STATEMENT

Synopsis of Research Report 122

HEALTH EFFECTS INSTITUTE

Evaluation of a Personal and Microenvironmental Aerosol Speciation Sampler

Over the last several decades, evidence has accumulated suggesting that exposure to ambient particulate matter (PM), which includes particles from different sources and of varying size and composition, may be associated with health effects on the cardiovascular and respiratory systems. Ambient PM tends to have a trimodal size distribution by diameter: coarse particles (> 1 µm), fine particles (0.1 to 1 µm), and ultrafine particles (< 0.1 µm). The main components of ambient PM are elemental and organic carbon, inorganic ions (ammonium sulfate and ammonium nitrate), and trace elements. Because of concerns about health effects, the US Environmental Protection Agency regulates through the National Ambient Air Quality Standards ambient levels of PM with a diameter of 2.5 µm or less ($PM_{2.5}$).

Although a large body of epidemiologic research suggests that ambient PM may cause both acute and chronic health effects, lack of information on several key measures of exposure to particles complicates interpretation of this research, assessment of human risk, and design of control strategies. An important step in improving exposure estimates in epidemiologic studies is to characterize personal exposure to PM and its components, especially in individuals who may be sensitive to the effects of PM. Although portable, lightweight samplers have been developed for measuring PM personal exposure on a mass basis, the lack of an instrument that can measure specific PM components simultaneously has been a major limitation.

In September 2000, Dr Alison Geyh of Johns Hopkins University submitted an application entitled "Field Evaluation of the Personal Particle Speciation Sampler" for testing in the field a prototype personal sampler capable of measuring simultaneously $PM_{2.5}$ mass, elemental and organic carbon, sulfate, and nitrate. The prototype had been developed by Dr Susanne Hering with HEI funding (HEI Research Report 114).

APPROACH

The primary objective of this 14-month study was to evaluate the precision and accuracy of the Hering prototype used as a microenvironmental or personal sampler in two locations with different PM composition: Baltimore, Maryland, and Fresno, California. Geyh and coworkers also made a number of modifications to the prototype's design, which necessitated further laboratory tests. They renamed it the *personal and microenvironmental aerosol speciation sampler* (PMASS) to reflect its possible uses in the field.

The PMASS consists of a size-selective inlet with a size cutpoint of 2.5 µm through which ambient air is drawn at a flow rate of 4 L/min. Downstream from the inlet, the airflow splits between two channels to allow collection of particles on different substrates for compositional analysis. In the Geyh study, one channel contained a quartz fiber filter for measurement of elemental and organic carbon; the other channel contained a denuder, a primary Fiberfilm filter, and a backup filter for measurement of $PM_{2.5}$ mass, sulfate, and nitrate. The purpose of the backup filter was to capture nitrate that might be lost from the primary filter.

Dr Geyh and colleagues evaluated the precision and accuracy of the PMASS as a microenvironmental sampler in Fresno (outdoors) and Baltimore (indoors) and as a personal sampler in Baltimore. At the Fresno site, selected for its high ambient levels of nitrate, the PMASS was compared to the Air and Industrial Hygiene Laboratory (AIHL) cyclone. In Baltimore, the PMASS was compared to the Harvard impactor for microenvironmental sampling and to the personal environmental monitor (PEM) for personal sampling.

Precision was calculated as the percent variation among measurements taken in the same location at

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This Statement, prepared by the Health Effects Institute, summarizes a research project funded by HEI and conducted by Dr Alison S Geyh at Johns Hopkins University, Baltimore MD. The complete report, *Evaluation of a Personal and Microenvironmental Aerosol Speciation Sampler (PMASS)*, can be obtained from HEI or our website (see reverse side). GEYH 122

the same time by two or three PMASS units. Accuracy was expressed as the percent difference between the PMASS measurements and the reference sampler measurements. Geyh and colleagues set a target of 10% precision and 10% accuracy for all species measured. However, high blank values precluded determination of PMASS precision and accuracy for sulfate in all field tests, and negative mass data for filters in the AIHL cyclone precluded determination of PMASS accuracy in Fresno. Accuracy was not determined for PMASS elemental and organic carbon and nitrate in comparison with the PEM.

RESULTS AND INTERPRETATION

The major modifications made to the Hering prototype included: (1) overall weight reduction of 50% (from 620 grams to 310 grams) by substituting low-density polyethylene for aluminum in the sampler body; (2) redesign of the size-selective inlet to fit into the new polyethylene body; (3) modification of the filter holders; and (4) use of orifice plates to compensate for differences in pressure drop across the filter media in the two channels.

Precision of the PMASS as a microenvironmental sampler was 13% to 18% for mass, 12% to 14% for nitrate, and less than 10% for elemental and organic carbon. When the PMASS was used as a personal sampler, precision was 8% for elemental carbon and around 20% for mass, nitrate, and organic carbon.

The best agreements for accuracy were reported between the PMASS and the Harvard impactor for organic carbon and between the PMASS and the AIHL cyclone for organic carbon and nitrate. The PMASS and the PEM differed by more than 20% for mass. The observed biases for several of the species measured may be due to sampler differences (eg, in flow rate or in PM penetration efficiency). The reference samplers used in this study are not gold standards; they may have biases relative to one another as well as to the federal reference method for $PM_{2.5}$. Some tearing of Fiberfilm filters when removed from the filter holders may be responsible for the poor precision and accuracy of $PM_{2.5}$ mass measurements. The lack of data for sulfate should be addressed in future tests.

Overall, the PMASS is an improvement over the Hering prototype and is competitive with other recently developed samplers for assessment of personal exposure to $PM_{2.5}$ and its chemical constituents. The field studies conducted revealed some limitations, however, such as problems with the Fiberfilm filters, lower-than-targeted precision for mass and nitrate, and poor accuracy for mass and elemental carbon. These limitations need to be addressed before the PMASS is ready for use. The lack of appropriate samplers that can be used as gold standards is common to the testing of new PM samplers, especially those for personal exposure measurements. Until some form of validation of PM samplers is available, use of these samplers in epidemiologic studies should proceed with caution.

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