Quarterly Progress Report:

Fourth Quarter Fiscal Year 1990

DOE Solar Industrial Program

Submitted By

Solar Energy Research Institute
Golden, Colorado

Sandia National Laboratories
Albuquerque, New Mexico

Issued October 1990

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FOREWORD

The research and development described in this report were conducted within the U.S. Department of Energy's Solar Thermal Technology Program. Quarterly reports for the Program are prepared jointly and report the work of both major field laboratories, the Solar Energy Research Institute and Sandia National Laboratories, and their contractors.

At the beginning of fiscal year 1990, the Solar Thermal Technology Program included both the Electric and Solar Industrial Applications and related research and development. With the recent reorganization within the Department of Energy's Office of the Assistant Secretary for Conservation and Renewable Energy, the Solar Thermal Technology Program has been split into two separate efforts. One is aimed at solar thermal electric application, and the other focuses on industrial applications of solar technologies.

The laboratories intend to maintain joint reports for each of the two programmatic areas. This report specifically describes the work included in the Solar Industrial Applications. A companion report is prepared for the Solar Thermal Electric Technology.

MANAGEMENT STATUS REPORT

Structure of the Solar Industrial Applications

The Solar Industrial Applications Program is structured to focus on a number of opportunities in commercialization for the solar technology while maintaining a baseline of research and development which is essential to achieving the long-term technological goals. The following elements constitute work under Solar Industrial Applications: Solar Detoxification Systems, Advanced Industrial Applications, and Industrial Applications Assistance Center.

Field Management--Structure and Responsibilities

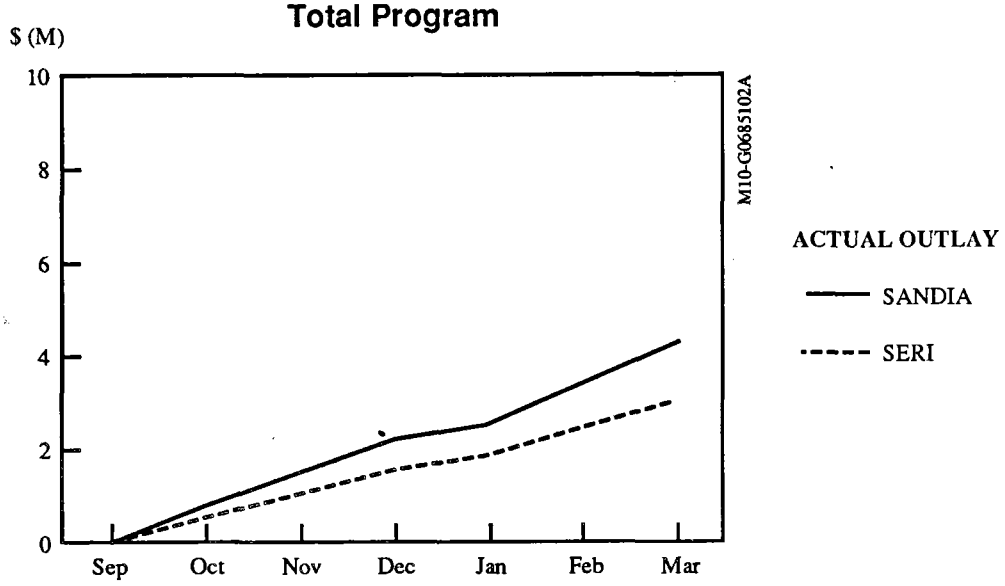
The lead responsibility for the implementation of the Solar Industrial Program is assigned to the Solar Energy Research Institute in Golden, Colorado. The two field laboratories, SERI and Sandia, are responsible for implementation of the research, development, and commercial application of the solar technologies. Activities are conducted both in-house at the laboratories and through subcontracts placed with private industry, other research organizations, and universities. In order to provide a clear delineation of management responsibilities for each programmatic activity, a lead responsibility is assigned for each of the current categories.

SOLAR THERMAL TECHNOLOGY PROGRAM
WORK BREAKDOWN SCHEDULE

PROGRAM ACTIVITY	LEADER (Individual)
Solar Detoxification Systems	J. Anderson, SERI C. Tyner, SNL
Advanced Industrial Applications	M. Carasso, SERI
Industrial Applications Assistance Center	B. Gupta, SERI

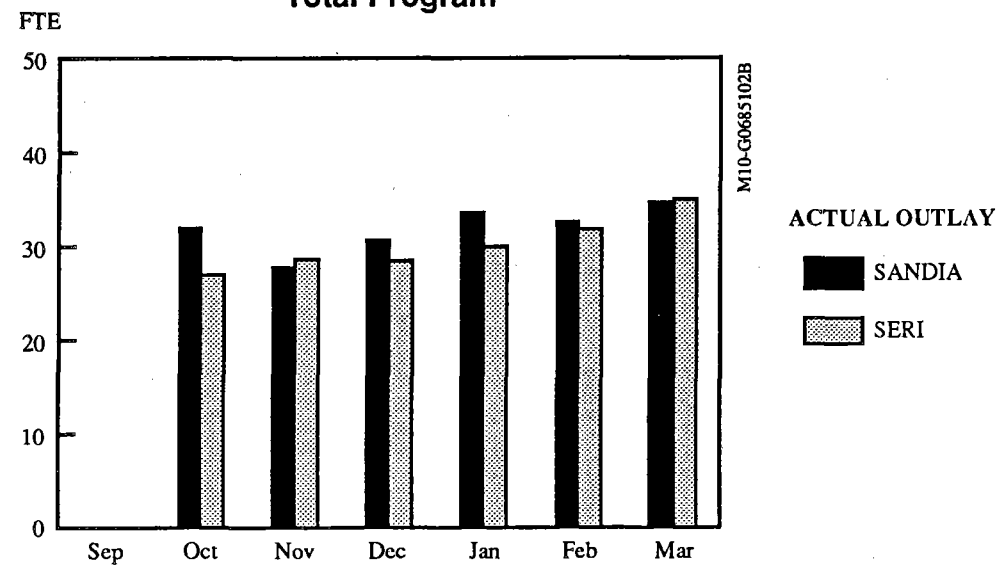
Resource Summary

BUDGET STATUS
Total Program



FISCAL YEAR 1990

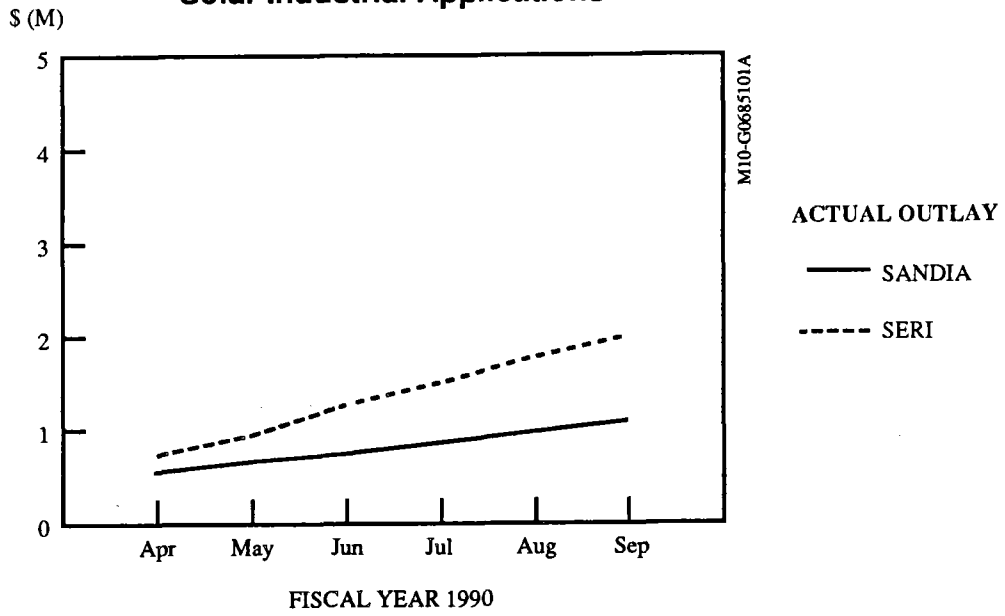
MANPOWER STATUS
Total Program



FISCAL YEAR 1990

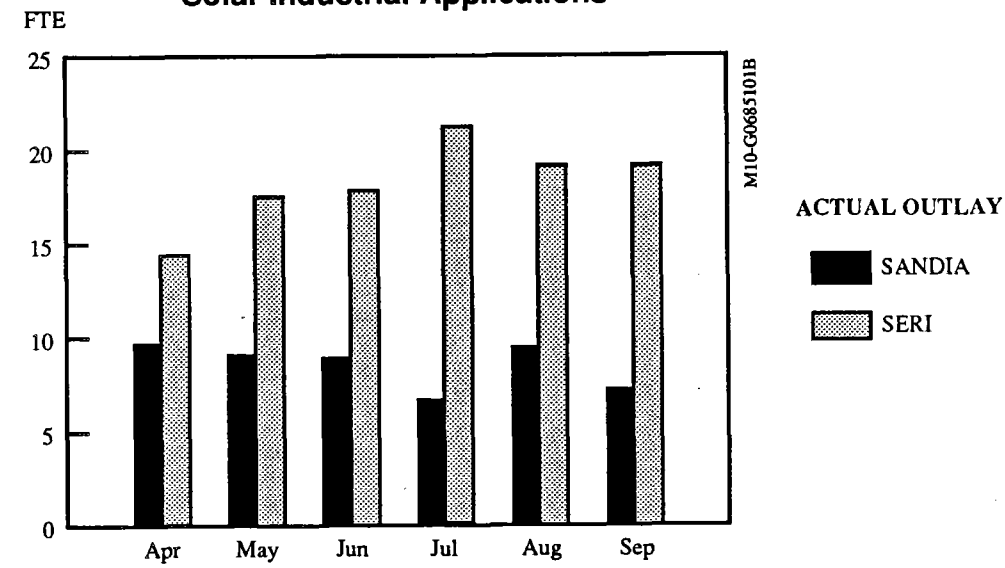
Resource Summary

BUDGET STATUS
Solar Industrial Applications



FISCAL YEAR 1990

MANPOWER STATUS
Solar Industrial Applications



FISCAL YEAR 1990

SOLAR THERMAL SUBCONTRACTS
PROCUREMENT PLAN AND STATUS SUMMARY

Task	Specific Contract Subject	Contractor	Lab Contract Number ($K)	Present Contract Value ($K)	Prior Year Funds ($K)	FY 1990 Funds	Period of Performance	Contract Type	Major Reports	Project Monitor
AIA	High Solar Flux Concentration	Univ. of Chicago	SERI X-06019-02	$100	$100	--	10/89-10/90	Univ.	TBD	B. Gupta
AIA	Chemical Research	University of Houston	SERI X07028-01	$200	--	$186	04/89-03/90	Univ.	Topical Report	G. Glatzmaier
Sol. Detox.	Solar Detox.	University of Arizona	SERI X-10035-01	$54	--	$54	01/90-02/91	Univ.	Topical Report	H. Link
AIA	Carbon Fibers	Georgia Tech	SNL40-2672	$260	$260	--	06/89-05/91	Univ.	TBD	G. Kolb
Sol. Detox.	Catalyst Development and Reactor Modeling	University of Houston	SNL55-4032	$225	--	$75	01/88-09/90	--	--	J. Sprung
Sol. Detox.	Solar Incineration of Hazardous Waste	University of Dayton	SERI X-06082-1	$170	--	$170	03/90-	Univ.	--	G. Glatzmaier
AIA	Design Installation of Instrument	Dan-Ka Products	SERI X-10081-01	$31		$31	06/90-12/90	Ind.	--	A. Lewandowski
Sol. Detox.	MBMS Data	TDA Research	SERI X-10070	$33	--	$33	04/90 - 04/01	Ind.	--	T. Milne
AIA	High Flux Processes	SRI Intn'l.	SERI X-10113	$100	--	$100	08/90 - 02/91	Ind.	--	M. Carasso

SOLAR THERMAL SUBCONTRACTS
PROCUREMENT PLAN AND STATUS SUMMARY

Task	Specific Contract Subject	Contractor	Lab Contract Number	Present Contract Value	Prior Year Funds	FY 1990 Funds	Period of Performance	Contract Type	Major Reports	Project Monitor
			($K)	($K)	($K)					
Sol. Detox.	Chemical Mechanisms	Univ. of N.C.	SERI	$100	--	$100	09/90 - 09/91	Univ.	--	D. Blake
Sol. Detox.	Solar Inc. of Hazardous Waste	Univ. of Dayton	SERI	$25	--	$25	06/90 -	Univ.	--	G. Glatzmaier
Sol. Detox.	Conceptual Design--Detox Plant	Bechtel	SNL 668697	$86	$86	--	07/90-02/91	Ind.	TBD	D. Alpert

KEY

AIA = Advanced Industrial Applications
Sol. Detox. = Solar Detoxification Systems
NOTE - This list contains subcontracts exceeding $25,000.

Major Milestone Schedule

The major milestones for each program task are summarized below in chronological order and by task reference. This set of major milestones forms the basis for progress reporting and tracking in this Quarterly Progress Report. Quarterly reports focus on the status of each milestone for the current quarter in the SIGNIFICANT ACCOMPLISHMENTS SUMMARY.

Laboratory--Date		Activity-Task Reference	Descriptive Title
Fiscal Year 1990			
First Quarter, FY 1990			
SN	December, 1989	1A-3	Complete CAESAR experiments using a non-uniform absorber.
SE	December, 1989	1B	High-Flux Solar Furnace operational.
SE	February, 1990	1A-2	Identify potential photocatalysts that will extend the active region toward the visible in the solar spectrum and assess the potential for improving the efficiency of water treatment.
Second Quarter, FY 1990			
SE	March, 1990	1A-3	Compare PIRs in photo, catalytic and thermal processes in order to show the benefits of the solar process.
SN/ SE	March, 1990	4A-3	Participate in the SOLTECH90 joint meeting.
SN/ SE	March, 1990	4B-1	Conduct a workshop for industrial participants at SOLTECH90 to encourage industrial involvement in photochemical systems.
Third Quarter, FY 1990			
SN	April, 1990 (September, 1990)	1A-3	Complete draft final report documenting the CAESAR experiments.
SN	May, 1990	1C	Review and evaluate merits of carbon fiber treatment with high solar flux.
SE	June, 1990	1B	Identify optical components for a wavelength shifting system and document expected efficiencies in solar applications.

Laboratory	Date	Activity-Task Reference	Descriptive Title
SE	June, 1990	4B-2	Complete tests on multiple compound mixtures that model those found in real sites under consideration for system experiment.
Fourth Quarter, FY 1990			
SE	July, 1990	1C	Evaluate the benefits of solar surface treatment of metals for specific applications.
SN	August, 1990 (February, 1991)	4B-1	Complete a conceptual design of a commercial-scale system for solar detoxification of water.
SE	August, 1990	4B-2	Select a preferred catalyst immobilization scheme for use in the first system experiment.
SE	August, 1990	4B-3	Identify the most promising applications of the solar detoxification of hazardous waste processes, develop a conceptual configuration, and compare the system performance and cost with conventional alternatives.
SE	September, 1990	1A-1	Assess the availability of near ultraviolet component of global normal and diffuse radiation at the Golden, Colorado, site and document a model that will allow predictions to be made at other sites.
SE	September, 1990	1A-3	Determine quantum yields for destruction of representative hazardous organic compounds in a high-flux system.
SN	September, 1990	1A-3	Complete initial phase survey of steam reforming of representative toxic organic solvents.
SE	September, 1990	4B-1	Complete site selection process for the first system experiment.

Laboratory--Date	Activity-Task Reference	Descriptive Title
Fiscal Year 1989		
(November, 1989)	C1-3	Convene an advisory group to evaluate progress and promise of carbon fiber treatment with concentrated solar flux, based on work at GTRI.
(March, 1990)	C1-1	Obtain results from laboratory experiments to explain the role of ultraviolet radiation (wavelength) in decomposition of toxic chemicals.
(December, 1989)	C1-2	Assess merit of scaling up laser experiments and optical concepts for achieving a source of lower wavelength laser beam.
(TBD)	M2-3	Complete CAESAR experiment.

NOTE: Dates that are in parentheses indicate a rescheduling.

SIGNIFICANT ACCOMPLISHMENTS SUMMARY

MAJOR MILESTONE		PLANNED	ACTUAL
o Evaluate the benefits of solar surface treatment of metals for specific applications. --This milestone was completed as scheduled.	SE (1C)	07/90	07/90
o Complete a conceptual design of a commercial-scale system for solar detoxification of water. --This milestone has been rescheduled.	SN (4B-1)	08/90 (02/91)	
o Select a preferred catalyst immobilization scheme for use in the first system experiment. --This milestone was completed as scheduled.	SE (4B-2)	08/90	09/90
o Identify the most promising applications of the solar detoxification of hazardous waste processes, develop a conceptual configuration, and compare the system performance and cost with conventional alternatives. --This milestone was completed as scheduled.	SE (4B-3)	08/90	08/90
o Assess the availability of near-ultraviolet component of global normal and diffuse radiation at the Golden, Colorado, site and document a model that will allow predictions to be made at other sites. --This milestone was completed as scheduled.	SE (1A-1)	09/90	09/90
o Determine quantum yields for destruction of representative hazardous organic compounds in a high-flux system. --This milestone was completed as scheduled.	SE (1A-3)	09/90	09/90
o Complete initial phase survey of steam reforming of representative toxic organic solvents. --This milestone was not completed and is being rescheduled.	SN (1A-3)	09/90	
o Complete site selection process for the first system experiment. --This milestone was completed as scheduled.	SE (4B-1)	09/90	09/90
o Complete draft final report documenting the CAESAR experiments. --This milestone was completed as rescheduled.	SN (1A-3)	04/90 (09/90)	09/90

NOTE: Dates that are in parentheses indicate a rescheduling.

TECHNICAL STATUS REPORT

SOLAR DETOXIFICATION SYSTEMS

Objective

In collaboration with industrial partners the intent of this work is to develop systems that will result in a solar-driven process that destroys toxic chemicals.

A. SOLAR DETOXIFICATION OF WATER

Accomplishments

System Analysis

- **The analysis of cost and performance of systems for solar detoxification of water was completed.**

  A revised version of the analysis of systems for solar detoxification of water was completed and transmitted to DOE-Headquarters. The analysis compares solar water detoxification to two conventional systems: granulated activated carbon and lamp-driven, advanced oxidation.

  A major change in this revision included the use of cost estimates and a methodology of estimating cost from the National Priority List (Superfund) site at Lawrence Livermore National Laboratory. This site is representative of a large number of sites throughout the U.S. that suffer from groundwater that is contaminated with volatile organic compounds. It also will be the site of the first field experiment of the system for solar detoxification of water. The analysis indicates that, in addition to reduced environmental impact, the solar detoxification system will be most cost effective when compared to both granulated activated carbon and lamp-driven systems (Figure 1). When final revisions of this document are complete, it will form an important technical document for explaining the solar detoxification program. (SERI)

- **A contract was placed with the Bechtel Corporation for conceptual design of a solar detoxification facility.**

  A contract was placed with the Bechtel Corporation to develop a conceptual design for the solar water detoxification facility. The conceptual design will provide a basis for planning the first field demonstration of a complete facility for the solar detoxification of water (now planned for FY 1992) and will identify any key technical or regulatory issues that must be addressed before the demonstration is fielded. Bechtel also will prepare a plan for obtaining the necessary permits for operating the facility and an estimate of its installed and operating costs. The project is scheduled to be completed in February, 1991. (SNL)

- **Proposals were received for the market assessment of the solar detoxification of water.**

  Proposals for the market assessment of the solar detoxification of water were received. The bidders all represented important players in the waste management industry, all of whom do basic research; develop and evaluate new technologies; and perform remediation work for government and industry. Among these bids, there were several excellent proposals. The technical evaluation team completed

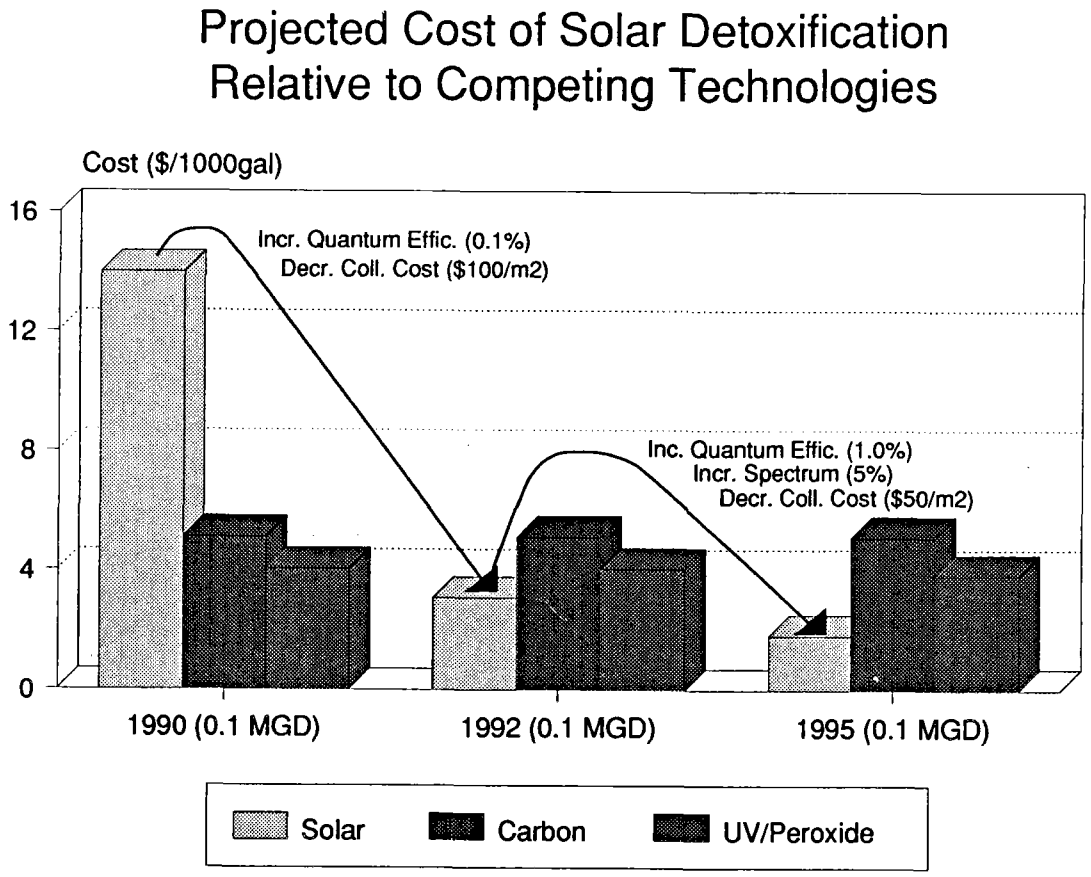


Figure 1. Projected Cost of Solar Detoxification Relative to Competing Technologies

its review of the packages and has made its recommendation for subcontracting. A business evaluation will be completed, and negotiations should begin with the selected bidder in the first quarter of 1991, with the issuance of the subcontract following shortly. (SERI)

- **Researchers completed a preliminary model for predicting the ultraviolet resource.**

Researchers have completed the draft of a report that correlates near-ultraviolet solar flux with full-spectrum flux. The correlation provides information on both direct-normal flux (for solar concentrating systems) and global-horizontal flux (for nonconcentrating systems). Figure 2 shows the ratio of five-minute averages of global-horizontal near-ultraviolet flux to full-spectrum flux as a function of an atmospheric cloudiness or clearness index (Kt), as measured at SERI's Solar Radiation Research Laboratory in Golden, Colorado, in 1989. Kt is the ratio of global-horizontal flux to extraterrestrial flux on a horizontal surface, or an indicator of bulk atmospheric transmittance. Under clear skies (Kt > 0.60), the near-ultraviolet constitutes about 5 percent of the total-spectrum flux at this site. As atmospheric transmittance decreases (due to clouds, haze, or higher air mass values), the global-horizontal near-ultraviolet flux decreases, but not as fast at the total-spectrum flux. Thus the ratio increases. The ratio of direct-normal near-ultraviolet flux to full-spectrum direct-normal flux is a strong function of air mass, and the effects of clouds would depend on whether or not the clouds obscure the sun's disk. These types of correlations permit researchers to estimate the performance of solar-driven, photocatalytic systems based on readily available resource maps of full-spectrum solar flux. This report completes the requirements for Milestone 1A-1. (SERI)

Laboratory Testing

- **A new catalyst treatment shows promise.**

Laboratory tests in September have increased confidence in the efficacy of a new catalyst treatment. The potentially patentable treatment had shown improved destruction rates of salicylate in August, 1990. September tests showed that the treatment also improved destruction rates of p-dichlorobenzene. P-dichlorobenzene has characteristics similar to those of trichloroethylene and other common solvents that are frequently found in contaminated groundwater. Tests also indicated that the treatment slowed or prevented a loss in catalyst activity over time. These results suggest that a relatively simple catalyst treatment can increase activity and lifetime of the supported catalyst—two very important characteristics of the catalyst to be used in a commercial detoxification system. (SERI)

- **Heat treatment of the catalyst also improved performance.**

Tests conducted with heat-treated TiO_2 provided more information on the advantages of this second option for catalyst treatment. The first series of tests indicated that catalyst activity increased by as much as a factor of twenty with one heat treatment. Subsequent tests indicated that heat-treating the catalyst that had been mounted on a fixed support also improved activity, although to a lesser extent. Tests also indicated a variety of phenomena that are not yet understood. Of particular note is that increases in activity tend to disappear with age. Aging seems to be affected by exposure to light and by immersion in water, although some evidence indicates that even a dry, stored catalyst is affected. Additional experiments are being conducted to better characterize and, hopefully, to minimize this aging effect. (SERI)

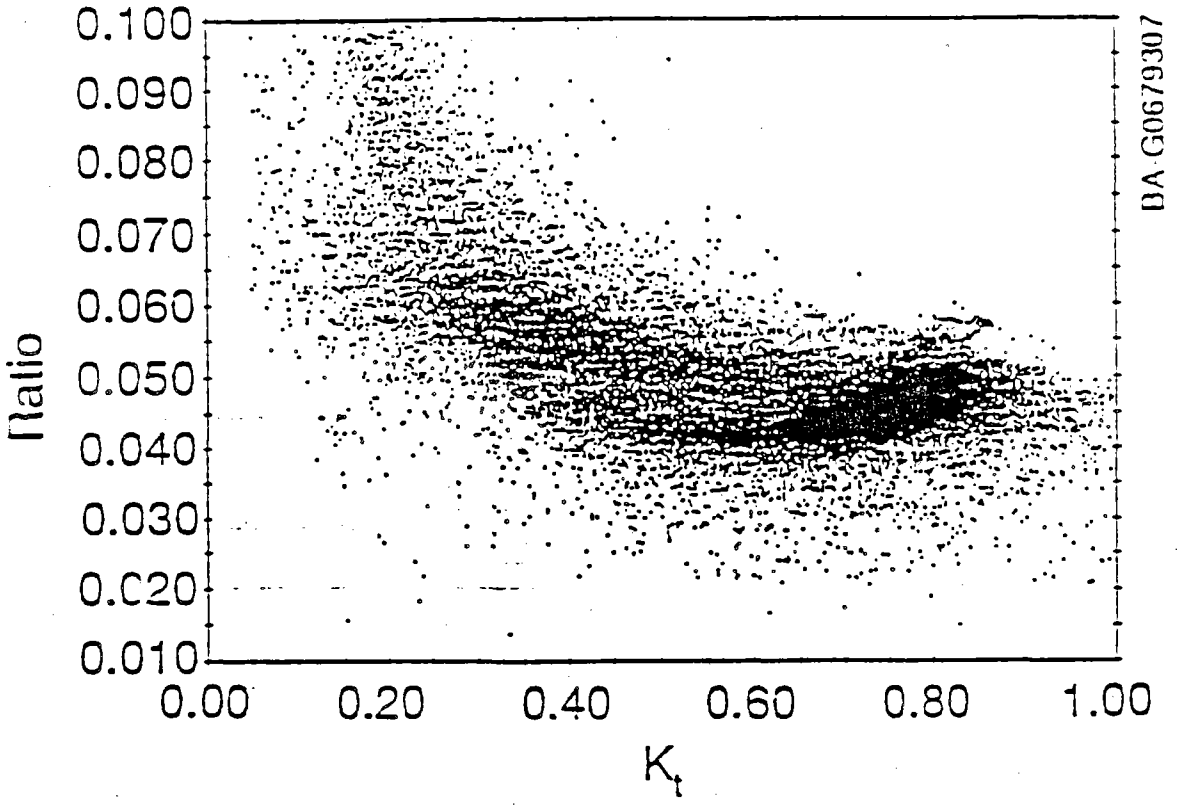


Figure 2. **Ratio of five-minute averages of near-ultraviolet (300-385 nm) in w/m^2 to full spectrum global-horizontal flux as a function of an atmospheric cloudiness/clearness index, Kt (see text). Measurements were taken at SERI's Solar Radiation Research Laboratory in Golden, Colorado, during 1989.**

- **A new indoor trough concentrator is on-line for catalyst tests.**

  A new test apparatus is now providing important information on performance of fixed catalysts. The new apparatus is a small indoor trough which duplicates the receiver configuration presently being used in both SERI's outdoor trough and Sandia's two-meter-wide trough. The indoor trough will permit testing of a variety of configurations for catalyst support under controlled conditions independent of weather. Since the indoor trough is only two feet long, potential configurations for catalyst support can be tested easily and economically. Initial tests have provided information on pressure drop for the mesh support likely to be used at the first field experiment. (SERI)

- **Bicarbonate has been shown to decrease destruction rates.**

  Laboratory experiments involving the photodegradation of trichloroethylene (TCE) in water spiked with sodium bicarbonate have shown that bicarbonate levels of 500 ppm can significantly decrease the observed rate of TCE destruction. Preliminary experiments had implied that bicarbonate did not reduce rates of destruction for TCE. However, later replicate experiments indicated that bicarbonate decreased the rate by a factor of 2 to 5 as shown in Figure 3. The observed variability in reaction rates is likely caused in part by the difficulty of adjusting the pH of unbuffered solutions (bicarbonate is a natural buffer). Analysis of kinetic rates for experiments with TCE and salicylate indicates that bicarbonate is much more likely to interfere with TCE destruction than with salicylate destruction. Groundwater at the field experiment site contains both TCE and bicarbonate. Therefore, knowledge of the reaction rate for TCE in the presence of bicarbonate is essential for predicting system performance and possible options for water pretreatment. (SERI)

- **The broader range of solar flux levels was tested.**

  Researchers have completed experiments that quantify the effect of light intensity on the destruction rate over a broader range of light intensities. Previous tests had investigated intensities ranging from 20 suns to 200 suns, typical of (or higher than) those achieved by high-performance trough concentrators. New tests studied intensities from 0.5 sun to 3 suns. Preliminary analysis of these test results supports the findings that photons are used more efficiently at lower light intensities. The change in efficiency is not readily quantifiable because it depends on specifics of the test apparatus and the type of contaminant and concentration. These results suggest that selection of an appropriate collector-concentration ratio will depend as much on collector cost and reactor performance as on efficiency of photon utilization. (SERI)

- **A model has been developed to predict times of destruction.**

  Researchers developed a simple phenomenological equation to calculate the time required to destroy a given amount of contaminant. This equation accounts for the production of intermediate compounds in the destruction process. If no significant amounts of intermediates are formed (as in the destruction of trichloroethylene), the equation reduces to the integrated form of the Langmuir-Hinshelwood equation. This more complete equation will be of major importance when more complicated organic materials, such as pesticides, are being destroyed. (SERI)

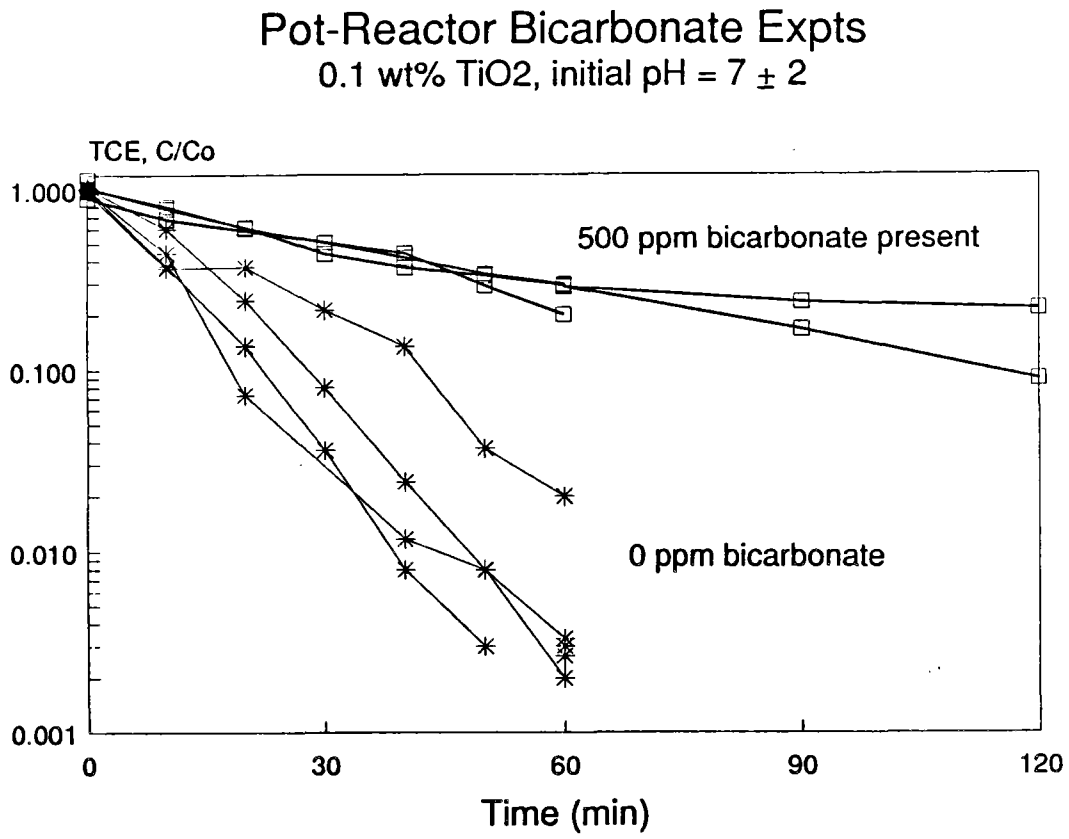


Figure 3. TCE/Bicarbonate Experiments

Solar Testing

- **Continuous ultraviolet monitoring is now on-line.**

Instrumentation installed at SERI's Solar Radiation Research Facility is being used to monitor both global horizontal and direct normal radiation in near-ultraviolet wavelengths ($360 < \lambda < 385$ nm). These instruments are providing continuous measurements alongside other instrumentation that is measuring full-spectrum radiation and atmospheric conditions. The data resulting from these measurements will permit researchers to better understand and to characterize the relationship between near-ultraviolet radiation and full-spectrum radiation. These characterizations will improve the accuracy with which the performance of solar-driven, photo-catalytic systems can be predicted. (SERI)

- **Designs of a fixed catalyst reactor were tested.**

Tests in the outdoor trough in this quarter provided performance data on three catalyst support configurations. (Figure 4). The tests provided both rates of contaminant destruction and pressure-drop data. In each of the configurations the catalyst was supported on a fiberglass mesh in a coating developed by Nulite Corporation of Ontario, Canada.

Initial tests had indicated that the mesh was almost as effective as catalyst slurries in destroying trichloroethylene. Subsequent tests identified some limitations to this good performance. First, destruction rates were found to have an unexpectedly strong relationship to water velocity through the reactor. This relationship is probably caused by reduced mixing of water and catalyst at the lower flow rates. The use of higher flow rates should increase destruction rates. A new pump is presently being installed, will allow testing at higher flow rates, but may also lead to excessive pressure loss through the reactor.

Second, two batches of mesh showed a significant reduction in catalyst activity after only a few tests. Figure 5 shows this effect. Similar types of reductions also have been seen in some cases in laboratory tests. However, the mechanism for this change is not yet understood. Future tests will investigate possible measures to prevent or reverse this reduction in activity.

The three configurations degraded trichloroethylene with similar efficiencies. This finding was somewhat unexpected, since the second two configurations should have provided better mixing of water and catalyst than the first configuration. Since the first configuration is quite simple to fabricate and had the lowest pressure loss, future tests in the outdoor tough will use the first configuration.

The results of these tests in the outdoor trough are crucial to the design of the field experiment. Unless a significantly better configuration for catalyst support is identified within the next few months, the mesh support is likely to be selected for that experiment. Performance, optimum operating conditions, and lifetime need to be well defined prior to the construction of that experiment. (SERI)

- **Large-scale experiments of water detoxification continued.**

Tests of solar detoxification of water continued in the large parabolic trough facility (450 square meters). The goal of this programmatic element is to demonstrate the feasibility of solar-driven destruction of organic compounds at a scale large enough to be practical for industrial applications.

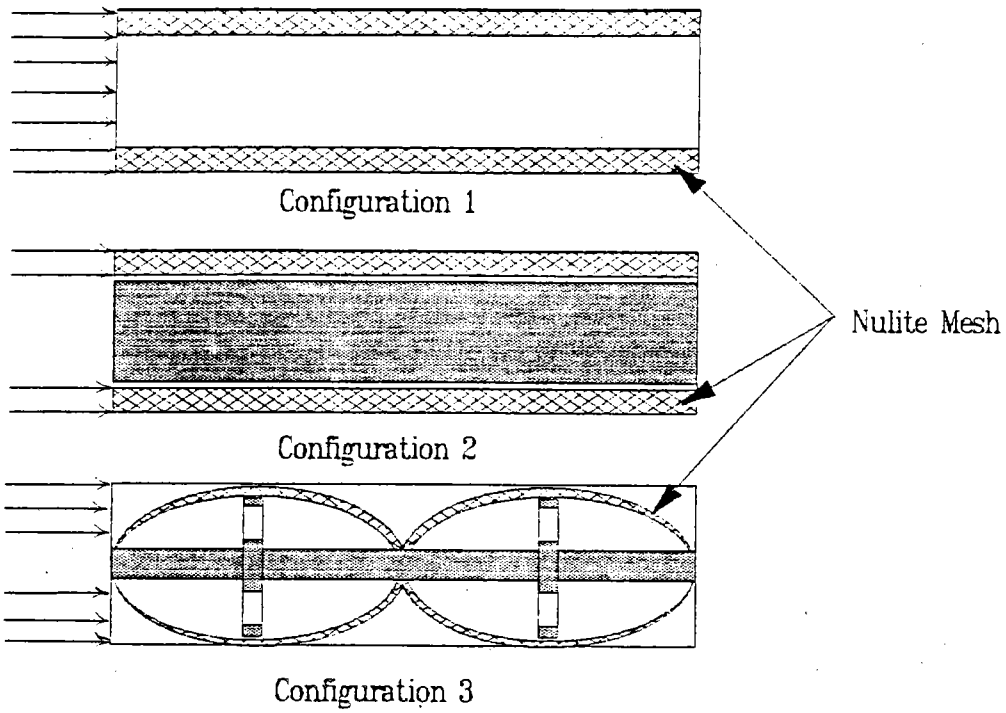


Figure 4. Catalyst Support Configurations

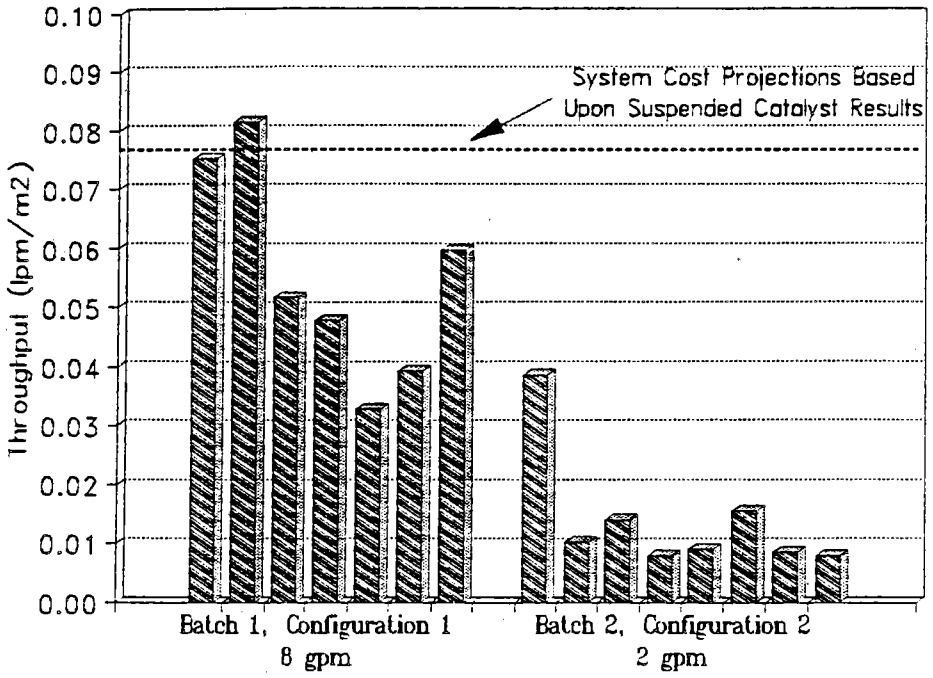


Figure 5. Nulite Mesh Configuration Experiments SERI Outdoor Trough

This quarter, experiments were performed to determine the destruction rates of TCE, TCA, and a mixture of the two compounds. The results are shown in Figure 6. The initial concentration of each compound was approximately 2 ppm. As expected, based on previous work in the literature, the destruction rate of TCA alone is much slower than for TCE (the circles). When the two are mixed (triangles), the rate of destruction of each component was not affected by the presence of the other. This critical result indicates that system designs will be determined by the concentration of the contaminant with the slowest rate of destruction. (SNL)

- **Rates of destruction in the large trough facility are slower for groundwater than for deionized water.**

Rates of destruction were determined for groundwater spiked with TCE. The groundwater was from a well (275 feet deep) and had not been chlorinated. Figure 7 compares destruction rates for TCE-spiked groundwater and deionized water. The destruction rate in groundwater is somewhat slower than in deionized water. Similar results have been reported by researchers using laboratory-scale equipment and a small trough. Groundwater contains a number of chemical species, such as carbonates and iron, that could inhibit the photocatalytic destruction process by scavenging hydroxyl radicals. An analysis of the water's ion content will be completed early next quarter. (SNL)

- **Development of an automated control system is underway.**

The design of an automated system to control processing rates and flows in a water detoxification system was initiated. The system will use a combination of measured ultraviolet intensity and outlet water temperature to control the processing rate and to determine if recirculation is required. Parts for the system have been ordered, and programming of a micro-computer is underway. The system will be tested first at the large trough facility, and a similar system will be installed at the planned field experiment at Lawrence Livermore National Laboratory. (SNL)

- **Calibration and characterization of a headspace gas chromatograph were completed.**

The headspace gas chromatograph was characterized and calibrated to determine the effects of bath temperature, equilibration time, sampling variation, and the presence of titanium dioxide on the response of the detector. Optimum bath temperature, equilibration times, and sources of scatter in the data were determined and documented. A standard calibration procedure for the gas chromatograph was developed. This work will be vital in understanding the source and magnitude of uncertainties in the measured concentration of organic compounds. (SNL)

- **Checkout of International Light's ultraviolet normal incident pyroheliometers was completed.**

Sandia's Primary Standards Laboratory completed its evaluation of the design and performance of International Light's ultraviolet detectors. An evaluation was required because these units are the only ultraviolet normal incident pyroheliometers that International Light has made. After making several modifications in the design, including the size of an internal aperture plate, researchers now have sufficient confidence in the units to send them to SERI for calibration with the researchers' Eppley instrument. (SNL)

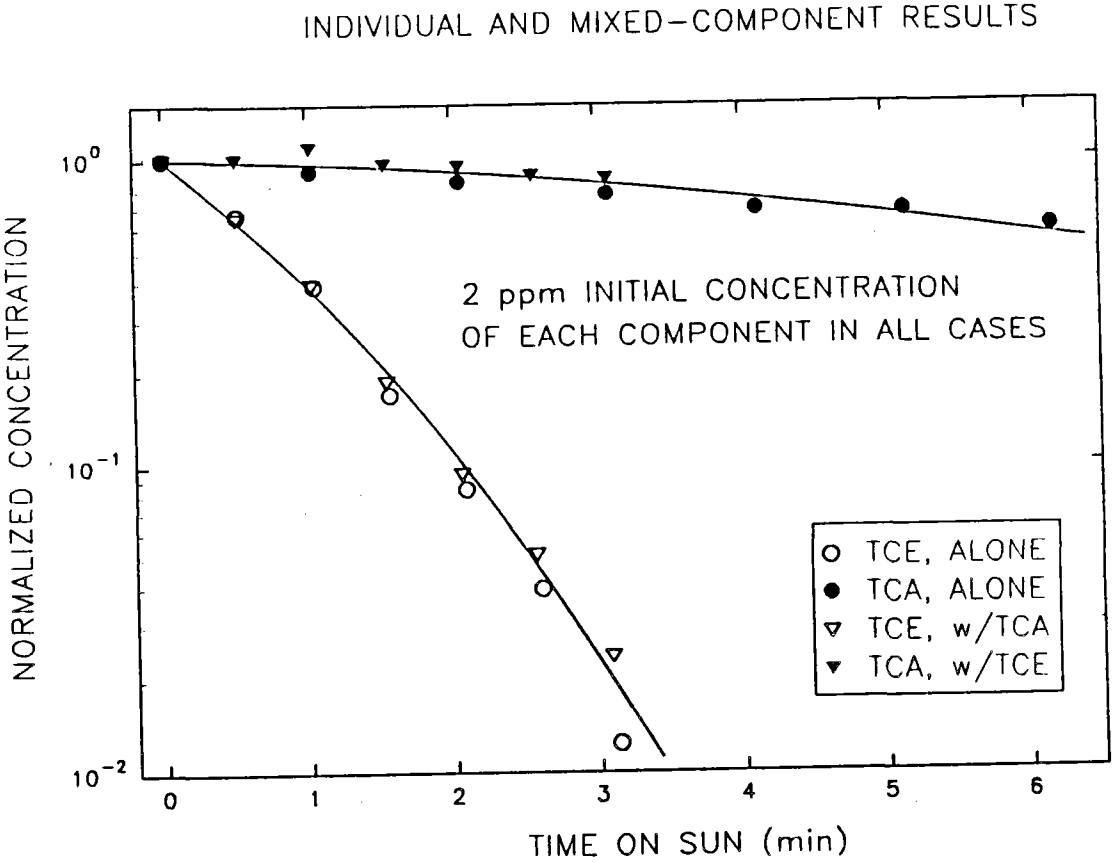


Figure 6. **Destruction of TCA, TCE and a mixture of the two in the large-trough facility. The destruction rate of TCA is slower than observed for TCE. There is no change in the observed rates when the two are mixed. (SNL)**

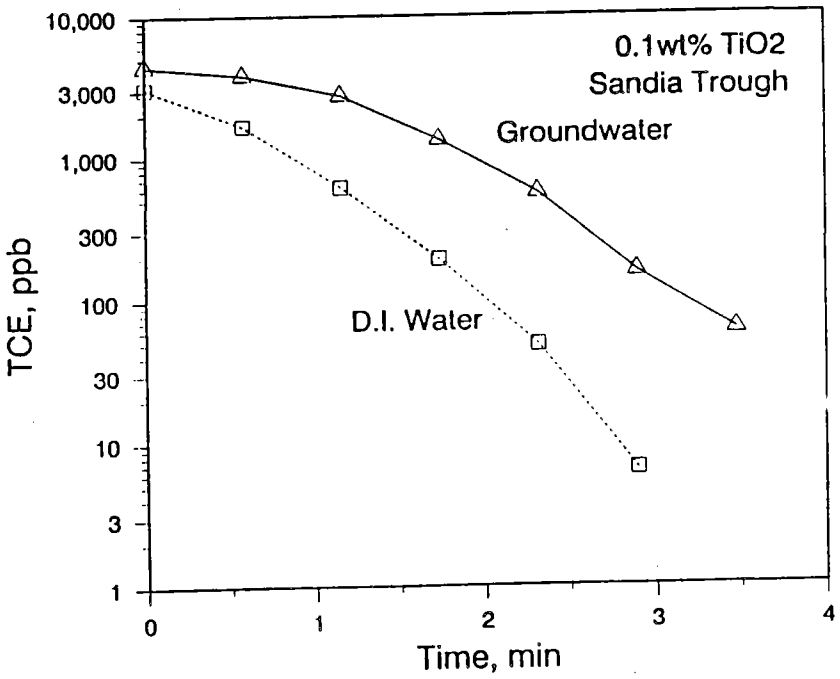


Figure 7. **Comparison of destruction rates in the large-trough facility of groundwater and deionized water spiked with TCE. The destruction of TCE in groundwater is likely inhibited by the presence of ions such as carbonate and iron. (SNL)**

Field Systems

- **A site for the field experiment was selected, and a conceptual design was completed.**

  Preliminary process-flow diagrams and process and instrument diagrams as well as preliminary data sheets were completed and issued for the field experiment to be located at Lawrence Livermore National Laboratory. Lawrence Livermore has been selected as the site of this experiment on the solar detoxification of water because of its well-characterized groundwater contaminant, high level of solar insolation, and existing utilities to support the development and operation of the experiment. A scope of work is being developed for issuing in a Request for Proposal for doing the detailed design engineering, procurement, and construction. Site selection for this field experiment was a Program milestone. (SERI)

- **A Request for Proposal for the parabolic troughs for the field experiment at Lawrence Livermore was prepared.**

  Researchers prepared a draft of a Request for Proposal for the parabolic troughs (approximately 7200 square feet) required for the field experiment at Lawrence Livermore. Completion of the draft is awaiting final specifications from SERI and Lawrence Livermore on several key items, including interfaces and seismic requirements. (SNL)

- **A Request for Proposal for a mobile solar detoxification unit was released.**

  In September, Requests for Proposals to design and to construct a mobile solar water detoxification system were sent to over one-hundred prospective bidders. This subcontract will result in a piece of equipment that will permit on-site treatability testing of contaminated groundwater and toxic wastewater. When completed, the unit will perform on-site tests to determine the rates of organic destruction achievable with a solar detoxification system. It also will provide a valuable means for technology transfer, since prospective users of solar detoxification will be able to observe a working system first-hand. (SERI)

- **The tube size of the reactor for the field experiment has increased.**

  Calculations of operating conditions in the first field experiment have indicated that high rates of water flow may be difficult to achieve through reactor tubes that are only one and a half inches in diameter. These results were not unexpected, since early tests at Sandia had suggested that commercial systems would require tubes as large as three inches in diameter. Although available data on pressure drop on a potential reactor configuration is limited, the recent calculations show that even a small experimental system will probably require tubes that are two inches in diameter (Figure 8). As laboratory effects increase the catalyst performance, water flow rates and the size of the reactor are likely to increase further. To address this issue, two-inch tubes were ordered for both the outdoor and indoor troughs at SERI. (SERI)

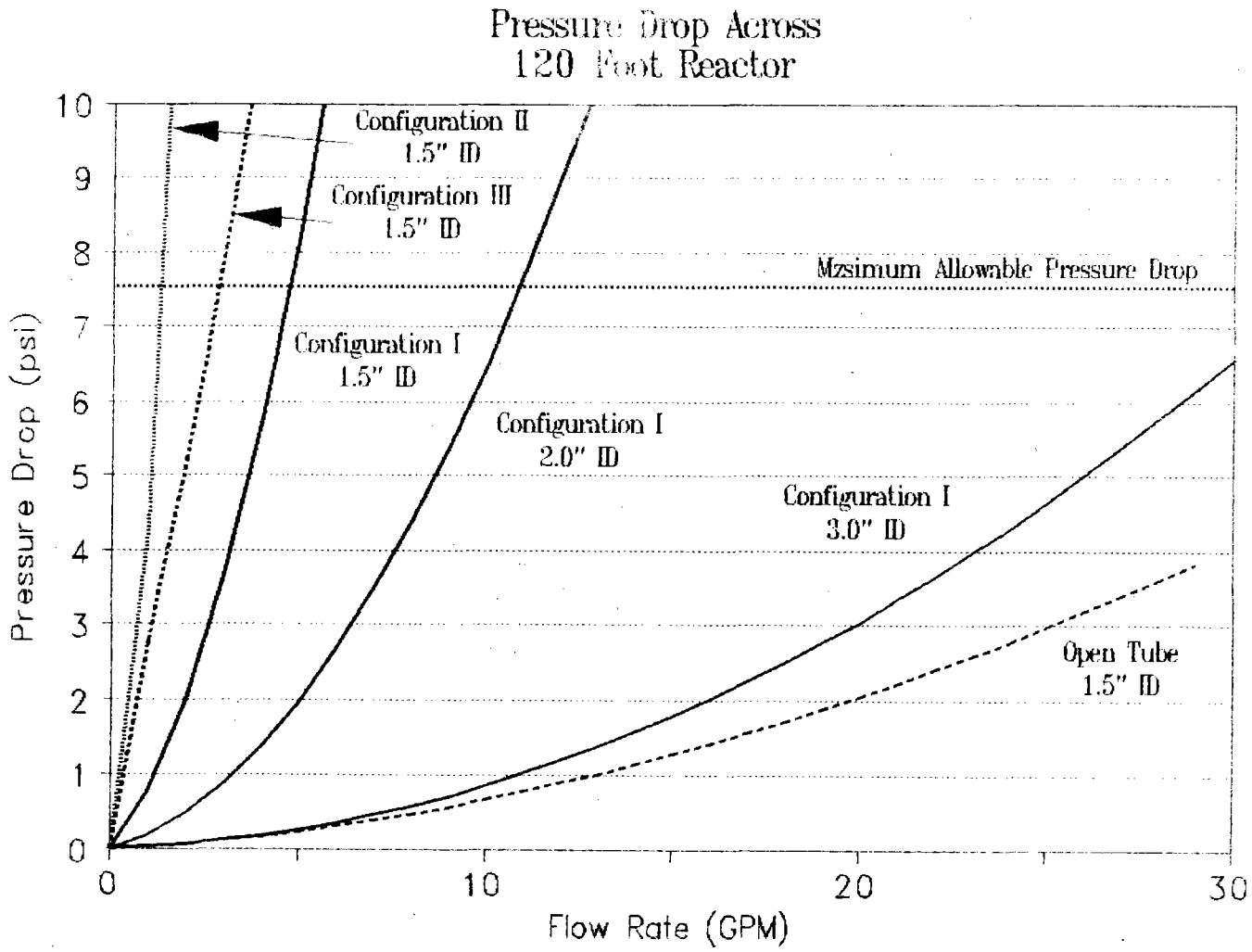


Figure 8. Projected Pressure Loss Through Various Water Detoxification Reactors

Meetings and Visitors

- **Engineers met with a representative of the Degussa Corporation to discuss technology transfer and commercialization.**

  C. Tyner and J. Pacheco met with Dr. J. Andrade, Director of Technology and Business Development for Degussa Corporation, to discuss the status of the solar detoxification program and possible technology transfer. Degussa is the supplier of the titanium dioxide catalyst used in Sandia's experiments, and Dr. Andrade has been instrumental in securing a supply of the catalyst. Degussa is interested in commercializing a solar detoxification system to complement its existing line of water treatment systems. Another meeting to explore further possible pathways to commercialization will be held next quarter. (SNL)

- **A researcher visited the solar detoxification facility at the Plataforma Solar de Almeria, Spain.**

  During a vacation in southern Spain, D. Alpert visited the Plataforma Solar de Almeria to discuss the status of Spain's water detoxification program. The goal of Spain's three-year program of $4.4 million is to establish at Plataforma Solar de Almeria a research center for the study of photocatalysis at a scale similar to that of Sandia's large-trough facility. The cost is being shared equally between Spain and the Commission of the European Communities. A detoxification loop has been built using 12, two-axis tracking troughs. The total aperture is 350 m^2. Future cooperative research for large-trough facilities also was discussed. (SNL)

- **ABC featured the large-trough water detoxification facility on its national "Nightly News" program.**

  A fairly lengthy segment on the solar detoxification project, featuring footage from the large-trough facility, was shown on ABC's "Nightly News with Peter Jennings." The segment also included some coverage of other ongoing work at the National Solar Thermal Test Facility. A copy of the tape has been provided to DOE Headquarters. (SNL)

Planned Activities for Next Quarter

- In the large-trough facility, testing will focus on treating different organic compounds, treating mixtures of compounds, and on treating groundwater spiked with a contaminant. In addition, the automated control system will be installed and evaluated. (SNL)

- The request for proposal for the parabolic troughs for the planned field experiment at Lawrence Livermore will be completed and issued. (SNL)

- Sandia's International Light ultraviolet normal incident pyroheliometer will be calibrated next to Eppley instrument. (SNL)

- A draft of a test plan for the first field experiment will be completed. (SERI)

- Three subcontracts under industrial technology development will be awarded for development of innovative photoreactors and innovative solar concentrators, and for construction of a mobile, solar-water-detoxification, treatability unit. (SERI)

- A complete analysis of groundwater samples will be obtained from the site for the first field experiment. (SERI)

B. SOLAR DESTRUCTION OF HAZARDOUS CHEMICALS

Accomplishments

Systems Analysis

- **Plans for assessing the potential of high-flux solar destruction processes were discussed.**

  SERI and Sandia met to discuss plans for assessing the potential of high-flux solar destruction processes, SOLTOX and PHOTOX. A plan was developed for FY 1991 that includes market assessment, performance assessment, and cost and economic assessments of both processes. Comparison of the expected performance and cost of the two solar technologies with conventional waste-destruction technologies also will be included in the study. The study will be conducted jointly by Sandia and SERI. Sandia will assume the lead role for establishing the ground rules for the study and for the market assessment. SERI will assume the lead role for the assessment of performance and cost and the comparisons with conventional technology. The goal of this work is to identify appropriate markets for the solar technologies and to determine whether they can be expected to compete with conventional technologies in those markets. Preliminary conclusions are expected by the third quarter of FY 1991 with a drafted report describing the work due at the end of FY 1991.

- **A preliminary market assessment and a system analysis were completed.**

  A system and market assessment of the high-temperature solar detoxification of hazardous wastes has been completed (Milestone 4B-3). The work had a number of components: market analysis, cost analysis of a solar-based process, and cost analysis of conventional processes. The market analysis identified two applications of the solar process as potentially attractive. The first application is the treatment of soils contaminated with TNT (trinitrotoluene) and other explosives. Estimates of the quantity of solids contaminated with TNT are as high as 5 to 10 million tons with some sites located in the Southwest.

  The second application is the cleaning of gas streams containing chlorinated organics that result from manufacturing or remediation processes. Methods were developed to determine the sensitivity of the cost of the solar-based process to various process parameters including reaction temperature; reaction residence time; fraction of the solar spectrum that is utilized photochemically; and absorptivity and quantum efficiency of the waste or catalyst. The work also included an analysis of the conventional methods for treatment of gas-phase chlorinated organics. Solvent recovery using activated carbon absorption with steam stripping and thermal oxidation were the two methods that were analyzed. The cost of processing a gas stream of chlorinated organics using each of these methods was determined and was compared to the cost of using a solar-based process.

  The most significant conclusion of the work is that solar-destruction processes can compete with the best conventional alternative, thermal catalytic oxidation, if the size and cost of the hardware can be significantly reduced. This can be accomplished by utilizing efficient solar radiant heating, by eliminating fuel and excess air, and by lowering the operating temperatures with photo-enhanced reaction rates. This work recommends that field testing and laboratory work focus on volatile chlorinated organics, particularly mixtures. Work should also include development of photocatalysts, both homogeneous and heterogeneous, that maximize the absorption and utilization of the solar spectrum. (SERI)

- **A status report was prepared to examine activated carbon systems.**

  A status report was drafted to summarize work on evaluating the potential role for high-temperature solar processes in waste treatment systems that use activated carbon. The report discusses the role that activated carbon plays in waste treatment systems and evaluates concepts for integrating a solar process into current activated carbon systems. It also includes recommendations for work in FY 1991 on this topic. The report, now being reviewed by researchers, will be updated and published in FY 1991. (SNL)

- **An infrared transport model for the new Photox reactor was completed.**

  Researchers have completed development of an infrared transport model for the annular receiver/reactor. This model complements the solar absorption model completed last quarter and, when coupled with models for convection and chemical reaction, will form a complete, detailed model of the annular receiver/reactor. The infrared model accounts for infrared transport in the receiver by tracking radiative emission and absorption by all surfaces and the participating media within the annular region. Like the solar absorption model, the infrared transport model uses the Monte Carlo method which allows the treatment of complex multi-dimensional geometry, participating media, and complex variations in spectral property. (SERI)

Laboratory Research

- **Researchers completed the milestone on the initial survey in reforming representative toxic organic solvents.**

  Researchers completed an initial survey of destruction efficiencies and product formation for a representative set of toxic organic compounds by using a molecular beam mass spectrometer. In most cases, high levels of destruction were obtained. For example, Figure 9 shows measured destruction efficiencies for several organic compounds at 800°C. The observed destruction efficiencies are greater than 99.99 percent (4 nines) for chlorocarbons, greater than 99 percent for aromatics, and greater than 90 percent for acetonitrile. At the higher temperatures expected in a full-scale solar-heated system, destruction efficiencies should be significantly greater. These studies also showed that steam reforming of simple hydrocarbons and chlorocarbons at 800°C produces only the expected reaction products, CO, CO_2, H_2, and HCl, without formation of detectable by-products. Methylthiophene, a sulfur-containing compound, was found to deactivate the catalyst, though it could be reactivated by heating in oxygen. A paper summarizing these results has been accepted for publication in Environmental Science and Technology. Next quarter, Milne and Nimlos will begin reforming studies of several phosphorus-containing compounds, surrogate-waste mixtures, and the effect of higher reforming temperature on the destruction efficiency of aromatics and sulfur-containing compounds (higher temperatures are expected to suppress catalyst poisoning by sulfur). (SERI/SNL)

- **Steam reforming reaction kinetics were measured for additional compounds.**

  Professor J. T. Richardson of the University of Houston determined steam reforming kinetics for the destruction of methylene chloride. When the gas hourly space velocity was 38,200, complete destruction of methylene chloride was attained at 800°C. Analysis of temperature-dependent results gave the following first order expression for the rate (moles of reactant per cm^3 of catalyst per second) of disappearance of methylene chloride:

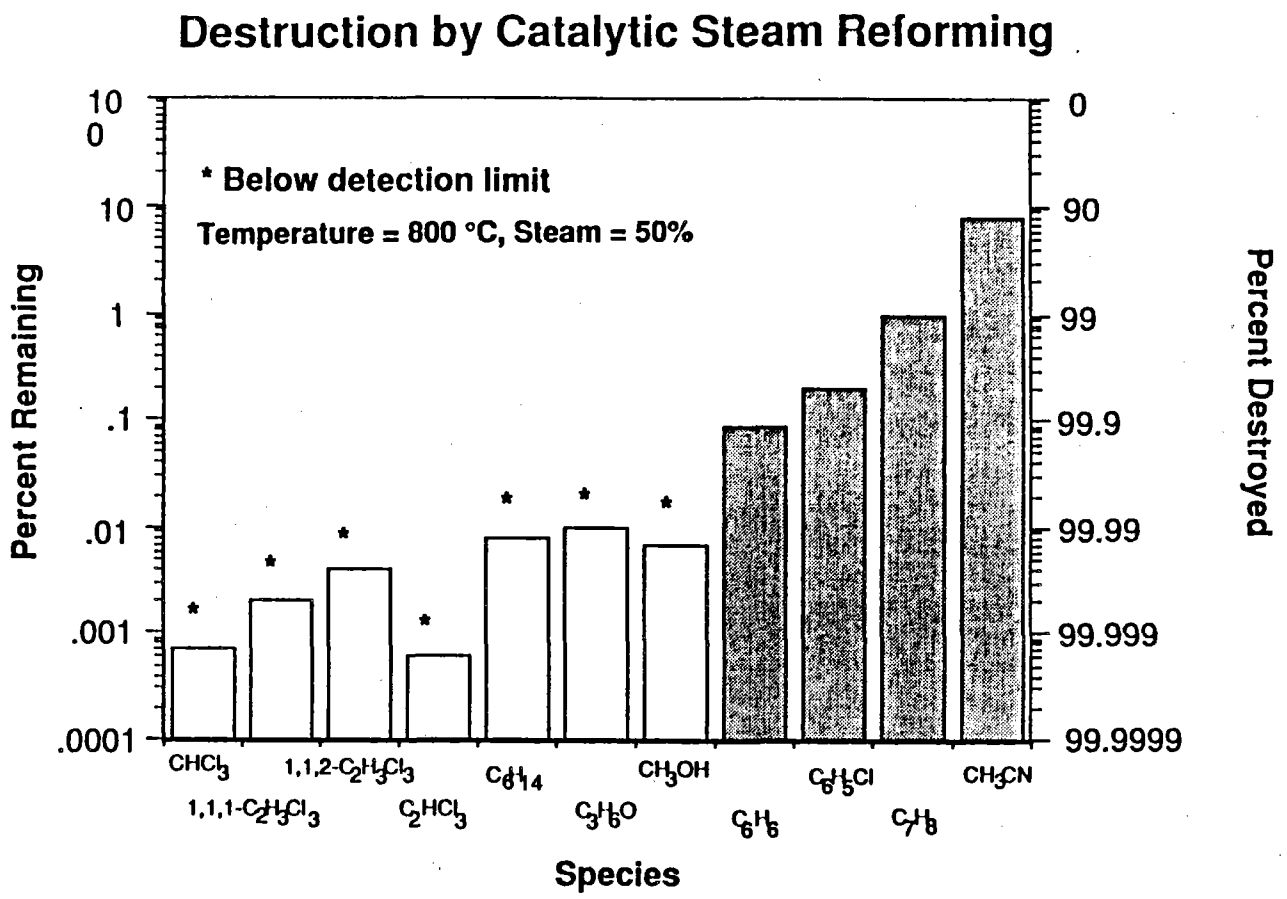


Figure 9. **Researchers measurements of the destruction efficiency of various organic compounds by steam reforming. The measurements are made with SERI's molecular beam mass spectrometer.**

Rate = 1.71×10^{10} exp {-44,133/RT} [CH2Cl2].

In addition, preliminary results suggest that at 800°C, the rate of destruction of methylchloride is about 12 times that of methylene chloride. (SNL)

- **Destruction of trichloroethylene, nitrobenzene, and dinitrobenzene by photo-oxidation has been demonstrated.**

Tests were conducted on the photo-oxidation of trichloroethylene (TCE), nitrobenzene, and dinitrobenzene. Results for the TCE showed that even though this compound does not absorb in the solar spectrum, a slight increase in destruction in the presence of ultraviolet photons was observed. This enhancement is presumably due to the photolysis of intermediates formed from the oxidation of TCE. This increases the likelihood that the Photox process may be generalized to include the destruction of species that do not directly absorb in the ultraviolet portion of the solar spectrum. High-temperature photo-oxidation of nitrobenzene and dinitrobenzene also were examined this quarter. These compounds were used to investigate the possibility of using the Photox process for the remediation of soil contaminated with TNT or RDX. The nitro group in these compounds causes large red shifts in the absorption spectra of organic molecules. As a result, nitro- and dinitrobenzene absorb light quite strongly in the ultraviolet region of the solar spectrum. As expected, these compounds showed a large increase in destruction rate in the presence of ultraviolet photons. Based on these results, it seems reasonable to expect the Photox process to work well with TNT and RDX. (SERI)

- **The validity of a methyl chloride photolysis kinetics model was demonstrated.**

TDA Research, under subcontract to SERI, continues its work on modeling chemical kinetics of gas-phase destruction of hazardous compounds. This quarter its work focused on modeling the photolysis of CH_3Cl (methyl chloride) and the use of photo-initiators. Initial experiments (with the laboratory reactor/MBMS) showed much faster destruction of CH_3Cl than predicted by the model. Small oxygen impurities were identified as a probable cause. Then, pyrolysis experiments in very pure He were run. These tests showed much slower pyrolysis than the original experiments and were in closer agreement with the model. In addition, the model predicted the general, observed behavior of several prominent intermediate products. (SERI)

- **The potential of photo-initiators was demonstrated.**

A kinetics model was used to explore the use of photo-initiators to accelerate the oxidation of compounds which do not directly absorb in the solar spectrum. Specifically, the oxidation of CH_3Cl in the presence of CH_2O (formaldehyde) and H_2O_2 (hydrogen peroxide) was examined. These photo-initiators photolyze to yield H atoms and OH radicals which initiate chain reactions that destroy the CH_3Cl. The accompanying graph (Figure 10) shows the results of a model for the oxidation of a one-percent mixture of CH_3Cl with CH_2O as the photo-initiator. The results show a dramatic increase in destruction of the CH_3Cl in the presence of sunlight. (SERI)

- **Products of incomplete reaction were identified in TCA steam reforming.**

The molecular beam mass spectrometer was used to search for products of incomplete reaction in the partial steam reforming of trichloroethane (TCA) over rhodium catalyst on alumina. This work was in support of Sandia's Soltox process and specifically addressed results from the University of Houston in which signs of products of incomplete reaction were seen during partial steam reforming

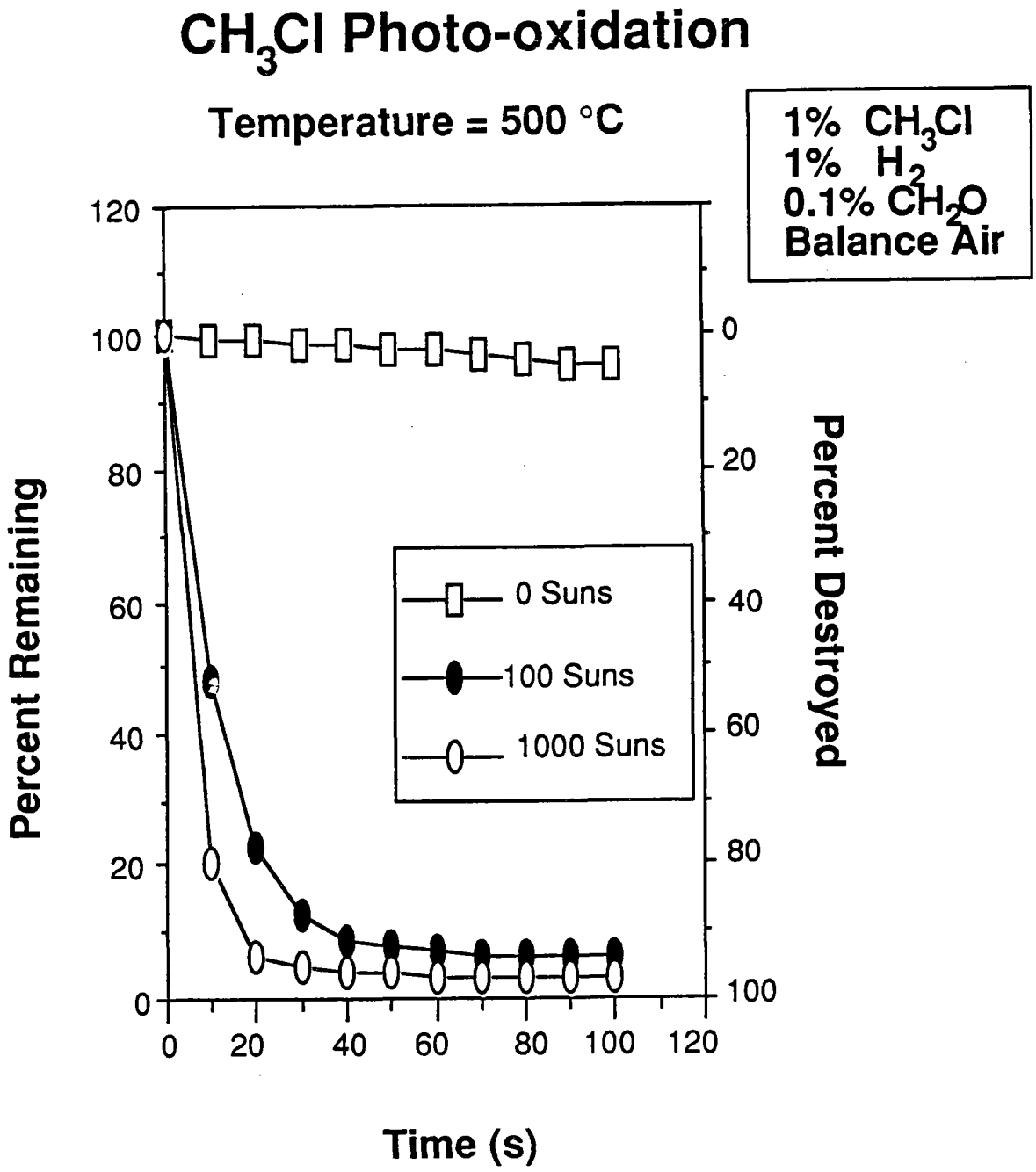


Figure 10. The results of a model for the oxidation of one percent mixture of CH_3Cl with CH_2O as the photo-initiator.

of TCA. The mass spectrometer showed that a major product of incomplete reaction, dichloroethylene, was observed and was more difficult to reform than TCA. This product of incomplete reaction was reduced at high levels of destruction. (SERI)

- **Quantum yields were measured.**

Researchers reduced and analyzed data from the molecular beam mass spectrometer runs made in August, 1990, (Milestone 1A-3). These data concerned the photothermal destruction of chloronaphthalene and nitrobenzene and were used to help evaluate the potential of using solar flux to destroy species that absorb solar ultraviolet photons. Solar destruction efficiency and measurements of the production of intermediates or products of incomplete reaction were included in the data reduction. In addition, bulk quantum yields for the destruction of chloronaphthalene were determined as a function of temperature, light intensity, and concentration. These data, along with data from the University of Dayton, complete Milestone 1A-3, "Determine quantum yields for the destruction of representative hazardous organic compounds in a high-flux system." (SNL)

Solar Testing

- **Pilot-scale reforming experiments were conducted.**

A meeting of experts in the areas of catalysts, materials, and thermal analysis was held on August 17, 1990, to review the status of pilot-scale testing and to identify possible improvements in the design of the Soltox reactor. Key issues included improvements in the method of attaching the catalyst to the ceramic support, alternative catalyst support materials, and changes in the reactor's internal design to reduce coking and to eliminate any flow that by-passes the high-temperature portion of the catalytic frit. Many of these issues are generic to any high-temperature solar-catalytic process.

All of the required materials are ordered, and the first reforming experiments with the improved design, probably on propane or butane, will begin next quarter. In addition, several improvements in the analytical train are being implemented. (SNL)

- **Progress was made on the field test of the new Photox reactor.**

Progress has been made on installation of hardware for the field tests of the new Photox reactor at the High-Flux Solar Furnace. Radiation shields for the reactor have been designed and constructed. These shields will allow for independent control of reaction temperature and flux. The devices for air pollution control have been designed and ordered. These include a condenser to reduce the temperature of the gas after it exits the reactor, a scrubber to remove hydrogen chloride from the gas, and an activated carbon filter to prevent emission of any unreacted organics to the atmosphere. Gas analysis for the tests will be performed by Fourier Transform Infrared Spectroscopy (FTIR). Supporting hardware, including mainly a vacuum system for the FTIR, has been designed, ordered and installed. (SERI)

Meetings

- **A meeting was held with a commercial firm currently marketing steam reforming of toxic chemicals.**

  On July 11, 1990, staff members visited Synthetica Technologies in Richmond, California, to discuss the advantages of solar-catalytic steam reforming. Synthetica has developed an electrically heated, non-catalytic method of steam reforming that can destroy wastes, including liquids, slurries, solids, and contaminants in soil. Synthetica personnel described their commercial system for electrically driven steam reforming and the likely markets that they have identified. Many areas of common technical interest were discussed, and possible areas for cooperative research and development were identified. (SNL)

- **Staff attended a DOE conference on treatment of contaminated soils.**

  A staff member attended DOE's Thermal Treatment of Soils Workshop in Richland, Washington. The workshop presented information on technologies being used or considered for treating contaminated soils at DOE sites. The technologies included steam stripping and vacuum extraction; supercritical water oxidation; plasma arc incineration; and in-situ vitrification. (SNL)

- **Staff attended a symposium of the National Aeronautics and Space Administration (NASA) on waste processing in space.**

  A staff member attended a NASA symposium entitled "Waste Processing in Space for Advanced Life Support." NASA is interested in adapting terrestrial systems for waste management to solve waste issues for future long-duration, manned space missions. Discussions with participants indicated interest in solar-based waste processes. (SNL)

- **A presentation on solar detoxification was made to Syntex (USA).**

  Staff met with environmental health and safety personnel from Syntex (USA), Inc., a worldwide pharmaceutical manufacturer, at their corporate headquarters in Palo Alto, California. Syntex was very interested in the information presented on both solar detoxification of water and the high-temperature solar processes. They are looking for an on-site treatment technology for a groundwater cleanup project at a site in the Denver area (local Denver-area contacts have been ongoing). They are interested in evaluating the solar detoxification of water technology for this project. In addition, Syntex expects the new Clean Air Act, when finalized, to include significant new requirements for VOC emissions controls. Syntex is a major user of solvents such as methylene chloride, and anticipates the need for a large amount of new control equipment for vent stacks. (SNL)

- **A researcher participated in proposal reviews.**

  A researcher participated in two reviews of DOE/EM proposals. The first was held in July, 1990, in Breckenridge, Colorado, and involved proposals for research and development of new technologies for treatment of hazardous waste. The second was held in September, 1990, in Idaho Falls, Idaho, and involved proposals for innovative technologies in waste treatment. In addition to providing a service to DOE/EM, the reviews provided researchers with an opportunity to learn about potentially competitive non-solar technologies in waste remediation. (SERI)

- **Staff visited a Swiss laboratory.**

  Staff visited Dr. M. Gratzel of the Institut de Chimie Physique of Ecole Polytechnique Federale in Lausanne, Switzerland, to discuss the DOE's solar detoxification program. Possible collaborative efforts were also discussed. Presentations on Sandia's and SERI's programs also were made. (SNL/SERI)

Planned Activities for Next Quarter

- Debugging and hot-gas testing of new Photox reactor will be completed. (SERI)
- Testing of homogeneous photo-oxidation of TCE will begin on the new Photox reactor. (SERI)
- The most promising semiconductors for heterogeneous photocatalysis will be identified. (SERI)
- The modifications to design of the pilot-scale, steam-reforming reactor will be completed, and reforming experiments will begin. (SNL)
- A Request for Proposal for an impartial market assessment of the high-temperature processes (Soltox and Photox) will be prepared and released. (SNL)
- The Univerity of Houston will begin kinetic studies of the destruction of chloroform and carbon tetrachloride. (SNL)
- Laboratory experiments will examine destruction efficiency and intermediate product formation for steam reforming of several phosphorous-containing compounds. (SERI)
- The DCAR and CIRCE computer models will be used to develop optimal dimensions for the layered catalytic frit to be used in the pilot-scale, steam-reforming experiments. (SNL)

ADVANCED INDUSTRIAL APPLICATIONS

Objectives

The objectives of work on Advanced Industrial Applications are to develop and to maintain the scientific, theoretical, and experimental base for achieving high solar concentration and to conduct fundamental studies on advanced concepts and applications, including solar chemistry and materials processing.

A. Advanced Processes Research

Accomplishments

- **The study of applications of concentrated solar photon by the National Research Council's (NRC) Energy Engineering Board (EEB) focused on workshops.**

  The study centerpiece consists of seven workshops. These will be hosted by SERI on November 7 and 8, 1990. The workshops have been organized by a committee selected by the Energy Engineering Board. The workshop topics are: "Water Treatment, Waste Treatment and Materials Processing," on November 7; and "Solar Pumping of Lasers, Photochemical Synthesis, Fuel Processing of Thermo/Photochemical Cycles, and Advanced Research," on November 8.

  The sessions are chaired by members of the study committee who are responsible for their conduct. SERI provided support by responding to the study director's request and nominating a SERI researcher to act as a resource person for each of the sessions. In addition, SERI researchers provided background literature and answered specific committee questions on selected topics. Arrangements for hosting the workshops at SERI have been completed. (SERI)

- **A study entitled "High Flux Photon Processes: Opportunities for Application" has been initiated by SRI International.**

  This six-month study is a systematic inquiry into specific industrial applications in the areas of materials processing, photochemical, and photothermal processes. It excludes water treatment and waste detoxification. The study director is Dr. Don Lorents, Scientific Director of SRI's Molecular Physics Laboratory. The study team draws on SRI researchers from their extensive laboratories as well as on outside consultants. (SERI)

Planned Activities for the Next Quarter

- On November 7 and 8, 1990, SERI will host the Committee on Applications of Concentrated Photon Workshops from the Energy Engineering Board of the National Research Council.

- A study by MIT Energy Laboratory on industrial applications of high flux photons will be initiated.

B. High Flux Optics

Accomplishments

- **SERI exceeded its previous world record for solar flux concentration in air.**

  The previous world record for solar flux concentration in air (18,000 suns) was exceeded during tests conducted on August 16 to 17, 1990, at the High Flux Solar Furnace. Concentrations of over 21,000 suns were measured by using a new secondary concentrator of identical design to the previous unit, but with an improved surface quality. The new unit was machined and polished to finer tolerances than the previous unit. The resultant silver reflective surface of the secondary was more specular than the original unit. Other conditions during the tests were very similar to those conducted in June, namely, the direct normal irradiance and general sky conditions.

  Average concentrations of 21,000 are very close to the expected values based on ray-trace modeling. The peak concentration was not measured, but based on the analytical predictions, researchers estimate that the peak flux to be near 25,000.

  These results, and others results characterizing the solar furnace were presented at the International Energy Agency's 5th Symposium on Solar High Temperature Technologies, in Davos, Switzerland, on August 26 to 31, 1990. (SERI)

- **Preliminary design of a turning mirror system was completed for the High Flux Solar Furnace.**

  In a subcontracted effort with Dan-Ka Products, the preliminary design of a turning mirror system is now complete, and detailed design is underway. The turning mirror is designed to intercept the concentrated beam just in front of the focal point and to redirect it in a downward direction. Since the mirror is in a reasonably high-flux environment, the thermal stresses in the reflector material and its support structure are of critical interest. Based on structural analysis of the design, it appears that stresses are well below allowable limits for the front surface aluminum reflector on Pyrex substrate. The mirror will be vacuum held to a water-cooled aluminum plate. The plate can be easily placed in and out of the beam for operation in both the nominal and turned-beam configuration. A new shutter system incorporated into the overall structure will be placed in front of the turning mirror so that the shutter can be used in either operational configuration.

  A modification to the SOLFUR computer code also has been completed and includes a turning mirror. The model allows for both flat and curved surfaces for the turning mirror. (SERI)

- **The University of Chicago will continue its research in non-imaging high flux optics and solar pumped lasers.**

  Prof. R. Winston announced the achievement of 84,000 suns concentration by using a primary (40.6 centimeters in diameter) and a sapphire (n = 1.78) secondary, at the University of Chicago. Prof. Winston and his researchers have demonstrated solar pumping of two solid-state lasers, and designed a solar-pumped dye laser. The latter is expected to have an overall conversion efficiency of 5.3 percent. (SERI)

Planned Activities for the Next Quarter

- o New experiments in both materials processing and destruction of hazardous waste will be conducted at the High Flux Solar Furnace. (SERI)

- o The turning mirror system will be installed and checked (December, 1990, Milestone). Operational experiments in materials processing with a horizontal orientation will be conducted. (SERI)

C. Solar-Induced Surface Transformation of Materials

Accomplishments

- **High-temperature superconducting thin films have been fabricated by rapid thermal processing in a solar furnace.**

  High-temperature superconducting thin films were fabricated for the first time in a solar furnace in July, 1990. Metalorganic precursors for the yttrium-barium-copper-oxide (YBCO) group superconductors were spin-coated onto single crystal yttrium stabilized zirconia (ZrO_3) and magnesium oxide (MgO) substrates, were dried in air, then were thermally processed in oxygen by using the High Flux Solar Furnace at SERI. The first measurement of transition temperature was on a film (1.2 μm thick), on single crystal MgO and indicated that relatively good properties had been obtained. More refined measurements have been made on this film, and the results are encouraging.

  After setting in air for a period of six weeks, the resistance curve has changed somewhat, and the transition is much broader than indicated by the first measurement. Onset of superconductivity occurs about 90 K. Mutual inductance measurements indicate that approximately 40 percent of the film is a superconducting phase. Critical current measurements at 4 K indicate a J_c of about 2750 A/c m^2 at zero magnetic field, and about 53 A/cm^2 at a magnetic field of 500 G.

  The implications of these measurements are that a substantial amount of the preferred 123 compound has been formed, but the grains are not well connected. That means that there is either a large number of poorly oriented grains, or more likely that there are impurities or defects at the grain boundaries that cause instabilities in the current flow at high currents in magnetic fields. Further difficulties surfaced when examining the sample with an electron microprobe. The bulk stoichiometry of the processed film is about 1/1.5/1.5, rather than the 1/2/3 ratio that was sought. There are two reasons for this. The manufacturer provided solutions that deviated significantly from the analysis provided, and there was a loss of Cu from the film. An examination of the literature provides an argument for the diffusion of Cu into the MgO substrate.

  These results are significant on several grounds. First, researchers have demonstrated successful formation of interesting high Tc compounds via a simple procedure using organometallic liquids to coat a substrate and rapid thermal processing in a solar furnace to produce the oriented 123 structure. Researchers produced uniform films of reasonably good quality on the first try. It should be relatively simple to optimize this process by controlling the starting stoichiometry of the precursor solutions and the rapid thermal processing of the materials in the solar furnace. Solar furnace technology can be scaled up to process sizes that are difficult to achieve with conventional technologies, especially for thin film work, and it can replace energy-intensive processing steps in the formation of superconductor materials. Finally, systems analysis indicates that for appropriate locations, batch processing with a solar furnace is cost-competitive with other radiant resource tools. (SERI)

Planned Activities for Next Quarter

- Studies on the growth of thin films on substrates heated in a reactive gas atmosphere will continue. The solar beam will be used to heat the substrate and to drive the reaction, and the resulting film growth will be screened for photolytic effects. Experiments this quarter will center on growing carbon coatings (hard carbon, diamond-like carbon, and diamond) on various substrate materials. (SERI)

- Preparations for a workshop on Solar Materials Processing will be made. The workshop is sponsored by the National Research Council's Energy Engineering Board and is expected to make recommendations for the future. The workshop is to be held at SERI on November 7, 1990. (SERI)

- Researchers will attempt to interest industrial partners in the application of solar rapid thermal processing to some specific problems. One area for development involves the joining of ceramics. Another possibility is in the area of the growth of hard carbon films. (SERI)

INDUSTRIAL APPLICATIONS ASSISTANCE CENTER

Accomplishments

- **A group met to plan SOLTECH 91.**

SERI representatives, together with representatives from Sandia, Albuquerque, and the Solar Energy Industry Association (SEIA), participated in the initial meeting for the planning of SOLTECH91. The meeting was held at Sandia, Albuquerque, on September 11, 1990. The objectives were:

- To evaluate and select a hotel for the meeting (the annual conference would be held in Sacramento, California);
- To select the date;
- To provide the participating solar technologies (Solar Buildings, Solar Thermal Electric, Solar Industrial, and Photovoltaics) the opportunity to present their proposed events and schedules;
- To coordinate the scheduling of the events by the technologies.

For SOLTECH91 the plenary sessions, seminars, and the exhibition will be held at the Hyatt Regency in Sacramento on February 18 to 22, 1991. Also, Albuquerque, New Mexico, was tentatively selected as the site for SOLTECH92. (SERI)

- **Materials were shipped for an exhibit in Washington, D.C.**

SERI completed and shipped the exhibit and displays that it will present as part of the Exhibition Program of the 1990 Annual Conference and Exhibition of the Water Pollution Control Federation to be held at the Washington, D.C., Convention Center on October 7 to 11, 1990. The Federation is one of the principal professional and educational associations in which producers and end-users of water treatment systems and water pollution regulatory authorities participate -- the target audiences of the Solar Detoxification Research and Development Program. (SERI)

- **A revised concept for the Industrial Application Assistance Program was developed.**

SERI completed a revised concept for the Industrial Application Assistance Program: (a) program and center goals and objectives; (b) a multiyear program plan, including milestones; and (c) a proposed program plan for FY 1991.

The technical areas covered in the program are as follows.

1. Solar detoxification of water
2. Solar detoxification of chemical wastes
3. Solar resource assessment
4. Materials
5. Concentrators
6. High-flux solar processing of materials and ultra-high-flux applications
7. Industrial process heat, hot water and steam

The proposed concept and program plans are being reviewed by SERI's management. SERI also completed the first draft of a recommended task in the FY 1991 Solar Industrial Program relating to solar Industrial Process Heat Technology. It is under review by SERI management. (SERI)

- **Staff identified future conferences to attend.**

As part of the FY 1991 Solar Industrial Applications Assistance Program, SERI identified the following annual conferences and exhibitions in which to consider participating:

Conference/Sponsor	Dates	Site
Annual Meeting and Exhibition/Water Pollution Control Federation	October 7-11, 1990	Washington, D.C.
SOLTECH91 National Solar Energy Conference/SEIA, SERI, and Sandia	February 18-22, 1991	Sacramento, CA
Joint Thermal Engineering and Solar Energy Conference/ASME	March 17-22, 1991	Reno, NV
Spring National Meeting and Exposition/American Institute of Chemical Engineers	April 7-11, 1991	Houston, TX
84th National Meeting and Exhibition/ Air and Waste Management Association	June 16-21, 1991	Vancouver, B.C. (Canada)
Annual Meeting and Exhibition/ American Water Works Association	June 23-17, 1991	Philadelphia, PA

The objectives in participating in these conferences are:

- To familiarize potential producers, end-users and energy and environmental policymakers and regulators in government agencies with the technologies and systems evolving from the Solar Industrial Program;
- To identify firms (producers and potential end users) that might be interested in participating in joint research and development or demonstration ventures with SERI; and
- To identify producer and end-user requirements (in order to optimally structure the research and development).

Participation in the aforementioned conferences provide SERI not only the opportunity to reach U.S. potential producers and end users, but also potential producers and end users in countries around the world. (SERI)

- **Treatability tests were completed on industrial samples.**

  Tests were completed on water samples received from a private industrial concern. Because the company is concerned about release of information, SERI did not analyze the water before or after the tests were completed. Instead, the samples were delivered to a commercial analytical laboratory for analysis. Tests conducted on the main contaminant, bis-2-chloroethyl ether (used as a reagent in the chemical industry), indicated that complete destruction of that material was obtained within 24 hours of exposure. Although this exposure time was longer than expected, the company involved in the work remains interested in ongoing work on the process. This type of treatability testing can provide both industry and the solar detoxification project with valuable information on the potential of solar processes for a broader range of contaminants. (SERI)

- **A proposal was sent for further treatability testing.**

  A proposal was sent to a potential industrial sponsor to investigate the applicability of solar water detoxification to its problem with contaminated groundwater. This potential sponsor is investigating a variety of technologies to remediate the problem. Its sponsorship would defray the costs of the efforts which would include determining destruction rates and briefly estimating costs for a solar water detoxification system. The sponsor will compare these projected costs with costs for other technologies and will determine which options to pursue with further development. Although this is not the first treatability study performed in the solar water detoxification program, it is the first time that funding has been sought from sponsors other than the DOE. As the interest in solar water detoxification increases, such activities in treatability are expected to require a significant level of work by the staff. Through the use of cofunding, such activities will enhance the knowledge of system performance on a variety of contamination problems without decreasing efforts to lower system cost. (SERI)

TECHNOLOGY TRANSFER

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Blake, D., J. Webb, C. Turchi, and K. Magrini, Kinetic and Mechanistic Overview of TiO_2-Photocatalyzed Oxidation Reactions in Aqueous Solution, Golden, CO: Solar Energy Research Institute.

Blake, D.M., K.A. Magrini, and J.D. Webb, Solar Detoxification of Water. Presented to the Symposium on Advanced Oxidation Processes, June 4-6, 1990, Toronto, Ontario, Canada.

Bohn, M.S. and M.S. Mehos, Radiative Transport Models for Solar Thermal Receiver/Reactors. Prepared for the ASME Solar Energy Conference, April 1-4, 1990, Miami, FL. 8 pp. Available NTIS: Order No. DE90000303.

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Pacheco, J.E. and C.E. Tyner, "Destruction of Organic Contaminants in Water Using Concentrated Solar Energy," SAND89-1082A, presented at the DOE Model Conference, October 3-6, 1989, Oak Ridge, TN.

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Second Quarter FY 1990

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Glatzmaier, G., K. Magrini, and M. Bohn, "High Flux Solar Destruction of Hazardous Waste," "Photocatalytic Decomposition of Aqueous Trichloroethylene and Direct Red-79 with Titanium Dioxide," and "Radiative Transport Models for Solar Thermal Receiver/Reactors," International Solar Energy Conference of the American Society of Mechanical Engineers, in Miami, Florida.

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