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Project Summary

Field and Laboratory Evaluations of a Real-Time PAH Analyzer

Mukund Ramamurthi and Jane C. Chuang

This study is a continuation of a previous evaluation of a real-time analyzer for polycyclic aromatic hydrocarbons (PAH) in air. The responses of the instrument, Gossen PAS Models 1000i and 1002i, were evaluated for vapor versus particle phase PAH, and for variations in the environmental conditions of temperature and humidity. The noise and ozone levels produced during operation were measured. In addition, a cigarette smoke generator was developed for use in field evaluations of the analyzer. The particle transmission efficiency was also measured for a range of particle sizes below 1 μm.

In general, the PAS responded only to PAH in the particulate phase. Small responses to vapor-phase PAH in two experiments were found to be associated with adsorption of the test PAH on particle surfaces. Small and insignificant ozone levels were measured within a few inches of the instrument. Its noise output was below the NC-35 criterion, except in the frequency range 1000 to 3000 Hz, where the noise approached NC-40. Temperature and humidity did not affect the response of the PAS to aerosols that were equilibrated at the test temperature.

The particle transmission efficiency through the PAS was determined for a range of aerosols 0.034 to 0.32 μm. Large particle losses below 0.10 μm were identified. A modified sampling configuration was developed, which increased the particle transmission efficiency to greater than 90% over the entire size spectrum, without having deleterious effects on the performance of the analyzer.

This Project Summary was developed by EPA's National Exposure 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

The PAH analyzers evaluated in this study were a Model PAS 1000i Photoelectric Aerosol Analyzer, manufactured by Gossen, GmbH (Erlangen, Germany) and two of a newer version, Model PAS 1002i, purchased from EcoChem Technologies, Inc. (West Hills, CA). The PAH analyzers are based on the principle of photoelectric ionization of PAH adsorbed on the surface of aerosol particles. Their operation is discussed in detail in the report on the first phase of this study (Report on Work Assignment 13, Contract 68-D0-0007).

The earlier evaluation showed the PAS provides a real-time (< 5 s) response that correlates with indoor fine particulate-phase PAH (< 2.5 μm) and does not respond to two-ring PAH vapors. The results suggested that the PAS had potential for screening and semiquantitative measurement of human exposure to airborne PAH in ambient and indoor air, and for indicating activities that may lead to PAH exposures.

The following objectives were established for this follow-on study to (1) determine whether the PAS responds to a number of different two- to four-ring PAH vapors, (2) measure the noise and ozone output of the PAS, (3) develop a cigarette smoke generator capable of use in field evaluations of the PAS, (4) determine the effects of temperature and humidity on the PAS operation, (5) investigate the transmission of aerosol particles through the PAS and modify it, if necessary, to improve this transmission, (6) investigate the response of the PAS to aerosols that do not contain PAH, and (7) compare the PAS measurements with PAH concentrations obtained by integrated air sampling followed by GC/MS analysis.

Results and Conclusions

The PAH analyzer did not respond to two- to four-ring PAH vapors, including naphthalene, 1-methylnaphthalene, chloronaphthalene, phenanthrene, and fluoranthene. A small signal, 0.008 pA, was observed for pyrene vapor at 3 ppb, when 50 to 60 particles/cc were also present in the chamber. This response was most likely due to condensation of pyrene on the surfaces of the particles.

The PAS noise level was generally below the criterion of NC-35, except at frequencies of 1000, 2000, and 4000 Hz, where the noise level was close to NC-40. These sound levels are between the noise levels typically encountered in private homes and large offices. The operation of the PAS did not increase indoor ozone levels significantly.

The cigarette smoke generator that was designed and fabricated is capable of providing field verifications of the performance of the PAH analyzer. Despite the inherent variability in the cigarette combustion process, the smoke generator elicits a reasonably characteristic frequency distribution of PAS responses during a cigarette test. Parameters that characterize this frequency distribution can then be compared with nominal ranges to verify operation in the field. Additionally, the PAS response was well correlated with the particle number concentration of the cigarette smoke.

Elevated or depressed temperature and humidity operating conditions do not have a significant impact on the response of the PAS to a cigarette smoke aerosol equilibrated at the test temperature.

The response of the PAS, operating at typical room conditions, does increase slightly, relative to particle number concentration, as the temperature of the sampled air increases. Although a mechanism for this insignificant increase is not established, it appears likely that as the aerosol temperature increases, the efficiency of ionization of the surface PAH is enhanced, requiring less energy for the photoionization process.

Aerosol transmission efficiency test showed that the PAS, in its original design configuration, had significant particle losses in the silicone tubing and in the electrofilter, particularly at particle sizes < 0.1 μm diameter, where the transmission efficiency was < 70%. A modified configuration, consisting of bypassing the electrofilter and using stainless steel tubing, provided transmission efficiency > 90% for all test aerosols, ranging in monodisperse size from 0.034 to 0.32 μm. Field trials in various indoor microenvironments indicated no deleterious effects on overall analyzer performance as a result of the modified design configuration. Under typical indoor conditions in both smoking and nonsmoking environments, an improvement in the sensitivity of the analyzer was also observed.

The PAS response to non-PAH test aerosols, normalized to aerosol number concentration, was very small and proportional to particle surface area for sodium chloride, ammonium sulfate, and phthalic anhydride aerosols generated from drying nebulized water solutions of the respective compounds. When the phthalic anhydride and dioctyl phthalate were nebulized from isopropyl alcohol, the PAS response was much smaller and only weakly proportional to particle surface area. The results suggest that the weak PAS response to non-PAH aerosols arises from impurities in the solvents used to generate the nebulized droplets.

In eight homes, fine particle PAH concentrations in indoor air, measured from integrated sampling and GC/MS analysis, ranged from 27 to 120 ng/m^3. These measured PAH concentrations were within one-fifth to two times the total fine particle PAH concentrations estimated from the PAS response, using a conversion factor of 3000 ng/m^3 per pA of electrometer signal.

Mukund Ramamurthi and Jane C. Chuang are with Battelle , Columbus OH 43201-2693.
***Nancy K. Wilson** is the EPA Project Officer (see below).*
The complete report, entitled "Field and Laboratory Evaluations of a Real-Time PAH Analyzer," (Order No. PB97-176 838; Cost: $28.00, subject to change) will be available only from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650
The EPA Project Officer can be contacted at:
National Exposure Research Laboratory
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

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