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Project Summary

Development of a Breadboard CO_2 Laser Photoacoustic Toxic Vapor Monitor

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This report describes the development of a breadboard version of CO_2 laser photoacoustic detector. The CO_2 laser photoacoustic technique has been demonstrated to be capable of detecting, with high specificity, a variety of toxic compounds a low parts-per-billion (ppb) levels in multicomponent air samples. The technique can be used for monitoring trace levels of various hazardous compounds in ambient air samples.

Key achievements during the program included: (1) The determination of CO_2 laser absorption cross-section data or seven compounds of EPA concern that are volatile constituents of hazardous chemical waste. These data show that the laser photoacoustic method could detect these compounds in the ambient air at levels well below their most stringent threshold limit values. (2) The development of an acoustic-frequency-tracking device that allows the use of a resonant photoacoustic cell for the first time under field conditions of changing temperature and humidity. (3) The identification of nonadsorptive materials for use in air sampliong lines and for coating the cell's interior to minimize sample adsorption and reaction losses. (4) The development of a pyro-electronic device that automatically determines the wavelength of a CO_2 laser transition. This device allows laser-wavelength selection to be under closed-loop control. (5) The placement of the breadboard detector under microcomputer control such that all wavelength selection and the calculation and display of the unknown concentrations of the gases in the air sample are automatic. (6) The analysis of laboratory-prepared air mixtures to determine the performance capability of the instrument.

Experiments on the laboratory-prepared mixtures showed that the fully automatic breadboard instrument can detect hydrazine, a toxic rocket fuel used by the Air Force, at concentrations as low as 5 ppb in the presence of three interfering gases at concentrations as much as 600 times greater.

This Project Summary was developed by EPA's Air and Energy Engineering Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

A breadboard version of a CO_2 laser photoacoustic detector has been developed for the U.S. Air Force Space Division (AFSD) and the Environmental Protection Agency (EPA), Air and Energy Engineering Research Laboratory. This detector can automatically and simultaneously monitor low parts-per-billion (ppb) level concentrations of several gases in laboratory-prepared air samples with high specificity.

When fully developed, this detector will be able to monitor areas that have potential hazards from toxic compounds will provide personnel protection not possible at this time. The Air Force is interested in using a fully developed version of this instrument for the rapid detection, at their threshold-limit-values (TLVs), of various toxic or carcinogenic compounds that may inadvertently be present in air samples at satellite launch sites.

Conclusions/Recommendations for Future Work

Several key results were achieved in the program. (1) Resonant photoacoustic cell designs were shown to offer advantages over nonresonant cells in terms of discriminating against window absorption and sample flow noise as well as minimizing the adsorption of polar compounds. (2) Signal risetime experiments carried out with the photoacoustic detector using 1 ppm hydrazine flows indicated that TFE Teflon is suitable as a cell-coating- and sampling-line-material to minimize adsorption losses of sampled gases. (3) An electronic device was developed that automatically maintains the modulation frequency of the laser at the acoustic resonance frequency of a resonant photoacoustic cell. This allows resonant cell designs to be used for the first time in field environments where the sample gas temperature and humidity may change often. (4) A pyroelectronic device was developed that can be used to determine the CO_2 laser wavelength. (5) This wavelength verification device allowed the laser's grating and PZT drive to be placed under computer control such that sample adsorbance measurements can be automatic at any desired set of laser lines. The computer can then use the absorbence data at m different laser lines to calculate the concentrations of $n \leq m$ components in a mixture using a matrix inversion program. The program employs a library of data containing absorption cross sections for the n compounds of interest at the m laser lines used for monitoring.

It should also be possible to use the detector in multipoint monitoring.

Several areas require resolution before a prototype version of the instrument can be developed for use in multipoint detection:

(1) The demonstrated feasibility of using CO_2 laser photoacoustic detection for multipoint detection.
(2) Improvement of the response time of the instrument so that it can provide a 90% full scale response in less than 2 minutes for two compounds of EPA concern at concentrations of 200 ppb in the presence of two interferences.
(3) The effects of humidity on the instrument's detection limits.
(4) The effects of aerosols that may be present in the air at monitoring locations on the instrument's detection limits.
(5) CO_2 laser absorption cross-section data, if not previously determined, for new compounds of EPA concern and for unexpected interfering compounds that may be present at monitoring locations.
(6) Verification that the water continuum, aerosol, and unexpected interferent effects described in items (3) through (5), above, are adequately addressed.
(7) Results of analyses of mixtures prepared with air from a site selected by EPA.
(8) Field evaluations of the instrument at the EPA site.

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The complete report, entitled "Development of a Breadboard CO_2 Laser Photoacoustic Toxic Vapor Monitor," (Order No. PB 88-224 332/AS; Cost: $19.95, subject to change) will be available only from:
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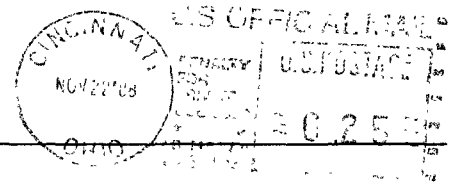

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