970 Clean Air Act. The concept is highly innovative and has many advantages over other sorbent injection processes.

Heterogeneous reactions between SO_2 and calcium-based sorbents are affected by the mass transfer between the two phases and the contacting patterns of the reactants. Fluidized bed systems have been found to be well suited to these reactions because of their turbulent mixing and ability to control gas and particle residence times. A unique type of circulating bed reactor, called a twin scrubber, is proposed for this retrofit application. Some of its advantages include very low space requirements, enhanced mass transfer, absence of a distributor plate, few sorbent injection points, and high turndown. The proposed Phase I program includes a feasibility analysis of this concept.

Topic J:
Waste Reduction and Pollution Prevention

25. Novel Chemical Process for Bleaching De-inked Pulp

Guild Associates, Inc.
4089 North Leap Road
Hilliard, OH 43026
(614) 876-5252
Wayne E. Ballantyne, Principal Investigator
EPA Region 5 Amount: $49,712

The proposal responds to the increasing pressure to recycle paper. Since nonbleached paper uses almost 100% recycle pulp, additional recycling must come from bleaching recycled pulp to be suitable for newsprint and white paper. The objective of the experiments is to demonstrate the feasibility of bleaching recycled pulp with a unique chemical mixture. The experiments will use samples of commercial de-inked pulp and a bench scale reactor to collect data on the increase in brightness with time and chemical concentration. Process calculations predict economic advantages of this process compared to conventional technology. The process should be applicable to existing de-inking plants as an added process step and applicable to new plant construction integrated with the plant design.

Current bleaching chemical cost for recycled pulp is around $20 per ton. The forecast chemical cost for this technology is $2 per ton. This represents annual savings of over $60 million on today's bleached recycled pulp. Since paper recycling is forecast to grow significantly, the savings will be much greater.

26. Environmentally Safer Zinc-Cadmium Alloy Dry Plating as a Substitute for Cadmium Electroplating

IonEdge Corp.
1713 Hull Street
Fort Collins, CO 80526
(303) 223-0665
Mandar Sunthankar, Principal Investigator
EPA Region 8 Amount: $46,918

Cadmium electroplating in cyanide baths is of significant environmental concern. As a consequence, a unique dry plating concept has been developed. Unlike conventional electroplating, this method would use no liquid chemicals. The dry plating concept utilizes a novel vapor deposition technique for cadmium or zinc. To minimize occupational hazards of toxic cadmium, and to accomplish *in situ* cadmium management, a reclaim method was also developed. The use of cadmium in dry plating could be further reduced by substituting a zinc-cadmium alloy for cadmium. The aims of the proposed research in the Phase I are (1) to demonstrate the feasibility of depositing zinc-cadmium alloy of the desired composition using the dry plating technique and (2) to measure the level of cadmium dust release in the environment, if any. If this research indicates acceptable results according to the current standards, further development of the technique would lead to a method which could potentially minimize environmental and occupational hazards of cadmium electroplating.

27. Electrolytic Regeneration of Acid Copper Chloride Etchant

Oxley Research, Inc.
25 Science Park
New Haven, CT 06511
(203) 786-5390
J. E. Oxley, Principal Investigator
EPA Region 1 Amount: $49,985

The proposal concerns development of an electrolytic process for the on-line regeneration of acid cupric chloride etching baths. Chemical regeneration on a batch basis is generally practiced today, utilizing chlorine and/or hydrogen peroxide to re-oxidize the Cu^{+}, formed by the etching process, back to Cu^{2+}. These processes suffer the disadvantage of resulting in a net increase in solution inventory

which must be disposed. Strong environmental and cost incentives exist for development of an efficient electrolytic regeneration process. Phase I will comprise the construction and operation of a flow loop to demonstrate continuous etchant regeneration, maintaining steady state concentrations of $CuCl_2$, CuCl and HCl, with avoidance of the parasitic electrochemical reactions of chlorine and hydrogen evolution. At the same time, cathodically generated copper metal will be extracted from the system, balancing that consumed in the etching process.

28. Elimination of Fertilizer Discharge from Greenhouse and Nursery Container-Grown Plants

Briggs Nursery, Inc.
4407 Henderson Boulevard
Olympia, WA 98501
(206) 352-5405
James A. Robbins, Principal Investigator
EPA Region 10 Amount: $50,000

In the U.S. there are over 24,753 acres of container-grown nursery plants. Reported annual rates of application of nitrogen (N) fertilizer range from 1036 to 4730 pounds of N per acre. Determinations of the environmental fate of the applied nitrogen shows that only 5-8% of the applied nitrogen is incorporated into the plant. The U.S. annual production of 24,753 acres of container-grown woody nursery plants with nitrogen applied at the rate of 1500 pounds per acre yields 37 million pounds of N per year. If 6% of the applied nitrogen is retained by the plant, then over 34 million pounds of N remain as a potential pollutant. Over 48% is leached from the plant container and discharged in the effluent from the container production area. High growth rates of nursery plants are associated with root matrix solutions containing 80-500 mg N/liter; nitrogen concentration of effluent from the root matrix with "best management" practices exceeds 282 mg N as nitrate/liter. The Public Health Service considers 10 mg NO_3-N per liter to be potentially hazardous.

The fertilizer "conserver" is designed to protect dry fertilizer under an inverted, impermeable cup from the mass flow of surface-applied irrigation water or precipitation. The objective of this project is to evaluate the technical feasibility of the fertilizer "conserver" to eliminate fertilizer discharge from a container production system. Proposed experiments are designed to evaluate materials and size of the fertilizer "conserver" that would eliminate fertilizer discharge and yet produce quality plants. The simplicity of the "fertilizer conserver" and anticipated elimination of fertilizer discharge from a container operation suggests rapid acceptance by the greenhouse and nursery industry worldwide.

29. In-Plant Reduction of Hazardous Waste Generation in the Fluorocarbon Industry

Chemical and Metal Industries, Inc.
4701 Dahlia Street
Denver, CO 80216
(303) 320-6151
John F. Elliott, Principal Investigator
EPA Region 8 Amount: $49,876

The fluorocarbon industry in the United States currently generates over 1,200,000 pounds of spent antimony fluorocarbon catalyst annually in producing 1,190 million pounds of fluorocarbons (CFCs, HCFCs, HFCs). This spent catalyst is a mixture of halogenated organic compounds (HOCs), antimony, and arsenic halides. It is extremely hazardous, toxic, and corrosive. It contains at least eight listed "characteristic" wastes (e.g., $CHCl_3$, CCl_4, C_2Cl_6, C_6Cl_6). Ironically, as ozone-damaging, fully halogenated chlorofluorocarbons (CFCs) are replaced by their less damaging or benign cousins, HCFCs and HFCs, spent catalyst generation will increase, since more catalyst is consumed in the production of these replacement species. This material is currently processed in the United States for antimony pentachloride recovery and recycle at an off-site facility.

The proposed Phase I work is aimed at demonstrating a procedure for the on-site handling of the catalyst that will permit the recycling of a major portion of the HOCs as well as the antimony catalyst itself back to the fluorocarbon process. It also incorporates the in-process use of the other contained HOCs and the isolation for sale of perchloroethylene, a byproduct of the process. In this fashion the HOCs that ultimately would constitute an incinerable waste are reduced to only 20% of that separated and incinerated using current technology. The process has the potential for reducing waste generation at the source of one-third that currently achievable using the best current off-site recovery and recycling technology.

Topic K:

Oil Spill Prevention, Cleanup, and Restoration Technology

30. Develop Biodegradable, Non-Toxic, Oleophilic Hydrophobic Sorbent for Oil Spill Cleanup

Sea Sweep, Inc.
3331 South Monaco Parkway, Suite B
Denver, CO 80222
(303) 759-8118
Thomas B. Reed, Principal Investigator
EPA Region 8 Amount: $50,000

Contamination of waters by spilled petroleum products, liquid hydrocarbons, continues to be a frustration to those responsible for oil transport and the environment. Presently, all remediation methods, including natural, chemical, and mechanical, have limitations. In particular, adsorbents that

adsorb oil onto surfaces are difficult to recover and have major disposal problems.

Sea Sweep, Inc., has developed and conducted preliminary tests on an absorbent material, called "Sea Sweep^T". Sea Sweep^T is oleophilic and, therefore, absorbs oil. It is also hydrophobic and floats on water. It is made from sawdust in a thermolytic process and is biodegradable. Particles of Sea Sweep^T can be easily removed from water, or they will be degraded with minimum harm to the environment because the oil is held inside each particle. Preliminary laboratory tests show that no visible oil remains after application of Sea Sweep^T.

The proposal is designed to find (1) the optimum method of preparation of the absorbent for representative oil viscosities, (2) the optimum particle size for absorption of various hydrocarbons, (3) potential toxicity of the absorbent material, and (4) the degree of water contamination remaining after removal of particles saturated with hydrocarbons.

31. A Natural Oat-Derived Oil Spill Dispersant

Basic Bio Systems, Inc.
2837 Fort Missoula Road
Missoula, MT 59801
(406) 728-0260
Richard C. Potter, Principal Investigator
EPA Region 8 Amount: $47,000

Basic Bio Systems, Inc., proposes to investigate a novel approach to oil spill cleanup utilizing a natural, oat-derived dispersant. Proteinaceous oat fractions developed by Basic Bio Systems, Inc. have the ability to absorb several times their weight of a wide range of compounds, including hydrophobic materials such as oils. In addition, these fractions can function as effective emulsifiers, forming emulsions under ambient conditions with low-energy mixing. The combination of these two characteristics allows these materials to function as oil spill dispersants. Placing the oat fractions on an oil slick causes absorption of the oil, producing an *in situ* emulsifiable concentrate. Subsequent wave and current action creates an emulsion, dispersing the oil into the water column.

Optimization of the dispersant type and physical form will be undertaken and comparisons in efficiency made with conventional surfactant dispersants using the Labofina test. Potential advantages of the oat-derived dispersant include low toxicity, ability to disperse "mousse," enhancement of the growth of hydrocarbon-metabolized organisms by providing a nutrient source, and providing an easily handled solid form.

1991 PHASE II ABSTRACTS

Topic B:

Municipal and Industrial Wastewater Treatment and Pollution Control

32. Emulsion Liquid Membrane Extraction of Phenol from Industrial Wastewaters

TDA Research, Inc.
12421 West 49th Avenue, #6
Wheat Ridge, CO 80033
(303) 422-7819
John D. Wright, Principal Investigator
EPA Region 8 Amount: $150,000

Phenolic compounds are the primary wastewater treatment challenge found in the aqueous effluents from petroleum refineries, coal conversion processes, petrochemical production, and the manufacture of phenols and related chemicals. Emulsion liquid membrane (ELM) separations are a developing technology with high potential for cost-effective removal and recovery of phenolic compounds. Unlike the current treatment technologies, ELM processes can almost completely remove phenolics from both high and low concentration feed streams, while producing a concentrated solute level in the stripping phase, simplifying final recovery. Further, ELM offers independent control over the solvent's solubility in water and its affinity for phenol, eliminating the need for a stripping column to clean the wastewater leaving the extractor. As a result, ELM is a much less expensive process for wastewater treatment than solvent extraction, the current technology of choice.

In Phase I, TDA Research, Inc., demonstrated the feasibility of the ELM extraction process. During Phase II, TDA will demonstrate the feasibility of the complete treatment process, including not only extraction, but emulsion coalescence and phase separation. The objectives are to optimize the extraction in a low-cost contacting device, optimize the electrostatic coalescence process, demonstrate the entire system, and use the results of the complete process demonstration as the basis for the detailed design and economic analysis of a full scale treatment plant.

Topic D:

Solid and Hazardous Waste Disposal

33. Innovative Hazardous Fly Ash and Industrial Process Dust Vitrification Technology

Vortec Corporation
3770 Ridge Pike
Collegeville, PA 19426
(215) 489-2255
James G. Hnat, Principal Investigator
EPA Region 3 Amount: $149,754

The disposal of all types of wastes—municipal, medical, and industrial—is a significant and increasing problem facing the world environment today. Most of the waste being generated is currently being landfilled; however, as many as one-third of the currently active landfills could reach capacity in the next four years. As the capacity of the landfills decreases and the landfilling costs increase, incineration becomes an attractive means of volume reduction. However, one byproduct of the incineration process, fly ash, contains a high concentration of heavy metals which may have to be disposed of in hazardous waste landfills at a significant increase in cost to the incinerator operators and, ultimately, the public. Municipal Solid Waste (MSW) incinerators alone produce approximately 450,000 to 800,000 tons of fly ash annually. Disposal of this fly ash in hazardous waste landfills could cost from $100 million to $800 million annually, depending on the location of the landfills.

The development of an advanced fly ash/dust vitrification system is proposed as a means of eliminating the fly ash disposal problem associated with incineration. The technology being proposed is based on advanced in-flight suspension glass melting technology being developed by Vortec Corporation for the U.S. Department of Energy.

Phase I of the program verified the technical and economic feasibility of the Vortec process in producing a vitrified product satisfying the leachability limits of CFR 40 Part 261.24 from an MSW incinerator fly ash/waste glass mixture consisting of 50% waste glass. The primary technical objective of Phase II is to determine the extent to which glass-forming additives can be reduced while still satisfying the leachability requirements specified in CFR 40 Part 261.24. The Phase II effort will include fly ash/waste glass feed stock preparation and analysis, vitrification testing using Vortec's experimental vitrification system, flue gas

emissions analysis, and commercial plant conceptual design.

34. Recycling of Solid, Inorganic, Zinc-Bearing Industrial Process Wastes

Chemical Reclamation Technologies
20749 Parkwood Lane
Strongsville, OH 44136
(216) 572-9225
Michael D. Waite, Principal Investigator
EPA Region 5 Amount: $150,000

Each year many millions of pounds of solid, inorganic waste is generated by zinc processing industries in the USA. In addition to zinc, these wastes typically contain other toxic heavy metals like barium, copper, cobalt, manganese, magnesium, lead, and nickel. Few of these wastes are recycled. Generally they are dumped into either a hazardous waste facility or sanitary land fill.

A recycle technology has been developed by Chemical Reclamation Technologies that is capable of nearly 100% recovery of such wastes. Samples of solid zinc-bearing wastes from zinc phosphate pretreatment, zinc plating, and steelmaking operations have been successfully reclaimed. The process generates two endproducts which are potentially marketable. Both endproducts have wide industrial application. The recovery technology features an electrochemical method of removing iron from the various waste sources. Iron is a major contaminant in nearly all zinc wastes.

The purpose of the Phase II effort is to continue to develop the technology to the point of commercialization. Four principal objectives must be met to accomplish the mission: (1) design and construct a prototype process, (2) pilot operation to determine optimum methods and cost, (3) adaptation of the process to other potential waste sources, and (4) front end engineering.

35. Recovery of Liquid Hazardous Wastes from Carbon Adsorption Steam Regeneration Streams

Membrane Technology and Research, Inc.
1360 Willow Road, Suite 103
Menlo Park, CA 94025
(415) 328-2228
J. G. Wijmans, Principal Investigator
EPA Region 9 Amount: $150,000

Common and particularly troublesome industrial waste streams are those consisting of volatile organic compounds (VOCs), particularly chlorinated solvents and water-miscible, less volatile (hydrophilic) solvents. The presence of the chlorinated solvents makes solvent reclamation very difficult, and the entire stream must often be treated as a hazardous waste and sent to incinerators fitted with appropriate scrubbers for disposal. These streams are commonly produced in regeneration of carbon adsorption beds used to remover VOCs from air, in solvent recycling operations, in surface treatment and coating operations, and in groundwater remediation.

Phase II will involve the application of the membrane process of pervaporation to the removal and concentration of chlorinated solvents and other VOCs from mixed waste streams. The process produces a small chlorinated solvent stream and an aqueous residue stream containing the relatively nonvolatile hydrophobic components which is sent to a conventional treatment system or discharged. In the Phase I program, the process was demonstrated with laboratory-sized membrane modules using water/acetone/methylene chloride mixtures and samples of more complex hazardous waste streams. In the Phase II program, a compact, portable system using industrial-sized modules will be built and operated with solvent mixtures of increasing complexity at Membrane Technology and Research, Inc.'s, (MTR) facilities. Based on the contacts generated during the Phase I program, MTR is confident that a compact, transportable pervaporation unit will receive great interest from potential industrial users, resulting in numerous field tests.

36. Application of Pulse Combustion in Solid and Hazardous Waste Incineration

Sonotech, Inc.
575 Travis Street, NW
Atlanta, GA 30318
(404) 525-8530
Douglas H. Neale, Principal Investigator
EPA Region 4 Amount: $149,942

Sonotech, Inc., in Phase II proposes to build on the success of its Phase I efforts which demonstrated that an incinerator's performance can be improved significantly by retrofitting it with a tunable pulse combustor which excites pulsations inside the incinerator. These pulsations increase the rates of heat, mass, and mixing processes which, in turn, improve the incineration process performance. The Phase I tests, conducted with surrogate wastes, have demonstrated that pulsations decrease exhaust soot emissions, improve high destruction and removal efficiencies (DREs) of principal organic hazardous constituents (POHCs), and improve efficiency of oxygen use. The goal of Phase II will be to obtain additional design data and develop a liquid fuel-fired pulse combustor which are needed for commercialization of the technology with von Roll, a major incinerator systems manufacturer. To meet these goals, Task 1 will determine the benefits of pulse combustion technology in batch type incineration of various surrogate wastes. Task 2 will develop a liquid fuel-fired tunable pulse combustion needed for the commercialization of the technology, and Task 3 will determine the benefits provided by the developed liquid fuel pulse combustor during steady incineration of contaminated liquid fuels which will be also used to fire the pulse combustor. In summary, Phase II will develop an

extensive design and incineration data base, and a liquid fuel-fired pulse tunable combustor needed for commercialization of the developed pulse combustor technology with von Roll under Phase III of this program.

Topic F:

Control of Acid Rain Precursors

37. Dry Scrubbing of SO_x and NO_x Over Lathanide-Oxygen-Sulfur Compounds

ElectroChem, Inc.
400 W. Cummings Park
Woburn, MA 01801
(617) 932-3383
Vinod Jalan, Principal Investigator
EPA Region 1 Amount: $150,000

Over the past decade, there has been a continuing effort by EPA, DOE, GRI, EPRI, and utility companies toward the development of an inexpensive and reliable method for the removal of SO_x and NO_x from combustion gases. Existing processes for the combined removal of SO_x and NO_x have not proven to be particularly effective in meeting cost objectives and current emission standards. Selective catalytic reductions for NO_x removal are reaching current emission standards, but they are prohibitively expensive because of the high initial cost of the catalyst and its replacement.

In Phase I, cerium oxide doped with strontium oxide, calcium oxide, or lanthanum oxide were identified for potential use for the removal of SO_x and NO_x from offgases generated by the combustion of fuels in boilers, internal combustion engines, and from IGCC power plants. These compounds have demonstrated many advantages over the state-of-the-art sorbents, and the potential exists for further improvements. Phase I results also demonstrated that cerium sulfate is effective for the reduction of NO_x using NH_3 as a reductant.

The successful utilization of doped cerium oxide sorbent and cerium sulfate catalyst for combined removal of SO_x and NO_x generated by the combustion of fuels requires additional research and development aimed toward optimizing the process and demonstrating the durability of such sorbents.

Topic H:

Air Pollution Control

38. Reduction of Indoor Air Pollution by Membrane Stripping of Water-Borne Radon Gas

ARETE Technologies
15 Withington Lane
Harvard, MA 01451
(508) 456-3852
Stephen L. Matson, Principal Investigator
EPA Region 1 Amount: $149,951

Radon-222 in indoor air has been identified as a pervasive pollutant and a significant health threat, and release of this volatile gas from water supplies containing elevated radon levels represents a significant source of exposure. The EPA will propose a stringent Maximum Contaminant Level for water-borne radon of 300pCi/L in mid-1991, consistent with the statement of agency personnel that water-borne radon may be responsible for more cancer deaths than all other drinking water contaminants combined.

In Phase I, Arete Technologies, Inc., established the technical and economic feasibility of using a gas/liquid contactor based on hollow-fiber membranes to strip radon from water with ambient air. The technology has significant benefits relative to the conventional approaches for water-borne radon mitigation, namely carbon adsorption and diffused-bubble or shallow-tray aeration.

In the Phase II program, Arete Technologies, Inc., seeks to further improve membrane, module, and system performance. Extended field tests will be conducted at multiple sites to assess potential operational issues, and a prototype membrane stripping system will be designed, constructed, and operated to remove water-borne radon from a household water supply.

39. A Process for Elimination of Paints Emitting Volatile Organic Compounds

JP Laboratories, Inc.
26 Howard Street
Piscataway, NJ 08854
(201) 968-6650
G. N. Patel, Principal Investigator
EPA Region 2 Amount: $149,751

Millions of gallons of solvent-borne paints are used to coat plastic parts used in the automotive industry. The solvent-borne paints emit volatile organic compounds (VOCs). In order to comply with the Clean Air Act, there is a need to make plastics paintable with water-borne paints.

Under the Phase I study, JP Laboratories, Inc., demonstrated that when treated with certain formulations, automotive plastics such as polyurea and SMC (a sheet molding compound), become wettable with water and can be metallized. The wettable and plated plastics can be painted with water-borne paints. The formulations are inexpensive, nontoxic, and nonpolluting. The finish and adhesion of the paints were satisfactory. The formulations/ processes can eliminate VOC emitted by the solvent-borne paints. Under Phase II, the formulations/processes will be optimized, scaled up and field tested.

40. Treatment of CFC and HCFC Emissions

Membrane Technology and Research, Inc.
1360 Willow Road, Suite 103
Menlo Park, CA 94025
(415) 328-2228
J. G. Wijmans, Principal Investigator
EPA Region 9 Amount: $150,000

CFCs emitted as purge streams from large industrial refrigerators are a considerable environmental problem and an economic loss. Membrane vapor recovery systems are able to treat these streams. In the Phase I program, existing membranes were fabricated into high-pressure modules and evaluated with a prototype treatment system. The system was able to recover 99% of the CFC vapors contained in the airstream for reuse in the refrigerator. The system performs better and has a lower cost than alternative processes.

In the Phase II program, Membrane Technology Research, Inc., proposes to completely demonstrate the technology by performing a range of parametric studies on pilot recovery systems and performing reliability studies over six months of continuous operation.

41. Catalytically Stabilized Thermal Incineration of Volatile Organic Compounds

Precision Combustion, Inc.
25 Science Park
New Haven, CT 06511
(203) 786-5215
William Pfefferle, Principal Investigator
EPA Region 1 Amount: $150,000

Catalytically stabilized thermal incineration of volatile organic compounds (VOCs) uses catalytic surface reaction to stabilize lean plug flow radical-enhanced thermal incineration, resulting in ultra-high destruction at low residence time of hazardous organics in any fume or air stream including those laden with particulates (whether organic such as cotton or grain dusts or inorganic submicron particles). Phase I work achieved ultra-high destruction levels of five sample VOCs: methylene chloride, toluene, methyl ethyl ketone, trichloroethylene, and ethyl benzene. Destruction in all tests was beyond detection limits. In the lowest detection limit test, 50 ppmv inlet concentration of methylene chloride was burned in a residence time of 17 milliseconds to below the detection limit of 2 parts per trillion (ptt). The 99.999995+% destruction and removal efficiency (DRE) for a chlorinated inlet starting at a low concentration is unique. Submicron and micron level particulate matter was not a problem in the tests. Separate early-stage modeling underway in an NSF project indicates that this result is a reasonable one to expect from the system and that destruction to sub-ppt level should be feasible even from highly concentrated fumes.

Design work also proceeded integrating this catalytically stabilized thermal incinerator into a gas turbine, with the result that the fuel is converted into high-value electricity. For units of moderate size in most situations, the value of the electricity exceeds all capital and operating costs. For smaller units, the electricity subsidizes the cost, reducing net costs to below the costs of alternate, lower DRE technologies.

In Phase II, Precision Combustion, Inc., will further develop the burner, testing a wider range of conditions and contaminants, demonstrating longer term durability, and finalizing a field unit design to fit into a program such as the Emerging Technologies Program or other field prototype testing.

42. On-Board Generation of Ignition Improvers for Methanol Diesels

TDA Research, Inc.
12421 West 49th Avenue, #6
Wheat Ridge, CO 80033
(303) 422-7819
Michael E. Karpuk, Principal Investigator
EPA Region 8 Amount: $150,000

Methanol-fueled diesel engines are an attractive means of meeting the stringent 1994 diesel particulate standards and are a topic of intense industrial interest. Unfortunately, because methanol's autoignition temperature is high and its ignition delay is long, some means of improving its ignition is required. The best current method, use of high exhaust-gas recirculation with a glow plug assist, reduces fuel economy, increases the complexity and cost of the engine, and increases maintenance costs. A promising solution is on-board generation of the gaseous ignition enhancer dimethyl ether (DME). This system will require minimal modifications to the engine design and will not degrade the thermal efficiency of the engine. In Phase I, TDA Research, Inc., measured the amount of DME required for efficient operation, the effect of DME on the combustion process, and the engine efficiency and emissions of CO, NO_x, and unburned hydrocarbons (HCs) as a function of speed and load. In Phase II, TDA will design and build an on-board reactor for converting methanol to DME and test the complete reactor and reactor control system mounted to a Cummins L-10 heavy-duty diesel engine.

Topic I:
Waste Reduction and Pollution Prevention

43. Valuable Products from Coal Burning Wastes

Science Ventures, Inc.
8909 Complex Drive, Suite E
San Diego, CA 92123
(619) 292-7354
Douglas H. Laird, Principal Investigator
EPA Region 9 Amount: $149,110

Coal combustion flue gas that is desulfurized with lime or limestone results in 30-35 million tons per year of gypsum-like waste. This presents a disposal problem which could be eliminated by conversion into marketable commodities.

Science Ventures, Inc., has been experimenting with a new high-speed chemical process to solve a related environmental problem. Their FLASC process recovers sulfur values from phosphogypsum for recycle to the wet phosphoric acid process. Synthetic aggregate for concrete is produced as well.

The proposed process would use similar entrained, slagging, mildly reducing conditions and equipment to produce cement and sulfuric acid for sale. Some of the coal ash would also be consumed this way.

Very fast conversion rates of these processes promise reduced capital costs per unit of products. In addition, fresh flue gas desulfurization waste requires substantially less fuel to process than natural or other byproduct gypsums.

Phase I crucible tests proved the cement quality to be acceptable and showed the practicality of entrained slagging equipment. Based on the positive Phase I results, Phase II should progress rapidly using existing bench scale apparatus.

44. Suppression of Cyanide Formation in Hall Process Potlining

EMEC Consultants
R.D. 3, Roundtop Road
Export, PA 15632
(412) 325-3260
Rudolf Keller, Principal Investigator
EPA Region 3 Amount: $150,000

Spent potlining from industrial primary aluminum production cells is a designated hazardous material because of its cyanide content. Over 100,000 tons of this material are annually landfilled or temporarily stored in the United States.

It would be desirable to avoid the cyanide formation during operation of the cells. EMEC Consultants proposes to continue investigations of the conditions at which cyanides form and migrate within the cell, to identify possible approaches to suppress cyanide formation, and to conduct experiments on industrial production units to test elements of a proprietary method.

If successful, the project would lead to a cost-effective method to suppress the formation of cyanide in the lining of industrial aluminum production cells.

Topic J:
Oil Spill Prevention, Cleanup, and Restoration Technology

45. Robotic Inspection of Crude Oil Carrier Tanks

American Research Corporation of Virginia
542 First Street
P.O. Box 3406
Radford, VA 24143-3406
(703) 731-0655
R. J. Churchill, Principal Investigator
EPA Region 3 Amount: $150,000

The inspection of very large crude carriers (VLCC) for structural reliability is a critical environmental concern. These large vessels transport crude oil in such quantities that the consequence of an oil spill due to a broken weld would be disastrous. Existing techniques for inspecting VLCC tanks require that the ship be taken out of service and brought to a repair facility where the tanks must be drained and their inner surfaces cleaned before inspection can begin. To reduce the time and cost involved in inspections and to identify damaged regions for effective maintenance, a robotic inspection system will be developed incorporating magnetic eddy current technology and video camera inspection. The program is innovative in providing a time sequence of nondestructive characterization images which can be used to identify growing cracks in VLCC structures. Phase I results show that frequency mixing can enhance the signal-to-noise ratio of fatigue cracks in welded steel, while cross-correlation techniques can be used to align scan images provide a history of damage development.

The Phase II technical objectives include development of eddy current probes, design of remotely operated vehicle correlation techniques for detection of crack growth, and optimization of a proof-of-concept system for Phase III commercialization. Detection of localized damage will be accomplished by segmenting the images into smaller cross-correlation regions for improved resolution. The proposed system will permit more frequent inspections and increase the safety and reliability of carriers operating under extended service.

Alphabetical List of Awardees

Hoyle Associates
631 Stevens Street
Lowell, MA 01851
(508) 459-3200 4

ICET, Inc.
916 Pleasant Street, #12
Norwood, MA 02062
(617) 769-6064 2

IonEdge Corp.
1713 Hull Street
Fort Collins, CO 80526
(303) 223-0665 9

JP Laboratories, Inc.
26 Howard Street
Piscataway, NJ 08854
(201) 968-6650 15

LSR Environmental Systems Co.
2352 Main Street (2-A3)
Concord, MA 01742
(508) 897-4345 ..... 8, 9

Membrane Technology and Research, Inc.
1360 Willow Road, Suite 103
Menlo Park, CA 94025
(415) 328-2228 ..... 6, 8, 14, 16

National Recovery Technologies, Inc.
566 Mainstream Drive
Nashville, TN 37209-1223
(615) 329-9088 4

Oxley Research, Inc.
25 Science Park
New Haven, CT 06511
(203) 786-5390 9

Precision Combustion, Inc.
25 Science Park
New Haven, CT 06511
(203) 786-5215 ..... 7, 16

Reaction Engineering International
44 West 300 South, #21075
Salt Lake City, UT 84101
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REMSA, Inc.
P.O. Box 189
Hampton, VA 23669
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Sea Sweep, Inc.
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Sonotech, Inc.
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TDA Research, Inc.
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