REAL-TIME PERSONAL MONITOR FOR THE DRYCLEANING INDUSTRY

SBIR Phase I Final Report

Contract No. 1 R44 OH7465-01

Sponsored by

Centers for Disease Control and Prevention
Atlanta, Georgia

Prepared by

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November 30, 2002

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LIST OF ABBREVIATIONS

Abbreviation	Name
Au	Gold
CDC	Centers for Disease Control
d	Electrode Spacing
EEPROM	Electrically Erasable Programmable Read Only Memory
GC	Gas Chromatograph
h	Hour
IDA	Interdigital Array
k	Conductivity
LOD	Limit of Detection
min	Minutes
mm	millimeter
nm	nanometer
NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
PCB	Printed Circuit Board
PCP	Ploychloroprene
P_e	Electrode Perimeter
PEL	Permissible Exposure Limit
PERC	Perchloroethylene
PIB	Polyisobutylene

LIST OF ABBREVIATIONS

Abbreviation	Name
ppm	Parts-Per-Million
s	Second
SBIR	Small Business Innovation Research
SNR	Signal-to-Noise Ratio
t	Thickness
TWA	Time-Weighted Average
μm	micrometer
Vol	Volume
wt	Weight

LIST OF FIGURES

ABSTRACT

This Small Business Innovation Research project addresses the development of a low-cost personal exposure monitor with real-time sampling and data logging capabilities for the drycleaning industry. Phase I research efforts, which are discussed in this report, were focused on the development of novel chemical microsensors for detecting perchloroethylene vapors. Additional research studies (i.e., Phase II) will enable their integration with a badge-size instrument. Once commercialized, these innovative monitors will be used to accurately manage risks associated with daily job functions (i.e., garment spotting, washer loading and unloading, machine maintenance, clothes pressing, etc.) by workers in this high-risk small business industry. At the present time, high costs associated with continuous exposure methods prevent employers from providing adequate monitoring of worker exposure to perchloroethylene. Innovative sensors that were developed during Phase I will enable the reduction of injuries and illnesses associated with chemical exposures to perchloroethylene as employees are made aware of risks and as employers strive to provide safer workplaces. These sensors will also enable precise exposure assessments to support epidemiologic studies, practical technology that can be applied at reasonable cost in the workplace, and validated sensors for measuring relevant exposure and total dose data.

SIGNIFICANT FINDINGS

Phase I research efforts were focused on developing chemical microsensors for detecting perchloroethylene (PERC) vapors for the drycleaning industry. The proposed approach involved (1) concentration of this hazardous solvent into an optimized thin film composite consisting of carbon particles dispersed in polyisobutylene and (2) detection of part-per-million (ppm) concentrations of PERC vapors as a result of conductivity changes to the composite material. Key experiments were performed that optimized the performance (i.e., sensitivity, dynamic range, stability, etc.) of prototype sensors. The following results fully demonstrated the feasibility of the technology:

- Prototype sensors with low manufacturing costs (i.e., $0.75) were developed to enable their integration with microcontroller-based personal exposure monitors.
- The measured response of prototype sensors showed excellent sensitivity, reversibility, and stability characteristics.
- The limit of detection (LOD) of prototype sensors to PERC was 6 ppm based on a 4:1 signal-to-noise ratio (SNR).
- The dynamic range of prototype sensors to PERC was verified from 0 ppm to 1000 ppm.
- The measured response of prototype sensors to temperature and/or humidity variations were easily quantified with independent sensors for these two parameters.

USEFULNESS OF FINDINGS

Technical results realized during Phase I research efforts will enable the commercialization of personal exposure monitors having real-time sampling and data logging capabilities for detecting PERC vapors at concentrations that are relevant for the drycleaning industry. Recent studies by the National Institute for Occupational Safety and Health (NIOSH) provide detailed information about the potential hazards of PERC exposures in this high-risk industry. For example, key findings from these reports are summarized below:

- Uncontrolled use of PERC has the potential to cause widespread harm to the health and safety of workers in this multibillion dollar industry.
- Modern controls that are currently available are cost prohibitive to over 95% of the commercial drycleaning industry.
- There are currently 56,536 commercial drycleaners in the U.S. and 433,926 workers in this industry that could benefit from the technology discussed in this report.

Once commercialized, personal exposure monitors employing the prototype sensors will enable precise exposure assessments to support epidemiologic studies, practical measurement techniques that can be applied at a reasonable cost in the workplace, and validated methods for measuring relevant exposure and total dose data.

SCIENTIFIC REPORT

1. Technical Background

This Small Business Innovation Research (SBIR) project addresses the development of a low-cost personal exposure monitor with real-time sampling and data logging capabilities for the drycleaning industry. The badge-size instrument shown in Figure 1 is being developed with CDC (Centers for Disease Control) SBIR funding to help manage chemical exposures to perchloroethylene (PERC) vapors, which result from daily job functions by workers in this high-risk, small business industry.[1,2] At the present time, high costs associated with commercially available equipment prevent most employers from adequately monitoring hazardous PERC exposures that routinely occur multiple times per day to their workforce.[1] Phase I studies, as discussed herein, were performed to address the development of low-cost chemical microsensors for these instruments with the following properties:

Figure 1. Photograph of prototype monitor being developed at Eltron.

- Rapid, reliable, and reproducible response to part-per-million (ppm) concentrations of PERC vapors.
- Stable over long periods of time without the need for recalibrating the sensor.
- Effects due to environmental factors either negligible or easily removed with simple software algorithms.
- Integratable with a microcontroller-based instrument having both continuous and time-weighted average (TWA) monitoring capabilities.

Phase I results fully demonstrated the technical feasibility of these innovative sensors for reliably detecting PERC vapors at regulated exposure standards provided by the Occupational Safety and Health Administration (OSHA) and the National Institute for Occupational Safety and Health (NIOSH).[3] For example, prototype sensors had a limit of detection (LOD) of 6 ppm, a dynamic range of 0 ppm to 1000 ppm, and an accuracy of 100% ± 15%. The permissible exposure limit (PEM) for PERC is 100 ppm, which was easily quantified with prototype sensors. Ceiling and peak exposure limits for PERC are 200 ppm and 300 ppm, respectively. These concentrations were also reliably measured with prototype sensors. The short-term stability of prototype sensors agreed well with their measured accuracy and precision. Additional experiments(i.e., Phase II) are required to evaluate their long-term stability. Effects due to temperature and humidity were easily quantified with low-cost sensors that are commercially available for these parameters. The extremely low power requirements and minimal electronic circuitry required for the chemical microsensors make them ideally suited for integration with microcontroller-based instruments that employ a 3 V lithium battery power source.

To summarize, the inherent properties that were measured with prototype sensors will enable their integration with personal exposure monitors having real-time sampling and data logging capabilities. Once commercialized, these innovative monitors will provide precise exposure assessments to support epidemiologic studies, practical measurement techniques that can be applied at a reasonable cost in the workplace, and validated methods for measuring relevant exposure and total dose data.

2. Work Accomplished

Phase I research efforts were focused on the development of low-cost chemical microsensors followed by their integration with a personal exposure monitor for rapidly detecting PERC vapors under conditions that are comparable to those found at commercial drycleaners. The following technical accomplishments were realized during this project:

- Developed low-cost manufacturing methods for fabricating innovative chemical microsensors for reliably detecting PERC vapors in the workplace.
- Developed chemical microsensors for detecting PERC vapors with 6 ppm LOD, 0 ppm to 1000 ppm dynamic range, and 100% ± 15% accuracy.
- Verified short-term stability of prototype sensors.
- Verified experimental methodology for removing environmental effects (i.e., temperature and humidity) during PERC measurements with prototype sensors.
- Evaluated power requirements and electronic circuitry necessary for integrating prototype sensors with microcontroller-based instruments.
- Designed personal exposure monitor that will employ prototype sensors.

3. Project Results

Research studies discussed in this report address the development of chemical microsensors for reliably detecting PERC vapors at concentrations that are relevant for the drycleaning industry. Figure 2 shows an optical photograph of the prototype sensor developed during Phase I. It consists of an interdigital array (IDA) of gold (Au) electrodes coated with a polyisobutylene (PIB) and carbon particle thin film composite. The size of the sensor die is 7 mm long by 6 mm wide by 1 mm thick. Through-hole electrical connections with printed circuit boards (PCBs) are made with two pins mounted to the sensor die. The costs associated with manufacturing these innovative sensors is only $0.75, which will enable them to be integrated with personal exposure monitors having a potential market of over 56,000 commercial drycleaners and 400,000 workers.

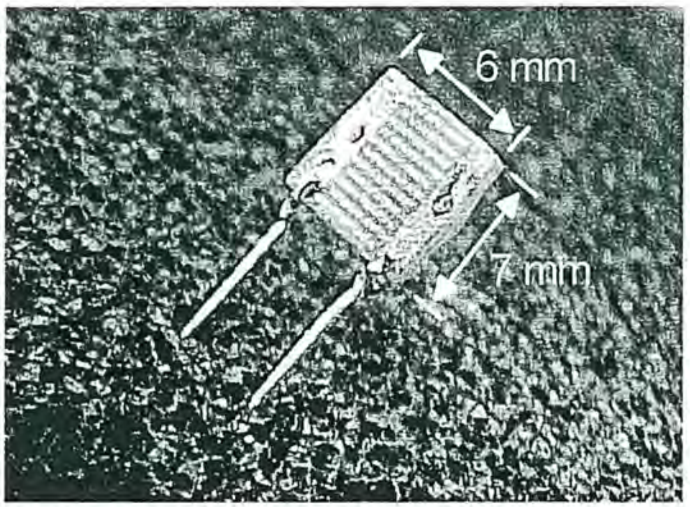

Figure 2. Photograph of optimized chemical microsensor.

Figure 3 shows the normalized resistance response, ΔR/R%, of a prototype sensor exposed to 100 ppm PERC after the experimental protocols for its manufacture were optimized for detecting this hazardous solvent. Data processing also included baseline compensation algorithms that correct for resistance changes resulting from environmental factors (i.e., temperature and/or humidity variations). The absolute resistance of the device was ca. 2000 Ω such that a 1% change in the signal response represents a 20 Ω shift in the measured resistance. From t = 0 s to t = 450 s, the chemical microsensor was exposed to a purified stream of air. The average deviation for the signal response was ±0.01% (±0.2 Ω). At t = 450 s, the purified air stream was switched to 100 ppm PERC in purified air. The resistance increase results from the disruption of conductive pathways between adjacent carbon particles as the PIB thin film expanded under the influence of PERC. The steady-state signal response was 0.62% ± 0.02% (12.4 Ω ± 0.4 Ω). At t = 1250 s, the gas stream was switch back to purified air. The decrease in resistance resulted from the PIB and carbon particle thin film composite returning to its original state. These data help illustrate three important conclusions for prototype sensors developed during Phase I:

- The LOD was determined to be 6 ppm based on a 4:1 signal-to-noise ratio (SNR).
- The resistance rapidly increased to a stable, steady-state value for a defined concentration.
- The measured response showed excellent sensitivity, reversibility, and stability characteristics.

Sections 3.1 and 3.2 provide additional details regarding Phase I research efforts addressing the development of these innovative chemical microsensors for detecting PERC vapors. Section 3.3 discusses the development of a personal exposure monitor having real-time sampling and data-logging capabilities.

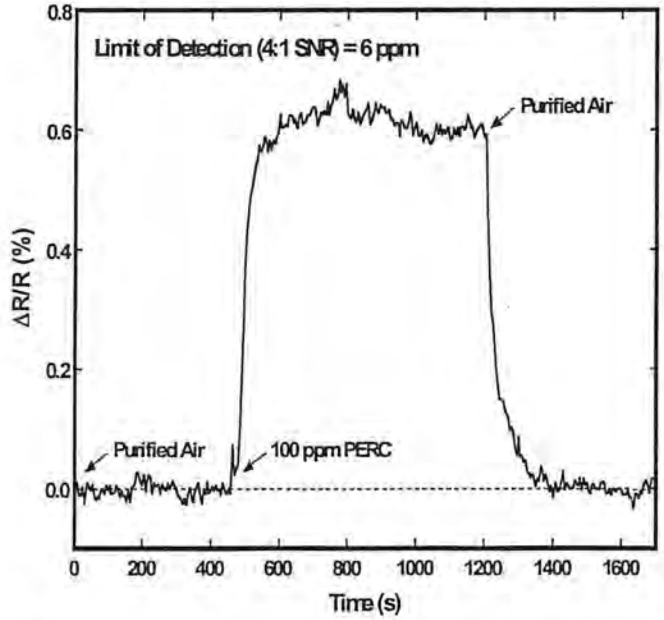

Figure 3. **Response of optimized chemical microsensor.**

3.1. Chemical Microsensor Optimization

Phase I research efforts were initially focused on developing chemical microsensors by optimizing the formulation and deposition protocols for thin film sensor coatings. Although it was proposed in the Phase I work plan that polychloroprene (PCP) would be an optimum candidate for the prototype sensors, the performance characteristics (i.e., sensitivity, reversibility, stability, etc.) of the thin film coatings were dramatically enhanced by replacing this polymer with PIB. In addition, the deposition conditions were simplified by replacing PCP with PIB. Based on these two results, the work plan for Phase I was modified to enable the development of prototype sensors with enhanced capabilities. The following sections provide detailed experimental results that were used to optimize the formulation of the thin film coating and the sensor configuration for detecting PERC vapors.

3.1.1. PIB to Carbon Ratio Optimization

It is well known that the response of chemical microsensors employing thin film coatings of carbon particles dispersed in polymeric materials depend on the volume fraction occupied by the conductive (i.e., carbon) component.[4,5] It is also well known that the sorption of organic vapors into these types of thin film coatings cause the resistance of the sensor to increase due to some of the conductive pathways breaking apart.[4,5] Although the mechanistic properties of this process can be approximated using percolation theory, empirical studies are always necessary to optimize the performance of chemical microsensors for specific applications. Phase I research studies were directed at determining the optimum percentage of carbon in PIB thin films for detecting PERC vapors over a range of concentrations that are relevant to the drycleaning industry.

Figure 4 shows the response characteristics of chemical microsensors in relation to the amount of carbon added to PIB. Protocols used to prepare prototype sensors involved (1) generating separate mixtures of PIB and carbon in toluene, (2) combining the desired concentrations of these two mixtures, and (3) spray depositing a thin film coating over an IDA of Au electrodes. The data points represent the average response of 3 distinct sensors exposed to 100 ppm, 500 ppm, and 1000 ppm PERC. The solid line is a linear curve fit to the data. The measured slope from these data were used to estimate the sensitivity of prototype sensors. For example, these data show that the magnitude of the resistance change could be readily varied by 2.5 times based on the amount of carbon loading. These data also show that the magnitude of the resistance change converged to a constant value for carbon loadings that were between 15% and 20% (wt/wt).

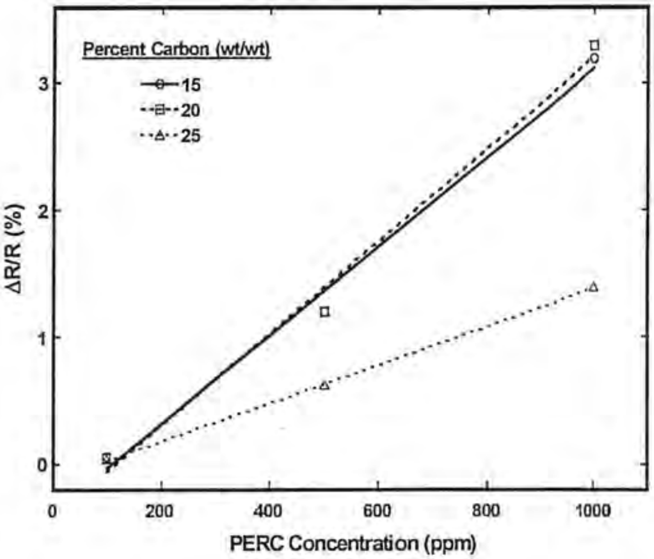

Figure 4. Response of prototype sensors in relation to carbon loading.

Based on the results shown in Figure 4, the PIB to carbon ratio for optimized chemical sensors was kept between 15 % to 20% (wt/wt).

3.1.2. Carbon Particle Size and Distribution Optimization

In addition to the volume fraction occupied by the conductive component, the response of chemical microsensors employing thin film coatings of carbon particles dispersed in polymeric materials also depend on the mobility of individual carbon particles. Figure 5 shows the response of prototype sensors in relation to carbon particle size and distribution. Once again, the data points represents the average response of 3 distinct sensors exposed to 100 ppm, 500 ppm, and 1000 ppm PERC. The solid line is a linear curve fit to the data. The two particle diameters that were evaluated during Phase I research efforts were 20 nm for carbon and 2 nm for C_{60}. (The size and mass of C_{60} was approximately 80,000 times smaller than carbon.) It is clear from these data that prototype sensors that had a mixture of diameters were over 30% more sensitive than devices with only carbon particles. These results provide a basis to further improve the response characteristics of prototype sensors.

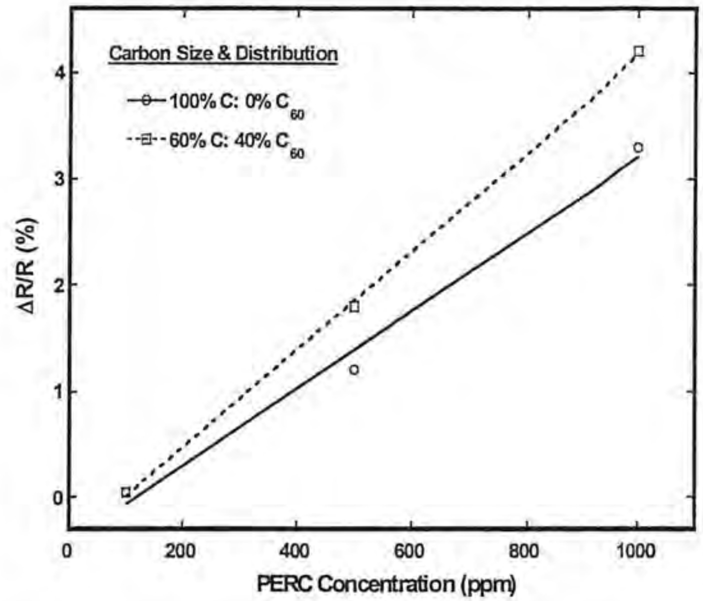

Figure 5. Response of prototype sensors in relation to carbon size and distribution.

3.1.3. PIB Molecular Weight Optimization

As previously discussed, PIB was chosen to detect PERC vapors because of its chemical affinity for this organic solvent as well as its highly reproducible and reversible sorption behavior as a thin film sensor coating. The chemical interactions that govern the polymer and analyte sorption process are very similar to those of a vapor in a liquid solvent. For example, it is well known that vapor molecules distribute themselves to form a thermodynamic equilibrium between the gas and liquid phases. The relative interaction strength depends on a combination of solute-solvent, solute-solute, and solvent-solvent forces. In addition to choosing a polymer with favorable sorption properties, though, the molecular weight of PIB was varied to further optimize its performance characteristics as a thin film sensor coating for PERC vapors.

Figure 6 shows the response of prototype sensors in relation to this physical property. Once again, the data points represent the average response of three distinct sensors and the solid line in a curve fit to the data. These data illustrate that the molecular weight has a significant influence on device resistance in relation to PERC concentration. For example, the response of prototype sensors was approximately 2 times higher for PIB with a molecular weight of 420,000 compared to 9,800.

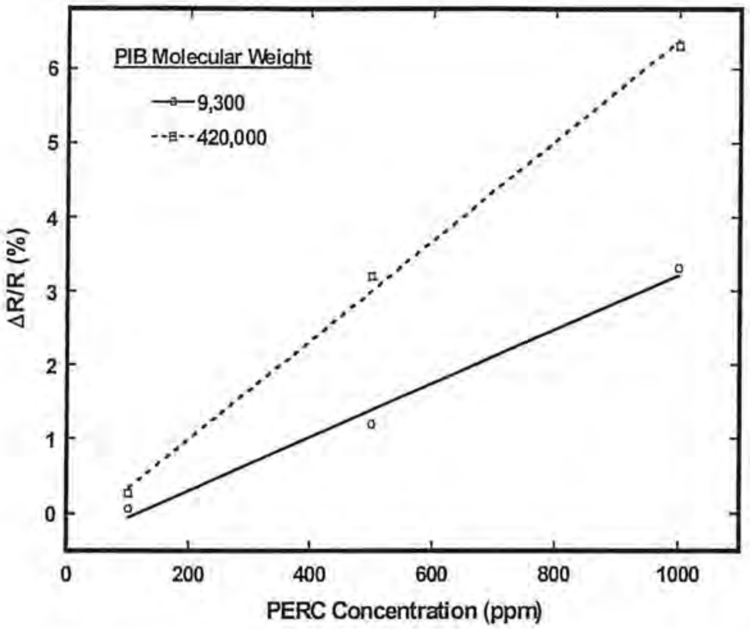

Figure 6. **Response of prototype sensors in relation to PIB molecular weight.**

Based on these results, it is clear that the response of prototype sensors could be dramatically enhanced by varying the molecular weight of PIB.

These results were used to further improve the detection limit of prototype sensors that were developed during Phase I.

3.1.4. Thin Film Thickness Optimization

The normalized response, or differential change in resistance, of prototype sensors depended on the absolute resistance, or thickness, of the PIB and carbon thin films. As previously discussed, the sensor coatings were prepared by spray depositing a mixture of PIB and carbon that was dissolved in toluene over an IDA of Au electrodes. Increasing the deposition time resulted in a thicker film and a lower resistance.

Figure 7 shows the response of prototype sensors for devices with baseline resistances of ca. 10,000 Ω, 1000 Ω, and 100 Ω. Once again, the data points represent the average response of three distinct sensors and the solid line in a curve fit to the data. Although the estimated thickness for these films ranged between 1 μm to 10 μm additional experiments are necessary to quantify these results. These data illustrate that the response characteristics of prototype sensors could be improved 2.5 times by increasing the thickness of the PIB and carbon thin film composite.

These data provide additional information for improving the performance of prototype sensors that were developed during Phase I.

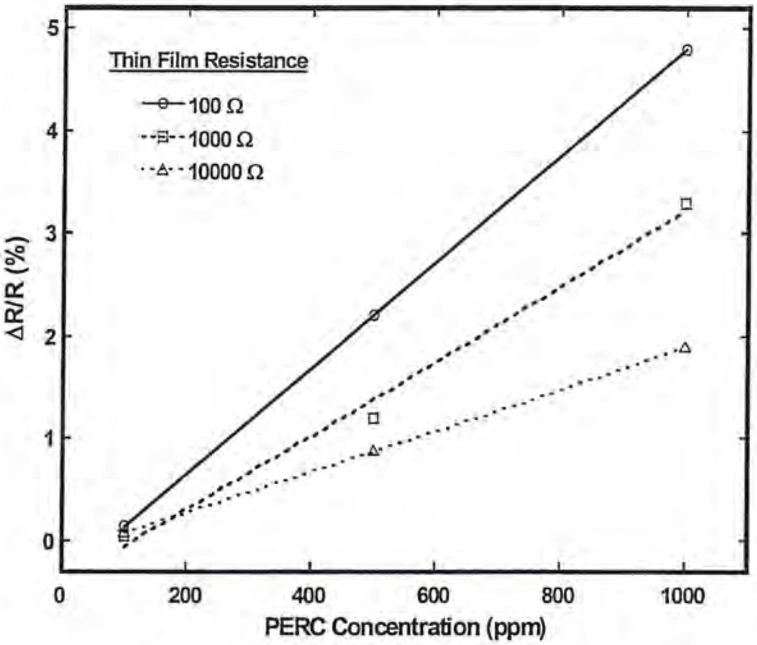

Figure 7. **Response of prototype sensors in relation to thin film thickness.**

3.1.5. Electrode Geometry Optimization

Phase I studies addressed the development of IDA features having electrode geometries of 100 μm, 300 μm, and 500 μm wide fingers to determine the performance of prototype sensors in relation to this effect. Previous studies have shown that a large ratio of electrode perimeter, P_e, to electrode spacing, d, facilitates the measurement of weakly conducting materials.[6] The measured conductance, S, of thin film sensor coatings can be described by Eq 1:[6]

$$S = (P_e/d) \times t \times k \qquad (1)$$

where t is the film thickness and k is the intrinsic conductivity of the thin film. If the value of P_e/d is large, S can be substantial even when t and/or k is small. Decreasing the size of the electrodes, therefore, provides a basis to develop micron thick sensor coatings with the desired performance characteristics. The IDA electrodes were fabricated with Au to enable a low impedance contact with the PIB and carbon thin film composite.

Figure 8 shows the response of prototype sensors in relation to electrode geometry. Once again, the data points represent the average response of three distinct sensors and the solid line in a curve fit to the data. These data show that the largest signal was measured for devices having 300 μm wide electrodes. These data also show that there is an optimum electrode geometry for the PIB and carbon composite.

These results were used to define the electrode geometry of prototype sensors that were optimized during Phase I.

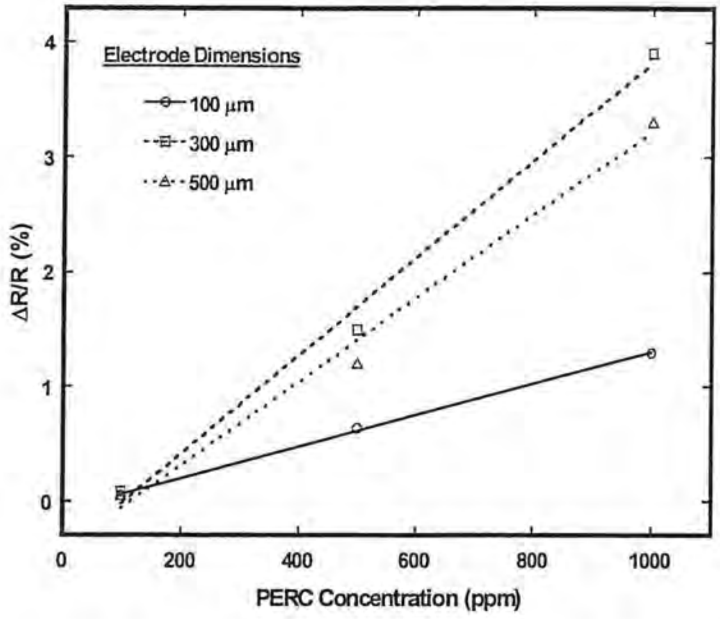

Figure 8. **Response of prototype sensors in relation to electrode geometry.**

3.2. Chemical Microsensor Evaluation

Once the fabrication parameters were evaluated for prototype sensors (i.e., section 3.1), key experiments were performed to estimate their detection limit, response time, dynamic range, and response to environmental factors (i.e., temperature and humidity variation). Due to time limitations for Phase I research projects, long-term studies (i.e., Phase II) are necessary to determine zero drift, span drift, calibration frequency, and lifetime data. Detailed information from these experiments will enable the development of a personal exposure monitor that employs the prototype sensors. The following sections provide results for the evaluation of the chemical microsensors to conditions that simulate those expected at commercial drycleaners.

3.2.1. Detection Limit and Response Time Measurements

Figure 9 shows the response of a prototype sensor exposed to 100 ppm PERC. The raw data points are shown as open circles whereas the solid line is a smooth curve fit. These data were used to estimate both the detection limit and response time of chemical microsensors that were developed during Phase I research efforts. For example, the noise signal (±0.01%) was first determined by monitoring the average change in resistance as purified air was passed over the prototype sensor. This value was multiplied by four to determine the minimum signal required to meet the 4:1 SNR requirement. Experiments were then performed to monitor the response of the prototype sensor once it was exposed to PERC.

As previously discussed, the LOD for prototype sensors was estimated to be 6 ppm (0.04%) based on the results from these experiments. Since this value is over 16 times lower than the PEL for PERC (i.e., 100 ppm), it was completely proved that prototype sensors developed during Phase I have the required sensitivity to detect PERC vapors at relevant concentrations for commercial drycleaner applications.

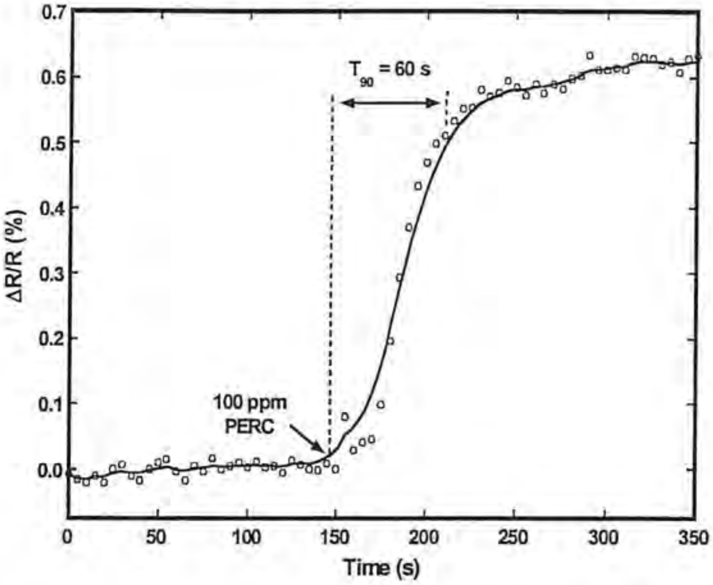

Figure 9. Response of prototype sensor to 100 ppm PERC.

The response time of chemical microsensors was determined as the time required for the prototype sensor to reach 90% of its steady-state value when exposed to a set concentration of PERC. At the present time, prototype sensors show response times of 60 s. Additional experiments are necessary to perform research studies that focus on decreasing the response time to values ≤10 s.

Previous studies at Eltron developing optical-based sensors have already shown that plasticizers added to polymer thin films can readily decrease the response time by a factor of 10 to 100. Experiments are currently underway to modify the formulation for preparing PIB and carbon composites with the appropriate plasticizer. Once these experiments are completed, it is expected that prototype sensors will meet the required response times necessary for rapidly detecting PERC vapors.

3.2.2. Dynamic Range Measurements

Figure 10 shows the steady-state response of a prototype sensor exposed to PERC between 0 ppm to 1000 ppm. The solid line represents a linear curve fit of the data. The sensitivity, which was determined from the slope of the curve fit was 0.007% ΔR/R/ppm. The R value for the curve fit was 0.999.

These results demonstrate the linear response of prototype sensors to PERC; that is, the change in resistance was directly proportional to the PERC concentration. These results also demonstrate the technical feasibility of prototype sensors to detect PERC vapors over a range of concentrations that need to be monitored for providing safe working conditions at commercial drycleaners. For example, it was previously discussed that PEL, ceiling, and peak limits for PERC are 100 ppm, 200 ppm, and 300 ppm, respectively.

The data shown in Figure 10 completely prove the capabilities of prototype sensors for detecting the range of PERC at concentrations that are regulated by OSHA and NIOSH.

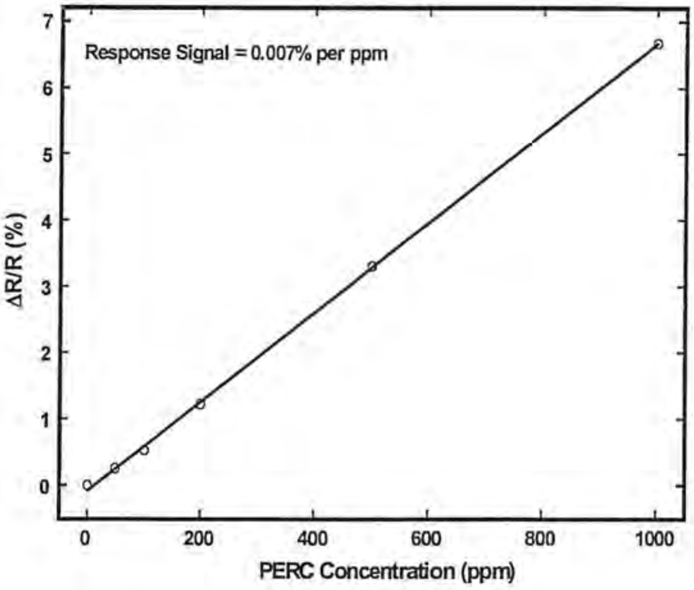

Figure 10. **Dynamic range of prototype sensor exposed to PERC vapors.**

3.2.3. Temperature and Humidity Measurements

Real-world applications of chemical microsensors at commercial drycleaner operations require that their response to temperature and humidity variations is either negligible or can be corrected to enable accurate PERC measurements. The approach being taken at Eltron is to develop personal exposure monitors employing three distinct sensors (i.e., chemical, temperature, and humidity) that can be used to accurately determine the ambient concentration of PERC vapors. Although additional measurements need to be performed, preliminary experiments completed during Phase I demonstrated that prototype sensors responded in a reproducible manner to variations in both the temperature and humidity. The following experiments were completed:

- The temperature was varied from 10 C to 40 C while prototype sensors were exposed to 200 ppm PERC.
- The humidity was varied from 0% to 70% while prototype sensors were exposed to 200 ppm PERC.

As expected, device resistance was proportional to both the absolute temperature and humidity. Exposure to PERC vapors at a specific temperature and humidity level resulted in a differential change in device resistance, which could be directly correlated with these two environmental parameters. Additional studies (i.e., Phase II) are currently required to fully evaluate the response of prototype sensors to temperature and humidity variations. Once these experiments are completed, it will be possible to develop simple algorithms that correct for these two parameters. This industry accepted approach provides an extremely powerful method for monitoring a single analyte vapor in the presence of temperature and/or humidity variations.

3.3. Personal Monitor Development

It was proposed in the Phase I work plan that prototype sensors discussed in sections 3.1 and 3.2 would be integrated with a personal exposure monitor. Due to time limitations, most of the research efforts in Phase I were limited to demonstrating the technical feasibility of innovative chemical microsensors for these instruments. The prototype monitor shown in Figure 1 was designed during the last part of the project to initiate the development of this instrument. Additional research efforts (i.e., Phase II) are necessary to complete the development efforts for these monitors, which are being designed to alert a worker of health hazardous conditions by continuously monitoring the workplace environment. Both visual and audible alarms will be used to minimize worker exposure to PERC vapors. The size of the device is currently 2" long × 1.4" wide × 0.5" thick. It can be easily worn within the breathing zone of a worker and not interfere with their job duties. An 8-bit microcontroller will be used to provide all of the required processing functions (i.e., taking resistance measurements, performing simple pattern recognition algorithms, storing chemical exposure data for further analysis, etc.). Power to the personal exposure monitor will be achieved with a 3 V rechargeable battery. It is projected that the personal exposure monitor will be sold to the end user for approximately $50 to $300 depending on the desired features as a direct result of low-cost chemical microsensors, which were developed during Phase I.

REFERENCES

1. National Institute for Occupational Safety and Health Publication No. 97-150, entitled "Control of Health and Safety Hazards in Commercial Drycleaners" (1997).

2. National Institute for Occupational Safety and Health Publication No. 99-107, entitled "Identifying High-Risk Small Business Industries" (1999).

3. National Institute for Occupational Safety and Health Publication Pocket Guide to Chemical Hazards (1999).

4. R.C. Thomas, Final Report on NSF Contract No. DMI-9760633, entitled "Handheld Environmental Monitors for Initial Site Characterization of Volatile Organic Compounds" (1998).

5. R. C. Thomas, Final Report on EPA Contract No. 68-D-99-043, entitled "Chemiresistor Microsensors for Environmental Monitoring Systems" (2000).

6. H. Wohltjen, W. R. Barger, A. W. Snow, and N. L. Jarvis, *IEEE Transactions on Electron Devices* **ED-32,** 1170 (1985).

PUBLICATIONS

Due to the proprietary nature of the information that was developed during the Phase I project, no technical papers have been submitted for publication at this time. Once the technology is commercialized, results from this work will be published in both scientific and trade journals.

DEPARTMENT OF HEALTH AND HUMAN SERVICES

Public Health Service
Centers for Disease Control
and Prevention (CDC)

Memorandum

Date: February 7, 2003

From: Adele M. Childress, Ph.D., Program Official
Office of Extramural Programs, NIOSH, E-74

Subject: Final Report Submitted for Entry into NTIS for Grant 5 R43 OH007465-02.

To: William D. Bennett
Data Systems Team, Information Resources Branch, EID, NIOSH, P03/C18

The attached final report has been received from the principal investigator on the subject NIOSH grant. If this document is forwarded to the National Technical Information Service, please let us know when a document number is known so that we can inform anyone who inquires about this final report.

Any publications that are included with this report are highlighted on the list below.

Attachment
cc: Sherri Diana, EID, P03/C13

List of Publications

Title:	Real-Time Personal Monitor for the Drycleaning Industry
Investigator:	Ross C. Thomas, Ph.D.
Affiliation:	Eltron Research, Inc.
City & State:	Boulder, CO
Telephone:	(303) 530-0260
Award Number:	5 R43 OH007465-02
Start & End Date:	9/1/2001–8/31/2002
Total Project Cost:	$99,999
Program Area:	Exposure Assessment Methods
Key Words:	dry cleaners

Final Report Abstract:

This Small Business Innovation Research project addresses the development of low-cost personal exposure monitor with real-time sampling and data logging capabilities for the dry-cleaning industry. Phase I research efforts, which are discussed in this report, were focused on the development of novel chemical microsensors for detecting perchlloroethylene vapors. Additional research studies (i.e., Phase II) will enable their integration with a badge-size instrument. Once commercialized, these innovative monitors will be used to accurately manage risks associated with daily job functions (i.e., garment spotting, washer loading and unloading, machine maintenance, clothes pressing, etc.) by workers in this high-risk small business industry. At the present time, high costs associated with continuous exposure methods prevent employers from providing adequate monitoring of worker exposure to perchloroethylene. Innovative sensors that were developed during Phase I will enable the reduction of injuries and illnesses associated with chemical exposures to perchloroethylene as employees are made aware of risks and as employers strive to provide safer workplaces. These sensors will also enable precise exposure assessments to support epidemiologic studies, practical technology that can be applied at reasonable cost in the workplace, and validated sensors for measuring relevant exposure and total dose data.

Publications

No publications to date.

ELTRON RESEARCH INC.

November 25, 2002

Centers for Disease Control and Prevention (CDC)
Acquisition and Assistance Branch B
Attn: Closeout Documents (SBIR)
2920 Brandywine Road, Suite 3000
Atlanta, GA 30341-4146

RE: Final Performance Report for Grant No. 1 R43 OH07465-01

The enclosed report (original and 2 copies) discusses the technical progress for the above referenced SBIR Phase I grant. Project identification information is summarized below:

Project Title:	Real-Time Personal Monitor for the Drycleaning Industry	
Grant No.:	1 R43 OH07465-01	
Project Period (MM/YY):	From: 09/01/01	To: 08/31/02
Inventions:	Novel chemical microsensors were developed during Phase I that were used to detect the presence of perchloroethylene vapors for the drycleaning industry. These devices will be integrated with badge-size instruments during Phase II that have real-time sampling and data logging capabilities.	
Institution and Address:	Eltron Research Inc. 4600 Nautilus Court South Boulder, CO 80301-3241	
Principal Investigator:	Dr. Ross C. Thomas rcthomas@eltronresearch.com 303-530-0263, ext. 132	

Please contact me if you have any questions and/or comments about this document.

Sincerely yours,

Ross C Thomas

Ross C. Thomas, Ph.D.
Principal Senior Scientist

Enclosures

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REAL-TIME PERSONAL MONITOR FOR THE DRYCLEANING INDUSTRY

SBIR Phase I Final Report

Contract No. 1 R44 OH7465-01

EQUIPMENT INVENTORY

No equipment was obtained under this grant.

Eileen E Sammells

Dated November 30, 2002

Eileen E. Sammells
VP-Administration
Eltron Research Inc.
4600 Nautilus Court South
Boulder, CO 80301