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ABSTRACTS OF PHASE I AND PHASE II AWARDS

Small Business Innovation Research Program
(SBIR)

FISCAL YEAR 1993

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 publication contains abstracts of the Phase I and Phase II awards made in 1993 by the Environmental Protection Agency's (EPA) 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 fields of environmental engineering and environmental monitoring instrumentation, where it is 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 1993, the SBIR Program received 442 Phase I proposals which resulted in 34 awards. Phase I provides up to $50,000 for six months to determine, as much as possible within these limitations, the small firm's concept feasibility and their capability to perform high-quality research. If a Phase I project achieves these goals sufficiently, and excels competitively, larger government support in Phase II is justified. 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 1993, 21 Phase II awards were selected from 41 Phase II proposals resulting from the 41 Phase I awards made in 1992.

Phase III is the product (or process) development phase, which may involve follow-on 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, however, EPA may use non-SBIR funds to support selected SBIR projects if deemed advantageous to the Agency's mission.

Donald F. Carey, Program Manager
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1993 PHASE I ABSTRACTS

TOPIC A: DRINKING WATER TREATMENT

1. Membrane Dissolution of Hydrogen Gas for Nitrate Removal From Drinking Water and Brines

Membran Corporation
1037 10th Avenue, SE
Minneapolis, MN 55414 (EPA Region 5)
(612) 378-2160
Dr. Charles J. Gantzer, Principal Investigator and Business Representative
Amount of Award: $50,000

Nitrate contamination of drinking water supplies is a recognized problem in certain locations of the U.S. Several technologies are capable of removing nitrate. Two promising related technologies are the direct biological denitrification of drinking water and the removal of nitrate by ion exchange with the subsequent removal of the nitrate from the regenerant brine.

Denitrification of drinking water and brines requires the addition of an electron donor, which can either be organic compounds or hydrogen gas. The use of hydrogen offers several operational and economic advantages over the use of organic compounds. The factor limiting hydrogen use is its low solubility, i.e., existing gas-dissolution technologies cannot dissolve high concentrations of hydrogen in a cost effective manner. Membran Corporation's patented membrane gas-dissolution technology provides a cost-effective means for dissolving the hydrogen required for denitrification.

The proposed study examines the technical feasibility of a Membran gas-dissolution device as the hydrogen source for the biological denitrification of drinking water and simulated regeneration brines.

2. Drinking Water Treatment by Directional Freeze Crystallization

Polar Spring Corporation
3501 Edison Way
Menlo Park, CA 94025 (EPA Region 9)
(415) 368-2852
Dr. William M. Conlon, Principal Investigator and Business Representative
Amount of Award: $50,000

Small water systems are increasingly challenged to comply with the Safe Drinking Water Act. Existing technologies impose heavy operational burdens on small systems and provide only narrowly focused solutions.

Polar Spring Corporation proposes to demonstrate the feasibility of Directional Freeze Crystallization (DFC) to significantly reduce the concentration of dissolved solids, organic chemical and particulates. The DFC method is expected to be especially suitable for small water systems because of its modularity, low maintenance, no expendable filters or membranes, and long life-time. Innovative process simplification and thermal optimization would minimize energy consumption. It uses commercially available vapor compression refrigeration equipment for cooling, so reliability is enhanced and field deployment can be accelerated. The DFC process is expected to remove a broad spectrum of contaminants, yet it works without expendable filters or membranes.

Water to be treated would fill a cylinder, and be cooled through the cylinder wall by a refrigerant. Crystals of purified ice would form on the wall, concentrating the contaminants within an unfrozen core. Typically, one-half or more of the water would be crystallized in batches. The liquid core would then be drained from the vessel and the purified ice melted using heat rejected from the refrigerant condenser.

TOPIC B: MUNICIPAL AND INDUSTRIAL WASTE WATER TREATMENT AND POLLUTION CONTROL

3. A Novel Process for Heavy Metal Removal From Industrial Waste Water

LSR Technologies, Inc.
898 Main Street
Acton, MA 01720 (EPA Region 1)
(508) 635-0123
Dr. ZhenWu Lin, Principal Investigator
Mr. S. Ronald Wysk, Business Representative
Amount of Award: $50,000

Protection of ground-water and marine waters is a complex issue and a vital public concern. Once contaminated, it can be technically difficult and enormously expensive to clean up. One way to protect these waters from contamination is through the control of industrial discharges. Often though, control processes are not practical in treating high flow rates or those with relatively low contaminant concentrations. This proposal involves a novel liquid membrane process for removing heavy metals from industrial wastewater streams. The specific contaminant addressed in this work is copper removal, which has become a serious concern because of its toxicity to aquatic life. The proposed liquid membrane process has several advantages over other methods such as solvent extraction, conventional supported liquid membrane and emulsion liquid membrane processes. Some of these advantages include: high permeability, membrane stability, combining extraction and stripping steps in the same unit, and the potential to produce high contaminant concentrations in the stripping solution. If the concept can be demonstrated on a small scale, it can also be applied to several contaminants other than copper.

4. Emulsion Liquid Membrane Extraction of Selenium from Refinery Waste Waters

TDA Research, Inc.
12345 West 52nd Avenue
Wheat Ridge, CO 80033 (EPA Region 8)
(303) 422-7819
Mr. John D. Wright, Principal Investigator
Mr. Michael E. Karpuk, Business Representative
Amount of Award: $50,000

Selenium is presently the primary wastewater treatment challenge for many West Coast petroleum refineries, and selenium is also present in significant quantities in wastewaters from coal-fired power plants. A suspected carcinogen, selenium is also harmful to fish and fowl when present in surface waters. Processes developed for selenium removal from drinking water (anion exchange and activated alumina) have technical limitations which make them too expensive for the treatment of industrial wastewaters. In particular, these processes are appropriate for small volumes of water with low levels of dissolved and suspended solids. For these processes to achieve high removal efficiencies, the selenium must be present as only one anionic species, and competing anions like sulfate or carbonate must not be present. Therefore, TDA Research proposes using Emulsion Liquid Membranes (ELM) to remove selenium from industrial wastewater streams. Based on their previous research with chromium (VI) contaminated water, TDA expects ELM to concentrate selenium by a factor of approximately 1000. In Phase I, they will conduct experiments to demonstrate process feasibility, and carry out economic analyses to compare their ELM process with other competing selenium concentration and/or removal processes.

TOPIC C: PREVENTION AND CONTROL OF NO_X, VOC'S, AND TOXIC AIR EMISSIONS

5. Removal of Automotive Pollutants Using New Metal-Supported Metal Catalyst

ACCEL Catalysis, Inc.
Technology Innovation Center
Oakdale Campus, University of Iowa
Iowa City, IA 52242 (EPA Region 7)
(319) 335-1359
Dr. Man-Yin Lo, Principal Investigator
Dr. Darrell P. Eyman, Business Representative
Amount of Award: $50,000

A new technique is proposed for the preparation of metal-supported metal (MSM) catalysts. The key feature of this technique involves the preparation of a thin layer of porous metal on top of a metal substrate such that the porous metal surface is an integral part of the metal support. Subsequent integration of Pt and Rh on the porous metal surface will produce the MSM catalyst. This catalyst is used as a three-way catalyst in catalytic converters for the removal of NO_x, hydrocarbons and CO from automobile exhaust gas. The MSM catalyst has a much better thermal conductivity than the state-of-the-art three-way catalyst using ceramic supports. The improvement in heat transfer will result in a more thermally stable catalyst, which will extend the life of the catalytic converter. The improvement in heat transfer will also give more efficient use of the precious metal components of the catalyst because of more homogeneous heat distribution. Better utilization of the precious metals would result in lower costs of the catalyst converter unit. The proposed MSM catalyst will be more durable and more cost effective than the state-of-the-art three-way catalyst presently used.

6. Low NO_x Multiple Flame Burner Concept

Altex Technologies Corporation
650 Nuttman Road, #114
Santa Clara, CA 95054 (EPA Region 9)
(408) 982-2302
Mr. John Kelly, Principal Investigator and Business Representative
Amount of Award: $49,941

Stringently regulated ozone nonattainment air quality regions will require the implementation of ultra-low-NO_x systems. Currently, only costly Selective Catalytic Reduction (SCR) systems can achieve very high levels of NO_x reduction. Inexpensive low NO_x burners, that can meet the regulations without SCR, are urgently needed by industry. Recently, progress has been made towards developing a sub-9 ppm NO_x gas-fired burner. However, the flexibility of this porous matrix surface burner is very limited, and its wide use is not expected.

Altex Technologies Corporation has identified the Multiple Flame Burner that has the potential to achieve very low NO_x, while maintaining the flexibility needed for widespread use of the burner. The burner uses the interaction of several flames to control emissions and enhance burner flexibility. To show the feasibility of this burner under the Phase I program, analyses will be used to refine the burner concept for an application of interest. A preprototype of the burner will then be fabricated and tested, under conditions simulating the application of interest. Lastly, the results of the analyses and testing will be used to evaluate the burner performance and costs, relative to existing burners with and without SCR.

7. Reducing Diesel NO_x and Soot Emissions Via Particle-Free Exhaust Gas Recirculation

CeraMem Corporation
12 Clematis Avenue

Waltham, MA 02154 (EPA Region 1)
(617)899-0467
Dr. Daryl L. Roberts, Principal Investigator
Dr. Robert L. Goldsmith, Business Representative
Amount of Award: $50,000

Diesel engines play an important role in the United States economy for power generation and transportation. However, NO_x and soot emissions from both stationary and mobile diesel engines are a major contributor to air pollution. Many engine modifications and exhaust-after-treatment devices have been proposed and tested to reduce the NO_x and soot emissions form diesel exhausts. Simple techniques for NO_x control such as exhaust gas recirculation (EGR) and injection timing retard increase soot formation. The control of soot formation is possible with diesel particulate filters (DPF's) with intermittent thermal oxidation of carbon soot. However, such filters have limitations associated with filtration efficiency and durability.

In this program, a novel diesel emissions control system will be developed. The system will utilize a high-efficiency ceramic filter to filter the exhaust gas. the filter will generate a particulate free exhaust gas, a portion of which will be used in EGR for NO_x emissions reduction. The ceramic filter will be regenerated by backpulsing with quick pulses of compressed air. In Phase I, a prototype filter/EGR system will be tested with exhaust from a 35 Kw diesel source and operated for up to one year.

8. Removal of Volatile Organic Compounds From Gaseous Effluent Streams by Novel Perfluoromembranes
Compact Membrane Systems, Inc.
325 Hampton Road
Wilmington, DE 19802 (EPA Region 3)
(302) 984-1762
Dr. Stuart Nemser, Principal Investigator and Business Representative
Amount of Award: $50,000

Volatile organic compound (VOC) effluent streams are a serious air pollution problem. Control technologies for VOCs have been oxidation or carbon absorption but recently membranes have shown effectiveness. Present membrane processes work by preferentially passing VOCs (versus air) through the membrane and then compressing and condensing out downstream VOCs. Advantages of this membrane process include simplicity, continuous operation, excellent small volume economics, and compactness. Key limitations of existing membrane processes include (1) excess costs from extra pumping stages whenever VOCs permeate the membrane and (2) high design costs since membrane-VOC interactions must be studied in each case.

Compact Membrane Systems, Inc., proposes developing a novel family of perfluoropolymer membranes having high air permeability, low VOC permeability, and chemical inertness. These perfluoro-polymer membranes should give (1) reduced capital and operating costs due to staging efficiencies since VOC stays on high pressure side of membrane and (2) low cost standardized universal design since performance is based primarily on known air permeabilities versus variable VOC permeabilities. Therefore, developing these fluoropolymer membranes will significantly reduce VOC recovery costs.

9. NO_x Stripping from Spark Ignition Automotive Engine Exhaust
Energy and Environmental Research Corporation
18 Mason
Irvine, CA 92718 (EPA Region 9)
(714) 859-8851
Mr. Jerald A. Cole, Principal Investigator
Dr. W. Randall Seeker, Business Representative

Amount of Award: $49,970

Approximately half of automotive NO_x is released in the initial minutes after startup, when the catalytic converter is cold, and is a significant source of acid rain. This project will determine the feasibility of reversibly adsorbing this "cold-Start NO_x in a sorbent bed and subsequently releasing the NO_x into a three-way catalytic converter to be reduced. This could reduce the environmental NO_x burden in many urban areas by as much as 25%. It could also permit the use of "lean-start" engines, which have the added advantage of reducing CO and hydrocarbon emissions. This device would be similar in design to existing catalytic converters.

Phase I will address the technical questions needed to determine feasibility. These include determining the capacity of the sorbent, the temperature/partial pressure relationship (adsorption isotherms), the kinetics of NO_x adsorption, thermal or chemical deactivation of the adsorbent, and any negative environmental effects. The experiments will be carried out in an isothermal packed bed reactor with on-line instrumental gas analysis. In demonstrating feasibility the Phase I effort will produce a model of sorbent behavior to allow design of a pilot-scale unit for development and evaluation in subsequent Phase II research.

10. Ultra Low NO_x Gas Fired Domestic Appliances
Energy and Environmental Research Corporation
Salem Industrial Park
Box 189
Whitehouse, NJ 08888 (EPA Region 2)
(908) 534-5833
Dr. Richard K. Lyon, Principal Investigator and Business Representative
Amount of Award: $50,000

Energy and Environmental Research Corporation (EER) has discovered a radically new method of burning natural gas. While the best presently available gas combustion technologies produce NO_x at the 10 to 20 ppm level, this new method allows the combustion of natural gas to be done with a production of NO_x well below 1 ppm.

This new technology is particularly well suited to application in gas fired domestic appliances such as hot water heaters. Pending regulations in Southern California and other regions of critical air quality problems would effectively ban gas fired appliances which are based on presently available technology, forcing the use of electrical appliances. Such a gas to electricity conversion would destroy much of the value of the natural gas distribution system, require major investment in new electrical generation capacity, and result in considerably less efficient use of energy resources.

Use of EER's new combustion technology would allow domestic gas fired appliances to satisfy the pending regulations by operating with extremely low NO_x emissions. In addition to providing a far more cost effective method of NO_x control, EER's new technology also has the potential for making hot water heaters less expensive to operate through improved energy efficiency, eliminating indoor air pollution from cooking ranges, and eliminating a major safety problem which is inherent in all gas fired appliances based on present technology.

11. In-Duct Selective Catalytic Reduction of NO_x
KSE, Inc.
P.O. Box 368
Amherst, MA 01004 (EPA Region 1)
(413) 549-5506
Dr. J. R. Kittrell, Principal Investigator and Business Representative
Amount of Award: $49,975

The conventional control device for NO_x emissions from stationary sources at 90% removal efficiency is the Selective Catalytic Reduction (SCR) system. Conventional SCR systems rely on monolithic catalysts; these

catalysts often represent nearly one-half the capital investment. In recent years, European regulations have prompted development of in-duct dust injection control processes for certain gaseous emissions. These in-duct systems have been demonstrated to provide lower capital and operating costs than alternative systems.

In the Phase I research, the technical feasibility is to be demonstrated of an in-duct SCR control process for NO_x control from gas-fired stationary sources. From preliminary laboratory experiments, this in-duct SCR technology appears able to utilize highly active, small particle SCR catalysts to achieve remarkable reactor productivity, with space velocities of approximately 1,000,000 hr^{-1}. The process reduces internal catalyst diffusion limitations, thereby capturing the inherent catalyst activity. The in-duct SCR technology holds promise of approaching the low life-cycle costs of NO_x control through non-catalytic urea injection, while achieving the high NO_x removal efficiencies of conventional catalytic SCR systems. Ammonia slip may also be more effectively controlled.

12. Improved Method for Heating Catalytic Converters of Vehicles to Attain Ultra-Low Emissions

Lynntech, Inc.
111 East 27th Street, Suite 204
Bryan, TX 77803 (EPA Region 6)
(409) 822-3149
Dr. Oliver J. Murphy, Principal Investigator
Dr. G. Duncan Hitchens, Business Representative
Amount of Award: $50,000

The three-way catalytic converter is the most important device making today's automobiles comply with existing emission laws. The first two or three miles in a typical 22-minute, 12-mile commute in today's vehicles result in the emission of half of the total non-methane hydrocarbons, which result in the production of urban smog, as well as half of the toxic CO emissions. This occurs because the catalyst in the converter will operate ineffectively until it reaches its optimal operating temperature. To meet new California and Federal standards specified for transitional low emission vehicles, low emission vehicles, and ultra-low emission vehicles, new technologies are presently being developed to lower the warm-up time for catalytic converters. This is required to bring about significant reductions in emissions of HC's primarily and CO and to a lesser extent in NO_x. Technologies involving "passive" and "active" methods for rapidly bringing catalytic converters to useful operating temperatures (250°C under cold-start conditions (nominally -10°C to 25°C) are currently being investigated. However, all of these technologies, including "close-coupled" catalytic converters, on-board heat storage systems, Exhaust Gas Ignition approach and electrically heated converters suffer from various disadvantages and drawbacks. In this proposal, a new chemical method of rapidly heating catalytic converters is proposed that addresses the weaknesses of the alternative technologies. Basically the new method involves using an on-board hydrogen bleed into the exhaust system upstream of the catalytic converter which will instantly allow the catalyst to reach its light-off temperature.

13. Recycle and Reuse of VOCs from Fugitive Emissions and Small Vent Streams

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

The Clean Air Act amendments of 1990 included standards for volatile organic compound (VOC) emissions from equipment leaks (fugitive emissions) and from small vent streams. Such emissions are estimated to total 330 million kg/year; additional controls required by the new act are expected to cost industry almost $120 million/year

for the next decade and beyond. Very small (1-3 scfm) membrane vapor separation systems will be a simple, energy-efficient method of VOC emissions control for many vent streams. Large cost savings could result since membrane systems recover the VOC as a condensed liquid, allowing recycling to the process.

However, before membrane systems can be applied to these small streams, a significant modification to the technology is required. The membrane module design must be modified so that good separations can be achieved with gas streams 50 - 100 times smaller then the streams treated to date. In the Phase I program, the technical and economic feasibility of a system incorporating a new module design will be determined.

14. Plasma Ignition Retard for NO_x Reduction

Plasmachines, Inc.
11 Mercer Road
Natick, MA 01760 (EPA Region 1)
(508) 650-9600
Mr. Michael P. Manning, Principal Investigator
Mr. Voislav Damevski, Business Representative
Amount of Award: $50,000

Plasmachines, Inc., has recently determined that an innovative plasma ignition system appears to extend the operating limits of ignition systems. This allows significantly improved NO_x reduction. An immediate application would be the large scale natural gas reciprocating engines used to drive natural gas transmission pipeline compressors.

15. Catalysts for the Control of Automotive Cold Start Emissions

TDA Research, Inc.
12345 West 52nd Avenue
Wheat Ridge, CO 80033 (EPA Region 8)
(303) 422-7819
Mr. Michael E. Karpuk, Principal Investigator
Mr. John D. Wright, Business Representative
Amount of Award: $50,000

Automotive catalytic converters are quite efficient once they reach operating temperature, typically destroying over 98% of the incoming hydrocarbons (HCs) and carbon monoxide (CO). However, up to 80% of the emissions during the Federal Test Procedure occur during the first few minutes when the engine is running rich, the oxygen sensor is not yet operational, and the catalytic converter has not reached its light-off temperature. Thus, to significantly reduce automotive emissions of HCs and CO, a method must be found which will reduce the emissions during the cold start period.

TDA has developed a new form of base metal oxide catalyst which has very high activity at low temperatures (these catalysts can completely oxidize CO at -70°C, and can be significantly more active than platinum for HC oxidation), and whose activity is not inhibited by the presence of water. In the Phase I project, TDA will use the best of the catalysts developed to date, test their activity in the laboratory under conditions which are representative of the automotive cold start application, prepare the catalyst in pellet form, prepare a packed bed catalytic converter, and test the effect of the converter on the start-up emissions of a 1984 Volkswagen Jetta.

16. Catalysts for the Oxidation of Chlorinated Hydrocarbons

TDA Research, Inc.
12345 West 52nd Avenue
Wheat Ridge, CO 80033 (EPA Region 8)
(303) 422-7819

Dr. Ron Cook, Principal Investigator
Mr. Michael E. Karpuk, Business Representative
Amount of Award: $50,000

Widely used chlorinated hydrocarbons (CHCs) such as trichloroethylene, perchloroethylene and methylene chloride are recognized as carcinogens and mutagens, and contribute to global warming and ozone depletion. Therefore, there is an increasing need for low cost and efficient methods for the control of CHC emissions. Catalytic incineration is generally the technology of choice because it has low energy requirements and produces few toxic byproducts. However, the current catalysts do not perform nearly as well as those used in the destruction of non-chlorinated volatile organic compounds. Precious metal catalysts such as platinum have low activity and must be run at temperatures in excess of 500°C to oxidize the CHCs and avoid catalyst degradation. Base metal catalysts are much more active, but are powerfully poisoned by water.

In Phase I, TDA will synthesize and characterize a series of highly active modified metal oxide catalysts whose activity is enhanced by the presence of water. TDA will test them against a range of CHCs, evaluate their kinetic performance, and carry out an engineering analysis to determine whether they are superior to currently available catalysts.

17. Selective Catalytic Reduction of NO_x with Methane
TDA Research, Inc.
12345 West 52nd Avenue
Wheat Ridge, CO 80033 (EPA Region 8)
(303) 422-7819
Mr. David T. Wickham, Principal Investigator
Mr. Michael E. Karpuk, Business Representative
Amount of Award: $50,000

Nitrogen oxides (NO and NO_2 or NO_x) are among the most pervasive and difficult emissions to control. Currently, there are no commercial catalytic processes capable of decomposing NO_x without the addition of a reducing gas. Current selective catalytic reduction (SCR) systems for use in oxidizing environments use ammonia as the reducing agent. Ammonia SCR requires the handling of large quantities of toxic gases, tight temperature control, relatively high reaction temperatures, and requires large amounts of catalyst because of the relatively low reaction rates. An SCR catalyst which could use methane instead of ammonia could lower the cost and difficulty of handling the reducing agent, and if it had higher activity than current catalysts, would reduce the catalyst cost and decrease the operating temperature.

TDA Research, Inc., has identified a family of SCR catalysts which have high reaction rates at 100°C and use methane as a reducing agent. They will synthesize and characterize a range of such catalysts, test them to determine their activity as a function of temperature, NO and CH_4 concentrations, carry out detailed kinetic analyses and long term testing of the best catalysts, and perform a preliminary engineering analysis to determine whether they merit further development.

TOPIC D: SOLID AND HAZARDOUS WASTE DISPOSAL

18. Silo Sulfonation Reactor for Waste Plastic and Rubber for Inclusion in High Performance Concrete
Coalition Technologies, Ltd.
P.O. Box 1391
3072 Vantage Point Drive
Midland, MI 48641-1391 (EPA Region 5)
(517) 832-8415

Dr. W. E. (Bill) Walles, Principal Investigator
Mr. Luis C. Mulford, Business Representative
Amount of Award: $50,000

Coalition Technologies, Ltd., (CTL) research had improved a simple gas phase treatment (sulfonation) of waste rubber and plastics. Results from laboratory scale experiments done at Michigan State University have shown that concrete made from sulfonated rubber and plastic provided by CTL has improved impact resistance as measured by ASTM standard tests. In many cases, waste plastics and rubber are contained in mixtures such as Auto Shredder Residue.

These mixtures of plastic and rubber are cost prohibitive to recycle with current technology. The sulfonation process provides chemical compatibility so that waste plastic and rubber can be diverted to High Performance concrete, the value of the waste plastic and rubber can be increased and the resulting product can be sold to the concrete industry. Sulfonation provides key advantages over other recycling technologies because mixtures of plastic and rubber can be used.

19. An Innovative Technology for the Destruction of Chlorinated Compounds in the Vapor Phase

Eckenfelder, Inc.
227 French Landing Drive
Nashville, TN 37228 (EPA Region 4)
(615) 255-2288
Dr. Ann N. Clarke, Principal Investigator and Business Representative
Amount of Award: $49,740

The cost of off-gas treatment during remediation of hazardous waste sites can typically increase the cost by 50% or more. This research is targeted towards developing a simple cost effective technology to destroy chlorinated organic solvents in the vapor phase. The process uses a dry chemical at a slightly elevated temperature. The research involves testing of a variety of related dry chemicals in a temperature range of 500°C or less. The thermodynamics have been evaluated for the destruction of several chlorinated solvents. The very large negative value for the Gibbs Free Energy of Formation, *delta*G°, on the order of -1,000kj/mole, for each reaction indicates that the reactions should occur spontaneously. the kinetics, however, are unknown and will be studied during the conduct of this research.

20. Fixation of Lead and Select Organic Compounds Using a Cold Mix Asphalt Process

Eckenfelder, Inc.
227 French Landing Drive
Nashville, TN 37228 (EPA Region 4)
(615) 255-2288
Dr. Ann N. Clarke, Principal Investigator and Business Representative
Amount of Award: $50,000

Many contaminants of concern at hazardous waste sites are difficult to treat because of their chemical and physical characteristics. Constituents which have low vapor pressure, low water solubility, and low potential for biodegradability are not candidates for many technologies. Metals are a prime example as are polychlorinated biphenyls (PCBs). The proposed technology is a cold mix asphalt emulsion process which is based upon a proprietary process successfully being used for the remediation of sites containing petroleum products. Not only will this process target mixed wastes of metals and organic compounds in soils, but this process also has the added benefit of being able to incorporate contaminated building rubble as part of the asphalt aggregate system. The materials thus produced can be used in various applications including road paving, parking lots, capping landfills, etc.

21. Utilization of Scrap Prepreg Wastes as a Reinforcement in a Wholly Recycled Plastic

Foster-Miller, Inc.
350 Second Avenue
Waltham, MA 02154-1196 (EPA Region 1)
(617) 890-3200
Dr. Kent G. Blizard, Principal Investigator
Mr. Ross R. Olander, Business Representative
Amount of Award: $49,951

Foster-Miller proposes to utilize scrap prepreg waste as a reinforcement in recycled polyethylene. By reinforcing recycled plastics such as polyethylene with scrap prepreg and suitable binders, an economical useful product can be obtained. At the same time, this innovation will also help to reduce 2.5 million pound/yr of hazardous waste -- uncured prepreg scrap. Foster-Miller is working with a composites user who is developing alternative high value uses for scrap prepreg in order to eliminate the hazardous waste disposal problems. By utilizing post-consumer plastic waste as the matrix material, this product will also contribute to eliminating the landfill space problem. In addition, since the raw material costs of this recycled reinforced plastic are nominal, Foster-Miller's material will be cost-effective and consequently attractive to the commercial sector.

Since carbon fiber has a tensile modulus of 200 GPa and strength of 2760 MPa, Foster-Miller's innovative recycled material should be ideal for construction applications, overcoming the mechanical property limitations of current reinforced recycled plastics that utilize reinforcements such as wood fiber or fiberglass which have substantially lower properties than carbon fiber. With proper interfacial control between the reinforcement and the plastic matrix, their proposed recycled construction material should have mechanical properties competitive with wood, such as tensile strength of 75 MPa and modulus of 15 GPa. To show feasibility, they will compare the properties of their material to wood and demonstrate the effectiveness of the binder they choose. Practical extrusion processing conditions will be determined and a prototype extruded construction material produced. Phase I to thus enable them to move quickly to full-scale development in Phases II and III.

22. Scrap Tire Pyrolysis -- Production of Highly Enhanced Marketable Products

HiChem Corporation
1800 West Cornelia Avenue
Chicago, IL 60657 (EPA Region 5)
(312) 871-2289
Dr. Martin E. Carrera, Principal Investigator
Dr. V. B. Kulkarni, Business Representative
Amount of Award: $50,000

Research will be conducted by HiChem Corporation, to develop a new technology for pyrolysis of scrap tires. Disposal of used tires is a big problem in the world, especially USA, since more than 2.5 million tires are discarded each year. Most of these tires are disposed in landfills. Pyrolysis of scrap tires helps to recover and reuse most of the valuable chemical available in tires. Pyrolysis of scrap tires under inert atmospheres produces reusable gas, oil, and char. However, at present, these products have low market value because of their poor quality. Therefore, disposal of the tires by pyrolysis is marginally attractive as a business venture. The proposed research aims to prove that pyrolysis products produced by the HiChem process will produce reusable oil and char of higher quality. These products will be competitively marketable in the existing market with an advantage of low priced feedstock. The researchers also aim to show how to significantly shift the proportionality of the byproducts (carbon and oil) produced using the HiChem process to a higher quality and quantity product.

23. Application of Artificial Intelligence to Automated Waste Recycling

National Recovery Technologies, Inc.
566 Mainstream Drive
Nashville, TN 37228-1223 (EPA Region 4)
(615) 734-6400
Dr. Edward J. Sommer, Jr., Principal Investigator
Mr. Charles T. Crow, Business Representative
Amount of Award: $49,972

Diversion of plastics from landfill to recycling can potentially save the energy equivalent of 60 million barrels of oil annually and reduce landfill volume requirements by up to 20%. The U.S. Environmental Protection Agency has recommended that source reduction, recycling, volume reduction, and landfilling be applied, in that order, in the treatment of municipal solid waste (MSW). Recycling has recently become a major component of municipal waste management programs. High cost of labor intensive curbside recycling programs have brought about a second generation technology, mixed waste processing, for accomplishing higher levels of recycling at reduced costs. The economics of mixed waste processing depends upon efficient automated processes for recovering recyclables from MSW. Efficient automated technology exists for recovery of steel, aluminum, compostable food waste and paper products from MSW. These items make up the bulk of MSW. However, the only existing method to recover glass and plastic containers from MSW is to manually handpick them from the waste. The objective of the Phase I research program is to determine feasibility for development of an efficient automated process for recovering post-consumer plastic and glass containers from MSW using recognition algorithms incorporating artificial intelligence techniques.

24. A Process for Increasing the Amount and Quality of Recycled Plastics Resins

National Recovery Technologies, Inc.
566 Mainstream Drive
Nashville, TN 37228-1223 (EPA Region 4)
(615) 734-6400
Dr. Edward J. Sommer, Jr., Principal Investigator
Mr. Charles T. Crow, Business Representative
Amount of Award: $49,948

Each year, Americans dispose of an estimated 29 billion pounds of plastics which consume up to 20% of our nation's annual landfill capacity. Recent environmental and political pressures have led to rapid establishment of plastics recycling facilities. Limited markets for low quality recycled resins require reclaimers to produce the highest quality recycled resins in order to compete with virgin resins. An increasing number of reclaimers are turning to automated sorting technology to help achieve this goal.

Currently, PET from soda bottles is the most recycled plastic. The second most recycled plastic is HDPE comprised mostly of milk jugs and bases from PET bottles. It is presently difficult to expand post-consumer plastics recycling beyond the easily recognized PET soda bottles and HDPE milk jugs, which together constitute only 6% of plastics disposed annually and only 14% of plastic containers and packaging. According to the U.S. Environmental Protection Agency a major limiting factor in quality of recycled resins and in expanding plastics recycling to include a broader spectrum of plastics is lack of automated plastics sorting technology. The objective of the Phase I research program is to determine feasibility for development of a high speed automated system for high accuracy sorting of plastics by polymer type.

25. Separation of Post-Consumer PET and PVC Plastics in the Regrind Flake Form

National Recovery Technologies, Inc.
566 Mainstream Drive
Nashville, TN 37228-1223 (EPA Region 4)

(615) 734-6400
Dr. Edward J. Sommer, Jr., Principal Investigator
Mr. Charles T. Crow, Business Representative
Amount of Award: $49,903

The last three years have seen a dramatic increase in the number of companies processing post-consumer plastics from products such as soft drink containers, detergent bottles, milk jugs and water bottles. While this has to some extent diverted these materials from landfills, it has caused an economic anomaly. The high costs of manually sorting the plastics so they can be reprocessed makes them unattractive to most processors resulting in an oversupply which drives the price of recycled resins below the cost of production expenses. Processors are increasingly turning to automated sortation technology as a means of cutting costs. National Recovery Technologies, Inc., has developed and successfully commercialized a system for automatically sorting PVC and PET bottles. This system routinely produces a PET product with less than 50 ppm PVC contamination. While this level is adequate for processors at this time, it is predicted that the purity specification will drop to 5 to 10 ppm in the near future. Therefore, a secondary sortation system will be necessary to detect and remove residual PVC. Residual PVC is present due to bottle cap liners, shrink labels and PVC bottle pieces broken during handling which are too small to detect with existing technology. This proposal seeks to design, test and begin commercialization of a secondary sortation system for handling post consumer plastic flake to meet the demanding standards of plastic processors. This system will greatly improve the quality of the product while reducing costs resulting in an overall increase in plastic recycling.

26. Development of a New Lead Fixation Technology
Wamax, Inc.
4473 142nd Avenue, SE
Bellevue, WA 98006 (EPA Region 10)
(206) 643-4755
Dr. Rong Wang, Principal Investigator
Mrs. Dora F. Wang, Business Representative
Amount of Award: $49,941

Lead in soil must be treated in order to reduce the exposure risk associated with lead migration and lead bioavailability. Since the level of lead in contaminated soil is usually very low, a cost-effective and safe lead fixation technology is needed. This research will investigate a novel lead fixation technology based on natural soil chemical reactions with environmentally safe materials. Phase I will demonstrate the effect of soil impregnation and lead fixation. Phase II will develop commercial materials and engineering practices for fixation of contaminated soils and reduce lead leachability in these soils.

TOPIC G: POLLUTION PREVENTION

27. Extraction of Copper and Zinc From Mixed-Metal Cyanide Solution Using Solid Phase Extraction
ChromatoChem, Inc.
2837 Fort Missoula Road
Missoula, MT 59801-7407 (EPA Region 8)
(406) 728-5897
Dr. Richard F. Hammen, Principal Investigator and Business Representative
Amount of Award: $50,000

Removal of toxic metals from wastewater streams has become a problem of increasing national importance, as a result of increasing concern for our environment, and increasingly stringent waste disposal regulations. ChromatoChem, Inc., has developed an economical and effective new technology for the removal of low levels of

toxic metal ions from wastewater streams, using Solid Phase Extraction (SPE). This SPE technology uses metal-selective reagents covalently bound to a silica solid support by means of a proprietary hydrophilic tether molecule. This research will use SPE to address the environmental and economic problems resulting from the copper and zinc cyanide waste products created by heap-leaching practices used in the gold mining industry. The Phase I work will investigate methods to separate the copper and zinc cyanide complexes from gold cyanide. The benefits of such separation will include: decreased introduction of metal cyanide complexes into the environment, and reduced mining costs by recycling of cyanide and the recovery of copper and zinc metals.

28. Selective Elimination of Waste in a Metal Finishing Operation
IonEdge Corporation
1713 Hull Street
Fort Collins, CO 80526 (EPA Region 8)
(303) 223-0665
Mr. Mandar Sunthankar, Principal Investigator and Business Representative
Amount of Award: $50,000

Chromate conversion coatings are routinely applied to cadmium in electroplating. This metal finishing process generates large quantities of hazardous hexavalent chromium and heavy-metal waste. This is a major environmental concern. Consequently, an environmentally benign coating finish is proposed as a suitable alternative to the chromate conversion coating. This coating will be applied using the unique dry plating process developed at IonEdge Corporation. This benign material will eliminate chromium waste in cadmium plating. Simultaneously, the dry plating will eliminate liquids, and will in situ recycle solid cadmium, In this research, the feasibility of applying a desired quality of this material to the dry plated cadmium will be investigated. Variation in its physical properties related to the processing conditions will be studied. A successful demonstration of this new concept could result in total elimination of hazardous liquids in a cadmium plating operation. In addition, the dry plating will minimize solid waste.

29. A New Membrane Process for Air Pollution Minimization in Chlor-Alkali Plants
Membrane Technology and Research, Inc.
1360 Willow Road, Suite 103
Menlo Park, CA 94025 (EPA Region 9)
(415) 328-2228
Dr. Ingo Pinnau, Principal Investigator
Ms. E. G. Weiss, Business Representative
Amount of Award: $50,000

Chlorine ranks among the ten most important commodity chemicals. Approximately 54% of the total U.S. chlorine production is liquefied for sale or for in-plant transport. Tail gas produced from the chlorine liquefaction process is the principal source of chlorine-containing waste gas streams produced by chlor-alkali plants. Currently, such streams are treated by absorption in carbon tetrachloride; however, carbon tetrachloride has a high ozone depletion potential. It is estimated that at least 8.8×10^6 lb/yr of carbon tetrachloride are emitted by chlorine liquefaction tail gas treatment. Because of the serious environmental threat of carbon tetrachloride emissions the Environmental Protection Agency had mandated that these emissions be eliminated; carbon tetrachloride production will cease after 1995. Therefore, the chlor-alkali industry must find an alternative treatment technology.

Membrane Technology and Research, Inc. (MTR), proposes to develop a new membrane process to recover chlorine from tail gas streams in the chlor-alkali industry that will eliminate the use of carbon tetrachloride. The chlorine recovery will be recycled back to the plant.

Preliminary studies at MTR have demonstrated that rubbery membranes are highly selective for chlorine. In the Phase I program, a laboratory system using these membranes will be tested for its chlorine removal efficiency. An application study will be performed to identify the most efficient methods to capture chlorine from liquefaction tail gas.

30. In-Process Recycling of Acetic Acid From Dilute Aqueous Waste Streams

Membrane Technology and Research, Inc.
1360 Willow Road, Suite 103
Menlo Park, CA 94025 (EPA Region 9)
(415) 328-2228
Dr. Richard W. Baker, Principal Investigator
Ms. E. G. Weiss, Business Representative
Amount of Award: $50,000

Dilute acetic acid wastewater streams are produced in large quantities by the synthetic organic chemical industry, for example, in the synthesis of terephthalic acid, the precursor of polyethylene terephthalate. Recovery of acetic acid from these wastewaters for in-process recycling of the acid would reduce waste and save valuable resources. This proposal describes the development of a process that combines selective dialysis followed by bipolar-membrane electrolysis to recover and concentrate this acid. Although the program focuses on acetic acid recovery, the technology could be applied to recovery and recycling of other weak acids such as acrylic acid, lactic acid, and phenols.

31. Development of Ink Recycling Process Technology

Resource Recycling & Remediation, Inc.
800 Vinial Street
Pittsburgh, PA 15212 (EPA Region 3)
(412) 323-1733
Mr. Michael Jones, Principal Investigator and Business Representative
Amount of Award: $49,993

While printing packages for the consumer products industry printers generate hazardous ink waste in quantities that qualify the industry as one of the nation's largest sources of hazardous waste. In fact, solvent components in ink waste are among 17 chemicals targeted by the Environmental Protection Agency (EPA) for minimization.

The proposed process technology recycles ink waste on-site versus disposal. By merging state-of-the-art spectrophotometry, new software and innovative filtration methods, ink waste destined for incineration becomes reusable ink.

This prototype process originated from a successful study funded in part by an EPA grant. The process begins with a procedural change from waste management to resource management and requires disciplined ink waste collection and segregation into chemical type and primary color. Segregated materials are analyzed using advanced spectrophotometric instrumentation, identified by a unique software, and remanufactured using proprietary technology. The process results in a closed loop of ink and solvent resources recycled into press-ready ink.

Success of the project will result in a demonstration of the commercial feasibility of recycling for nearly 1,000 package printers and 300+ product printers. Further success will lead to other segments in the printing industry comprising over 52,000 plants.

32. Unique, On-Site Destruction of Transformer Askarels Using a Low-Temperature, Mild Chemical Method

Veritay Technology, Inc.
4845 Millersport Highway
P.O. Box 305
East Amherst, NY 14051 (EPA Region 2)
(716) 689-0177
Dr. Ian Webber, Principal Investigator
Dr. Kathy L. Bernard, Business Representative
Amount of Award: $49,999

These is a great need for a safe, energy-efficient, on-site method for decontaminating various chemical toxins. Nearly all (i.e., 99.8%) of the polychlorinated biphenyls (PCBs) found in current applications are used as dielectic fluid. This amounts to about 30,000,000 gallons of PCB-contaminated fluid. To reduce this exposure risk the Environmental Protection Agency is requiring the accelerated phaseout of PCB transformers. Presently, there is no cost-effective method for providing on-site decontamination of PCB-contaminated fluids; nor is there a mild chemical method for their ultimate disposal.

A novel PCB dechlorination method has been identified, which has potential utility for the detoxification of transformer PCB fluids that presently represent a significant health hazard. Initially investigated at the University of Louisville and evaluated by the proposed Principal Investigator, the hydrogenation method, which uses an expensive noble metal catalyst but operates at room temperature, has been shown to achieve virtually complete dehalogenation in minutes. By systematically evaluating different catalysts, solvents, and processes, Veritay Technology, Inc., proposes to find and demonstrate a commercially feasible, mobile PCB treatment protocol based on the chemical dechlorination of concentrated PCBs. The approach offers numerous advantages including the avoidance of extreme conditions such as high temperature, which, in the case of partial pyrolysis, leads to the increased production of dioxins and dibenzofurans.

TOPIC H: CONTINUOUS MONITORING OF PROCESSES FOR COMPLIANCE AND CONTROL EFFECTIVITY DETERMINATION

33. Continuous Emission Monitor for Halogenated Compounds
ADA Technologies, Inc.
304 Inverness Way South, Suite 110
Englewood, CO 80112 (EPA Region 8)
(303) 792-5615
Dr. David E. Hyatt, Principal Investigator
Dr. Judith A. Armstrong, Business Representative
Amount of Award: $49,971

The emission of halogen containing pollutants from a variety of power generating, waste processing, chemical production, and solvent using industries is an environmental concern of major significance. Inorganic halogen species, including hydrogen chloride and hydrogen fluoride, represent major potential health threats to both human, animal, and plant communities. Organic halogenated compounds (HOCs) have been indicted as severe health risks at very low levels, have been found to be carcinogenic in several instances and a class of these materials (CFCs in particular) are at the center of ozone depletion chemistry and the subject of recent control under the Montreal Protocol.

At present, these is no continuous emission monitoring (CEM) technique or instrumentation to reliably monitor emissions of these halogenated materials at the thousands of sites at which they may be released in the United States (and in fact, worldwide). Without this CEM capability, minimization of emission of these dangerous

pollutants and optimization of control system performance to assure continued emission minimums cannot be a reality.

The Phase I proposal presents an innovative spectrometric concept which will be ideal for the continuous monitoring of organic and inorganic halogenated compound emissions from all sources. The concept is based on the use of a microwave plasma emission instrument, well suited for continuous on-site operation as a CEM, which will respond to all of the halogen species at concentrations extending down to trace levels. The results of the successful Phase I effort will lead directly to the development of a prototype monitor in Phase II and to on-site testing of this instrument at actual field sites during that project stage.

34. Catalytic Bridge, Chemical Monitor
Envirochem, Inc
54 Bridge Street
Lexington, MA 02173 (EPA Region 1)
(617) 863-1334
Dr. David Ham, Principal Investigator and Business Representative
Amount of Award: $50,000

This proposal presents a concept for a chemical monitor based on differential catalytic reactivities and large reaction exothermicities. The simplicity of the proposed sensor concept promises an economic and reliable monitor for in-situ measurement of a variety of gases. In this project, Envirochem, Inc., will investigate the application of this concept for measuring ammonia in flue gases. A sensitive, in-situ, real-time ammonia monitor is required for control of many NO_x control processes that either use or produce ammonia.

The goal of a Phase I project is to measure the sensitivities, selectivities, and linearities of a laboratory instrument version of the proposed as functions of catalyst material, catalyst temperature, and gas composition. For selected promising cases, they will test the catalyst wires for longevity and poisoning by likely contaminants. In a Phase II project, a prototype commercial system can be assembled and tested over a broader range of parameters and compared with other monitors in real environments.

1993 PHASE II ABSTRACTS

TOPIC B: MUNICIPAL AND INDUSTRIAL WASTEWATER TREATMENT AND POLLUTION CONTROL

35. A Low Life-Cycle Cost UV Source and Reactor to Oxidize Aqueous Phase Organics

Energy & Environmental Engineering, Inc.
P.O. Box 215
East Cambridge, MA 02141 (EPA Region 1)
(617) 666-5500
Dr. James H. Porter, Principal Investigator and Business Representative
Amount of Award: $150,000

The oxidation of dilute concentrations of organics in aqueous solutions using hydrogen peroxide and/or ozone as the oxidant in the presence of ultraviolet (UV) light has been demonstrated and is offered commercially by several corporations. Present systems seem to be limited to low concentrations of organics (< 10 ppm), if costs are to be maintained at less than a few dollars per thousand gallons of water treated. Further, oxidation is often not complete and low molecular weight acids, aldehydes, and ketones may remain in the treated water as final oxidation products.

Improved photochemical reactor design using low life-cycle cost UV sources is proposed. The reaction system will exploit newly discovered oxidation chemistry which leads to the complete oxidation of unsaturated organics in aqueous streams.

TOPIC D: SOLID AND HAZARDOUS WASTE DISPOSAL

36. Photo-Thermal Conversion of CFCs and Halons to Valuable and Environmental Safe Materials

M.L. Energia, Inc.
P.O. Box 1468
Princeton, NJ 08542 (EPA Region 2)
(609) 799-7970
Dr. Moshe Lavid, Principal Investigator
Ms. Nira Lavid, Business Representative
Amount of Award: $150,000

There is presently a wide range of applications using vast amount of chloroflurocarbons (CFCs) and bromochlorofluorocarbons (Halons). However, these compounds pose a serious threat to the stratospheric ozone layer, and thus must be removed from service, as specified in the Montreal Protocol and by new Federal regulations. Consequently, it would be of great economic and environmental benefit if these materials could be safely and efficiently converted into less ozone-depleting substitutes.

A novel technology has been proposed by M.L. Energia, Inc., for on-site conversion of CFCs/Halons to environmentally benign and saleable materials. The process is Photo-Thermal Hydrodehalogenation (PTH). It converts CFCs and Halons into hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), fluorocarbons (FCs) and other high-value materials. The scientific foundation of this innovative PTH process lies in the combined use of reducing atmosphere and ultraviolet light to efficiently remove chlorine and bromine atoms from CFCs and Halon molecules at moderate temperatures. These atoms participate in chain-propagating reactions promoting high conversion of CFCs/Halons to valuable HCFCs, HFCs, and FCs depending on the specific compound and the operating conditions.

Phase I results have already demonstrated the feasibility of the PTH process and identified potential commercial applications. The primary goal of Phase II is to obtain all the necessary technical information for design and construction of a prototype PTH reactor. To this end, a comprehensive four-task work plan has been proposed. Under Phase III, the PTH process will be ultimately commercialized in collaboration with M.L. Energia, Inc.'s industrial partner, which has already provided a Follow-on Funding Commitment.

37. A Low Cost Automated Process for Recovery of Recyclable Plastic and Glass Containers from Solid Waste

National Recovery Technologies, Inc.
566 Mainstream Drive
Nashville, TN 37228-1223 (EPA Region 4)
(615) 734-6400
Dr. Edward J. Sommer, Jr., Principal Investigator
Mr. Mark T. Schell, Business Representative
Amount of Award: $149,936

The disposal of municipal solid waste (MSW) is a costly problem for all municipalities. The U.S. Environmental Protection Agency has recommended that source reduction, recycling, reduction and landfilling be applied for the treatment of MSW. Recycling programs are rapidly becoming the most popular method for waste reduction. Municipalities are implementing curbside programs and central Material Recycling Facilities (MRF) to recover valuable items such as newspaper, cardboard, aluminum, glass and ferrous alloys. Increasingly, municipalities are realizing the cost advantages of using automated technology to separate the recyclable materials. National Recovery Technologies, Inc., has completed a Phase I research program which successfully demonstrated the feasibility of using the bounce characteristics of most recyclables to cause them to be separated from non-recyclable items. This research culminated in the manufacture of a working prototype which has been further tested with true MSW since the end of the Phase I program with very positive results. These results indicate that this device produces a concentrated stream of recyclables from mixed MSW. This proposal will outline those results and propose a means for developing and testing a commercial scale unit. This unit would be economically feasible for MRF's of all sizes, or facilities separating mixed recyclables collected through curbside programs.

38. Method for Opening and Emptying the Contents of Plastic Bags Entering Recycling Facilities

National Recovery Technologies, Inc.
566 Mainstream Drive
Nashville, TN 37228-1223 (EPA Region 4)
(615) 734-6400
Dr. Edward J. Sommer, Jr., Principal Investigator
Mr. Mark T. Schell, Business Representative
Amount of Award: $149,999

Many U.S. municipalities are integrating recycling programs into the management of their solid waste in order to minimize landfill requirements. These program often include a Materials Recycling Facility (MRF) where the municipal solid waste (MSW), curbside collected recyclable materials, and other bagged waste are transported to a central facility for the retrieval of recyclable materials before landfilling or incineration. Operators of these facilities have long noted the need for an automated device which can open and empty the thousands of plastic bags entering the MRF daily. In the Phase I research, a prototype system was tested which takes advantage of the weakness of plastic bags to heat as the means for opening the bags and which uses a mechanical vibratory system for emptying the opened bags. In the Phase II research, testing will continue on several Phase III prototypes to quantify performance of the technology and to determine avenues for improvement. Modifications to the design will be investigated to improve bag opening and emptying, to ensure the environmental soundness of the technology, and to extend the technology to perform additional valuable functions in the processing of waste.

39. Conversion of Waste Stream Plastics Into Polymer Matrix Composite Materials
Robert Morgan & Company, Inc.
271 Helmer Road
Battle Creek, MI 49015 (EPA Region 5)
(616) 962-5592
Mr. Michael D. Monfore, Principal Investigator and Business Representative
Amount of Award: $149,998

Secondary recycling of many waste materials has been limited by chronic technical and economic barriers. However, recent advances in the processing of mixed waste plastics has led to the development of innovative polymer matrix composites. Materials research by the Robert Morgan & Company, Inc., has shown great promise for the utilization of mixed waste materials, including plastics, paper and fiberglass. This formulation and processing technology allows direct conversion of commingled post-consumer and post-industrial waste into useful composite materials. Phase I SBIR research by Robert Morgan & Company, Inc., has demonstrated these materials capable of delivering mechanical performance similar to many reinforced and non-reinforced polymer materials used in automotive components. It is anticipated this technology has the potential to provide many industries with a new source of inexpensive, high performance engineering materials. Phase II research will provide a practical demonstration of this technology through the production of full-scale prototype products. The investigators will produce a prototype pallet system from a range of materials demonstrated in Phase I. The design of this prototype will allow evaluation of the research materials across a variety of design features and attributes. Success of the Phase II research will finalize commitments with several commercialization opportunities.

TOPIC G: CONTROL OF ACID RAIN PRECURSORS

40. ENO$_x$ Process for NO$_x$ and Unburned Hydrocarbon Emissions from Combustion Sources
Plasmachines, Inc.
11 Mercer Road
Natick, MA 01760 (EPA Region 1)
(508) 650-9600
Mr. Michael P. Manning, Principal Investigator
Mr. Voislav Damevski, Business Representative
Amount of Award: $150,000

The proposed research will open new areas of electronically excited chemical plasma reduction of pollutant emission rates. The proposed research will determine the efficacy and mechanism of the process and report data allowing comparison of this process with previous proposed processes.

41. Direct Sulfur Recovery
Sorbent Technologies Corporation (formerly Sanitech, Inc.)
1935 East Aurora Road
Twinsburg, OH 44087 (EPA Region 5)
(216) 425-2354
Mr. Sidney G. Nelson, Principal Investigator and Business Representative
Amount of Award: $150,000

The objective of the proposed project is to develop and demonstrate a low-cost alternative to a modified Claus plant for conversion of SO_2 to elemental sulfur. More specifically, the objectives are to optimize an existing acid-rain sorbent regeneration process developed by Sorbent Technologies Corporation to yield directly a pure elemental sulfur product and to apply the technology to gas streams having a wide range of compositions.

In Phase I, of three strategies examined to increase elemental sulfur yields, one strategy, gas recycling, was observed to be exceptionally effective, yielding 100% conversion of the sulfur released during regeneration to elemental sulfur, with no sulfur species remaining in the exiting gas. Later, an important discovery was made. It was observed that MgO or TiO_2 will act as a catalyst for the direct conversion of SO_2 to elemental sulfur.

In Phase II, the research in Phase I will be carried forward. The technology will be scaled up to a larger size, evaluated in continuous, long-term runs, and optimized.

42. Bifunctional Catalysts for the Decomposition of Nitric Oxide

TDA Research, Inc.
12345 West 52nd Avenue
Wheat Ridge, CO 80033 (EPA Region 8)
(303) 940-2301
Dr. David T. Wickham, Principal Investigator
Mr. Michael E. Karpuk, Business Representative
Amount of Award: $150,000

Nitrogen oxides (NO and NO_2 or NO_x) are among the most pervasive and difficult emissions to control. Although the decomposition reactions of both NO and NO_2 are thermodynamically favored, there is no commercial catalytic process 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. NO_x decomposition catalysts would be useful in stationary applications because the reducing gas and associated equipment contribute roughly one-half of the total clean-up cost. Such catalysts would also find ready acceptance in mobile applications as there is currently no practical catalytic method for NO_x reduction in diesel exhaust.

TDA Research, Inc., proposes to synthesize and test coprecipitated bifunctional catalysts capable of carrying out the decomposition reaction, In Phase I, they modified a metal oxide catalyst to reduce the affinity of the catalyst for oxygen, therefore, allowing the NO decomposition reaction to proceed at rates much greater they those observed on the unmodified catalyst. In Phase II, they will synthesize and test new catalyst formulations. They will perform additional characterization experiments with the goal of understanding the nature of the bifunctional catalyst effect in order to optimize the catalyst composition.

TOPIC I: AIR POLLUTION CONTROL

43. A Novel Membrane System for Recovering Volatile Organic Contaminants from Air

Bend Research, Inc.
64550 Research Road
Bend, OR 97701-8599 (EPA Region 10)
(503) 382-4100
Dr. Scott B. McCray, Principal Investigator
Dr. Rod Ray, Business Representative
Amount of Award: $149,706

The removal of volatile organic contaminants (VOCs) from industrial process gases constitutes a significant industrial and environmental problem worldwide. Recovery of VOCs is advantageous for environmental process-efficiency reasons, but conventional technologies and "first generation" membrane technologies for VOC removal have drawbacks that limit their use for this application. These drawbacks include limitations on the percentage of VOCs that can be removed, excessive energy consumption, and inability to withstand exposure to the feed-stream components and harsh operating conditions.

The overall goal of this program is to develop a membrane-based system for recovering VOCs that avoids the drawbacks of conventional unit processes and first-generation membrane technologies. This new membrane-based VOC-recovery system will be applicable to a wide range of VOCs and will be capable of reducing the concentrations of VOCs from very high concentrations to the 20-ppm level or below, recovering the VOCs in liquid form for disposal of reuse.

In Phase I, system feasibility was demonstrated. Hollow-fiber membranes were successfully developed from new solvent-resistant polymers, incorporated into high-efficient modules, and tested. The modules effectively reduced the concentration of a target VOC--toluene--in nitrogen feed streams from 5,500 ppm to 20 ppm and maintained performance in long-term (650-hour) tests. An economic analysis showed the proposed system offers major cost advantages over competing technologies.

The focus of the Phase II program is to:

1. Optimize the VOC-selective coatings used on the hollow fiber membranes;
2. Scale up the membrane modules to a size that will allow field tests and pilot tests at a reasonable scale; and
3. Field-test this technology.

44. A Low Cost Catalytic Filter for Simultaneous VOC and Particulate Removal

CeraMem Corporation
12 Clematis Avenue
Waltham, MA 02154 (EPA Region 1)
(617) 899-0467
Dr. Daryl L. Roberts, Principal Investigator
Dr. Robert L. Goldsmith, Business Representative
Amount of Award: $150,000

Emissions of VOC's are subject to control by the EPA both because VOC's are regarded as ozone precursors and because many specific VOC's are hazardous air pollutants (HAP's) under the Clean Air Act Amendments. A number of industries generate offgases with both fine particulate matter and VOC's and require emission control technology for both. The research in this program expands on the successful Phase I proof-of-principal testing of a novel catalytic filter for simultaneous removal of VOC's and particulate matter. The overall objective of the Phase II program is to develop improved catalytic filters which have the performance required for industrial acceptance of the technology. Specific product development technical objectives for industrial acceptance of the technology. Specific product development technical objectives include the following (at a space velocity of 40,000 hr^{-1}; and operating temperature of about 550°F; and a pressure differential of <15 inches water):

1. VOC removal efficiency of 95% or greater for a variety of organic vapors, including chlorinated hydrocarbons.
2. Substantially complete particulate removal efficiency (>99.9%); and
3. Ability to maintain clean catalytic filter pressure drop over repetitive filtration cycles.

Other projects objectives include:

1. Demonstration of a catalytic filter at an asphalt concrete plant for a 4-6 week period; and
2. Development of system installation and operating costs and comparison with costs for conventional technology.

45. A New Vapor Recovery Nozzle for Air Pollution Control

H&R Technology, Inc.
15 Voss Terrace
Newton, MA 02159 (EPA Region 1)

(617) 969-0650
Mr. Joshua E. Rabinovich, Principal Investigator and Business Representative
Amount of Award:$149,978

The vapor recovery nozzle is an air pollution control device which relates to Stage II emission control equipment designed to capture gasoline vapors during automobile refueling at service stations. The existing vapor recovery nozzles are difficult to handle, the bellows prone to cuts, and the vacuum assist pumps require frequent and costly maintenance.

The primary objective of this project is to develop a new, more effective, low initial cost and low maintenance cost vapor recovery technology. This technology is based on a proprietary bellowless vapor recovery nozzle with an onboard vapor recovery pump, and aims at solving major problems inherent in previous designs.

In Phase I of the project a preliminary model of this nozzle was constructed, tested and evaluated. It has proved the proposed technology's feasibility of achieving compliance with all UL, California Air Resource Board, Weights and Measures, EPA and Fire Marshal agencies standards and regulations.

Phase II of the project will consist of the improvement and fine-tuning of the vapor recovery nozzle developed in Phase I and the building of Phase II preproduction prototypes, which will comply with all standards and regulations of the regulating agencies.

46. Carbon Adsorption/Membrane Regeneration Hybrid System
Membrane Technology and Research, Inc.
1360 Willow Road
Menlo Park, CA 94025 (EPA Region 9)
(415) 328-2228
Dr. Kaaid Lokhavdwala, Principal Investigator
Ms. Elizabeth G. Weiss, Business Representative
Amount of Award: $150,000

Current and future legislation will require U.S. industry to treat many low-concentration, organic solvent-containing air streams now being discharged to the atmosphere. Although carbon adsorption is a cost-effective, efficient treatment process for such streams, the regeneration step used to remove adsorbed organic from the carbon presents problems. Membrane Technology & Research, Inc., is developing a hybrid carbon adsorption/membrane vapor separation process that uses a membrane vapor separation system to regenerate the carbon bed. The organic compound is recovered as a pure product; secondary waste streams are eliminated. In the proposed process, both the carbon adsorption and membrane vapor separation technologies operate in their most favorable range.

The Phase I program demonstrated the feasibility of the hybrid carbon adsorption/membrane vapor separation process. The process was evaluated by using a small carbon drum to represent the carbon bed and a pilot-scale membrane system as the regeneration unit. The laboratory data were used to prepare an optimum process design and an economic and technical analysis. The analysis showed the process offers substantial operating cost advantages compared with steam regeneration. In Phase II, a 1,000-scfm proof-of-concept system will be constructed and operated in the laboratory and at a field site.

47. Novel High Efficiency Catalytic Converter for Utility and Other Engines
Precision Combustion, Inc.
25 Science Park
New Haven, CT 06511 (EPA Region 1)
(203) 786-5215
Dr. William C. Pfefferle, Principal Investigator
Mr. J. Kevin Burns, Business Representative

Amount of Award: $149,850

The thirteen million two and four-stroke gasoline utility engines sold in the U.S. each year are a major source of total U.S. air emissions. The California Air Resources Board (CARB) has set emissions standards for these previously unregulated devices, and the U.S. Environmental Protection Agency is now considering setting such standards.

In Phase I, the advantageous performance of Precision Combustion, Inc.'s innovative low cost utility engine catalytic converter was demonstrated through prototype testing. The emissions of hydrocarbon and carbon monoxide from both the two-stroke and a four stroke engine were reduced by 95-99%, to well below the CARB 1999 standards. NO_x emissions were not reduced, but can be controlled by other means (e.g., richer operation, EGR). The necessary excess air addition and cooling were accomplished simply and integrally to the converter.

In Phase II, optimized, manufacturable prototypes will be developed for several test engines, and long term durability will be demonstrated.

48. Novel Catalysts for the Low Temperature Oxidation of Volatile Organic Compounds
TDA Research, Inc.
12345 West 52nd Avenue
Wheat Ridge, CO 80033 (EPA Region 8)
(303) 940-2301
Mr. John D. Wright, Principal Investigator
Mr. Michael E. Karpuk, Business Representative
Amount of Award: $150,000

New regulations are forcing the control of very dilute volatile organic compound (VOC) emissions. Although catalytic incineration is increasingly the technology of choice, energy and catalyst costs rise dramatically as the VOC concentration decreases. Energy costs could be reduced dramatically if catalysts were available which were active at lower temperatures. In addition, the use of metal oxide based catalysts (instead of the platinum group catalysts currently used) would lower the initial cost of VOC control.

In Phase I, TDA Research synthesized and tested a fundamentally new type of metal oxide based catalyst that has the ability to oxidize CO, hydrocarbons and oxygenates at temperatures which are 100°C to 150°C (180°F to 270°F) lower than is possible with current catalysts. In Phase II, TDA will develop methods of supporting these catalysts on a honeycomb,determine the activity of the supported catalysts as a function of temperature against compounds representative of the various categories of VOC's, test their resistance to common catalyst poisons, and carry out an engineering analysis to determine their economic potential.

TOPIC J: WASTE REDUCTION AND POLLUTION PREVENTION

49. Mercury-Free High CRI Efficient Lamp
Fusion Systems Corporation
7600 Standish Place
Rockville, MD 20855 (EPA Region 3)
(301) 251-0300
Dr. Donald A. MacLennan, Principal Investigator
Dr. Leslie S. Levine, Business Representative
Amount of Award: $148,996

Fusion Systems Corporation's efficient, mercury-free, lamp has the potential of significant environmental mercury reduction by removing all mercury from light sources and by the reduction of electrical energy

consumption. During Phase I, they estimated the 96 LPW, buss bar, can be achieved in two years in a high-power mercury-free electrodeless, 480,000 lumen source. The 96 LPW figure represents a 140% improvement, closer to their Phase I objective of 150%. During Phase II, they will focus on improving bulb efficacy and starting, using the energy-saving ideas developed during Phase I. At the conclusion of Phase II work, they will have available tested high-efficiency mercury-free prototype bulbs. The major application, centralized/distributed lighting, would replace commercial fluorescent lamps with a high, efficiency mercury-free source. Centralized/distributed lighting has the potential to significantly reduce the total energy requirements associated with the heating, cooling, and illuminating of commercial and industrial buildings. Key to unlocking this commercial opportunity is the development of high powered, compact, high efficiency light sources that can be easily coupled to a centralized light distribution system.

50. An Aqueous-Based, Sulfur-Free Pulping Process - Phase II

Guild Associates, Inc.
4089 North Leap Road
Hilliard, OH 43026 (EPA Region 5)
(614) 876-5252
Mr. Salvatore T. DiNovo, Principal Investigator
Mr. Roy S. Brown, Business Representative
Amount of Award: $150,000

Kraft pulping, the accepted method for preparing chemical pulp for generations, is beset with problems. New kraft mills require enormous investments, over $1 millon per ton of pulp. An equally important problem is environmental aspects associated with the emissions of reduced sulfur compounds and the accompanying odors. These volatile sulfur compounds are pestiferous smelling gases which are released to the atmosphere. Thus siting a new kraft mill is virtually impossible. Another pollution problem exists with the nature of the pulp produced by the kraft sulfide reduction process. The pulp is very dark, requiring extensive bleaching. Bleaching is accomplished through use of chlorine, chlorine dioxide and sodium hypochlorite. These compounds are not only hazardous to handle but are implicated in the production of toxic organic chlorides (e.g., dioxins) which appear in the effluent wastewater streams and outfalls.

In Phase I, Guild Associates, Inc. proposed a process development effort which totally eliminated sulfur from the pulping process. Their target was to produce pulp at or below kappa no. 30. Phase I results demonstrated this capability unequivocally. Ancillary processing benefits in the chemical recovery section of the plan were also evident. The Phase II project will build on this base, examining key technical issues that were identified in Phase I as crucial to commercial development.

51. Elimination of Hazardous Waste Via Advanced Composite Dry Plating System

IonEdge Corporation
1713 Hull Street
Fort Collins, CO 80526 (EPA Region 8)
(303) 223-0665
Mr. Madar Sunthankar, Principal Investigator amd Business Representative
Amount of Award: $150,000

Liquid chemical electroplating is known to generate large quantities of solid and liquid waste. On the other hand, a unique dry plating process developed by the IonEdge Corporation eliminates liquid chemical and recycles pure solid metals in situ during plating. Recently, a composite electroplating process has emerged as an alternative to hazardous cadmium electroplating in the fastener industry. The feasibility of dry plating this composite in an environmentally safe manner was demonstrated in Phase I.

The dry plating of the composite was developed using a laboratory set-up. In Phase II, the IonEdge Corporation proposed to advance this method into a pilot-scale batch plating process and system. This apparatus

will be a scaled-up model of the Phase I proof-of-concept. The in situ reclaim features of the dry plating process will be incorporated. The physical properties of the composite will be optimized using statistical design of experiments. The composite plated components will be tested for commercial applications. After successful demonstration, the system will be evaluated on pilot-line by the commercial collaborators of IonEdge during Phase III.

52. Elimination of Toxic Effluent and Metallizing Process Waste via Jet Vapor Deposition

Jet Process Corporation
25 Science Park
New Haven, CT 06511 (EPA Region 1)
(203) 786-5130
Dr. Bret L. Halpern, Principal Investigator
Mr. Jerome J. Schmitt, Business Representative
Amount of Award: $150,000

Jet Vapor Deposition (JVD) is Jet Process Corporation's innovative, patented, proprietary process for manufacturing high quality coatings on substrates for diverse industrial consumer and military applications. JVD can be used to efficiently deposit many types of metal, ceramic and semiconductor coatings at low cost and high rate. The new JVD process is clean, dry, non-toxic, and pollution free. In this program of SBIR research, Jet Process Corporation further developed JVD's ability to compete technically and economically with electroplating. Electroplating is a major industrial process which generates significant water pollution nationwide. There can, therefore, be important environmental benefits if JVD is able to replace electroplating in major applications. There would be a significant reduction in generation of process waste and toxic effluent. In Phase I, Jet Process Corporation succeeded in broadening JVD's capabilities by developing jet sources for the important electroplating metals: chromium, nickel, copper, zinc, iron, tin, and silver. Jet Process Corporation tested the sample metal coatings and verified that quality was equivalent to or better than conventional coatings. They also deposited test coatings on larger substrates, and devised a reel-to-reel mechanism for JVD deposition on tapes. They investigated means to recycle JVD process gases. They analyzed the economics and projected markets for JVD processing. The latter effort involved significant communication with potential commercial customers of JVD processing service and equipment; in several cases, they supplied prototype coatings to those potential customers. They also succeeded in profitably supplying JVD production coating service to a commercial client, AT&T Bell Labs; based on this production, Jet Process Corporation have further proof of JVD's ability to compete on price and performance with electroplating. In sum, the Phase I effort succeeded in all respects, providing compelling evidence that JVD has enormous potential as a low-cost, pollution-free coating process, capable of displacing electroplating. Jet Process Corporation proposes in Phase II to build on their Phase I success and develop the JVD process further so that they may commercialize it widely in Phase III. General Electric Company (GE) has written a letter in support of this proposal; Jet Process Corporation plans to work with GE during Phase II.

53. Waste Reduction Through Benzene-Free Polymerization Technology

KSE, Inc.
P.O. Box 368
Amherst, MA 01004 (EPA Region 1)
(413) 549-5506
Dr. J. R. Kittrell, Principal Investigator and Business Representative
Amount of Award: $149,949

Waste reduction can be a highly cost-effective means of pollution control, by modifying the basic technology to fundamentally alter the raw materials used. Many organic chemical reactions use benzene as a classical reaction solvent, and are excellent waste reduction candidates.

In Phase I, the elimination of benzene as a solvent in a free radical organic polymerization process has been achieved, to produce a very high profile consumer product. All Phase I objectives have been met, providing critical

confirmation of the technical feasibility of using a novel "solvent-free" approach. The process has been scaled up to 1000 pound levels. As a result of an order of magnitude enhancement of reactor productivity, over 200% return on investment is forecast for production capacity less than 10% of the U.S. market. The elimination of benzene promises not only to be an effective waste reduction process, but also to provide technology which is more efficient and cost-effective than that based on the classical benzene technology.

A Phase II program is proposed to enhance ancillary polymer properties, to explore applications of the technology to a new derivative product, and to finalize manufacturing cost estimates and financial return forecasts.

54. Development of an Ultrasonic Prototype Instrument to Replace an Environment-Polluting Measurement Practice in the Composite Materials Industry

Xxsys Technologies, Inc.
4619 Viewridge Avenue
San Diego, CA 92123 (EPA Region 9)
(619) 974-8200 ext. 22
Dr. Yan Li, Principal Investigator
Mr. James L. Russell, Business Representative
Amount of Award: $150,000

The objective of this Phase II proposal is to develop an ultrasonic Lamb wave demonstration prototype to replace a widely-used, environmentally polluting industrial practice in composites manufacturing. The goal is to dramatically reduce industrial wastes and minimize health hazards to workers. The current practice generates about 1 million gallons of industrial wastes per year. Composites are increasingly replacing metals in many applications. This megatrend of metal replacement means increasing testing and escalating production of industrial wastes.

Phase I of this program developed an innovative waveguide design for selecting the Lamb wave mode and frequency to be transmitted and received. It demonstrated that propagation velocity of symmetrical mode Lamb waves, combined with accurate cutting and weighing, can be used to determine both resin content and fiber areal weight with high precision. Phase II will focus on the manufacture of a demonstration prototype to be used for validation of Lamb wave technology for measurement of resin content and fiber areal weight of uni-directional graphite prepregs, and for evaluation of its applicability to woven prepregs. Success in this program will alleviate the toxic waste problem anticipated as the megatrend of metal replacement accelerates in the next decade.

TOPIC L: IMPROVED MEASUREMENT TECHNOLOGIES FOR LEAD DETECTION IN LEAD-BASED PAINTS

55. Improved Technology for Measuring Lead Detection in Lead-Based Paint Phase II

Niton Corporation
74 Loomis Street, P.O. Box 368
Bedford, MA 01730-0368 (EPA Region 1)
(617) 275-9275
Dr. Charles G. Parsons, Principal Investigator
Ms. Anne McGuineas, Business Representative
Amount of Award: $150,000

Lead paint is a primary source of lead poisoning, particularly in children. A central problem to a more vigorous attack on finding lead-paint surfaces is the lack of an inexpensive, portable method for measuring levels of lead in concentrations as least as low as 1 mg per cm^2. In Phase I, Niton Corporation proposed to show the L x-ray lines of lead rather than K x-rays could be used to measure lead concentrations buried beneath many layers of non-lead paint. They further proposed to develop a portable, high-resolution detector of L x-rays of lead. They have surpassed all of the goals of Phase I. They have proved that L x-ray fluorescence can quickly measure lead

concentrations to well below 1 mg/cm^2, even when the lead is covered by many layers of paint of unknown thickness and composition. Niton Corporation has built a laboratory prototype of a small, portable unit, with excellent energy resolution and spectrum analysis, that demonstrates the effectiveness of the method. The response from lead inspection professionals has been very positive. It is the primary purpose of Phase II to develop the technique further with the specific aims of dramatically reducing the costs of the instrument. The commercial potential for such an instrument is extremely high.

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