STATEMENT
Synopsis of Research Report 114

HEALTH EFFECTS INSTITUTE

A Personal Particle Speciation Sampler

Particulate matter (PM) in ambient air is a complex mixture containing particles of different sizes and chemical composition. Characterizing the composition of particles and linking it to toxicity may help reveal the underlying biological mechanisms of health effects, and in turn that information may point the regulatory community to the types of particles most likely associated with toxic effects. In addition, characterizing particles may help to trace particles back to their sources.

Epidemiology studies often use area measures of exposure as surrogates for personal exposure measurements. Exposure of individuals reflects local conditions and time-activity patterns that can vary greatly from exposure measured by the centrally based monitors. Personal monitors can better represent such actual individual exposure and thus have been incorporated into some studies examining PM. Because the components of PM responsible for adverse health effects are not always evident, however, personal monitors are needed that can collect information on different aspects of PM, including physical and chemical constituents—both organic and inorganic. This information is important both to complement epidemiology studies and to understand how different sources contribute to an individual's overall exposure. However, no single method allows determination of all characteristics of PM, and different sampling substrates are needed for assessing the presence and concentrations of the PM constituents of interest. The Health Effects Institute funded the study described in this report to design a personal monitor that addresses these needs.

APPROACH

Dr Susanne Hering of Aerosol Dynamics Inc and her colleagues set out to design and validate a personal sampler for particles smaller than 2.5 µm ($PM_{2.5}$) that is suitable for subsequent chemical speciation work. Specifically, the sampler was intended to meet the measurement needs for $PM_{2.5}$ mass concentration and several of its major constituents (including elemental carbon, organic carbon, sulfates, and nitrates). To allow personal monitoring, the device had to be portable and capable of battery operation for 8 continuous hours. In developing the personal particle speciation sampler, Dr Hering and her colleagues selected and tested individual components of the sampler and then performed limited field tests of a prototype that incorporated the selected components.

The overall design of the personal particle speciation sampler consists of a size-selective inlet to remove all particles larger than 2.5 µm in aerodynamic diameter, 2 sampling channels, a flow controller, and a pump. An oilless, greaseless, size-selection inlet allows precise measurement of organic carbon without the contamination problems that often occur when oil or grease is used. The 2 sampling channels allow use of quartz and Teflon filters so that PM mass concentrations and specific chemical constituents can be determined by applying a variety of filter-based analytic methods. The investigators decided to use a single pump to keep weight and noise to a minimum. Design of the personal particle speciation sampler also included the option for a denuder (a device used to remove interfering vapors) and for recapture of semivolatile components of the particles, such as nitrate. Finally, to allow detection of mass in the small sample volume obtained by the personal samplers, the personal particle speciation sampler design was made compatible with β gauge determination of PM mass, a technique that measures the attenuation of β particles through a blank-loaded and PM-loaded filter and associates the measured difference in β attenuation to PM mass.

RESULTS

Investigators evaluated several designs for each of these objectives and ultimately selected the most appropriate components. Three types of size-selective PM inlets were tested: microtrap, spiral, and compact cyclone—a modification of the cyclone impactor. Of these, the compact cyclone inlet was chosen because

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This Statement, prepared by the Health Effects Institute, summarizes a research project conducted by Dr Susanne Hering at Aerosol Dynamics Inc, Berkeley CA. The complete report, *A Personal Particle Speciation Sampler*, can be requested from HEI (see reverse side).
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it performed closest to the federal reference method and provided the best exclusion of larger particles.

To measure the total mass and chemical components of PM in their sampler, Dr Hering used 2 sampling channels: one with quartz filters used to measure elemental and organic carbon and one with Teflon filters to measure particle mass and inorganic anions (such as sulfate, nitrate, and ammonium). A cellulose backup filter impregnated with sodium chloride was included downstream from the Teflon filter to capture volatile nitrate that might be stripped from the primary filter.

Of the two denuders evaluated, the activated carbon honeycomb denuder was chosen because it was more compact and more effective at removing nitric acid than the aluminum denuder coated with magnesium oxide. The only disadvantage of this denuder was that it required periodic regeneration (heating to 100°C for at least 1 hour) to prevent release of nitric acid. Four systems for using the β gauge technique were assessed for stability, precision, and effects of loading and unloading filter cassettes. Investigators chose the AT100 β source and an integrated solid-state detection system because of its strong β source (providing good counting statistics) and long-term stability.

IMPLICATIONS

For analysis of personal PM exposure, it is increasingly important to get speciation data from personal monitors. The careful attention to the weight and size elements, and the ability to measure $PM_{2.5}$ mass concentration, elemental carbon, organic carbon, sulfates, and nitrates in the same instrument, may make the personal sampler described by Dr Hering and colleagues a valuable addition to personal monitoring tools. Once validated, this sampler could allow measurement of personal exposures to fine PM over relatively short periods of time (ie, 8 hours) and could measure important PM characteristics such as size and chemical constituents. The lightweight, compact design makes it suitable for widespread use, including personal monitoring for children and the elderly.

The study met the 5 design requirements that it set: 2-channel sampling; an oilless, greaseless inlet; provision for denuders; compatibility with β gauging; and single-pump operation. However, issues such as saturation still need to be addressed (as in environments high in tobacco smoke, ammonia, or nitric acid). Before being used widely, the sampler needs more comprehensive laboratory and controlled field testing, as is currently underway. This sampler therefore holds promise but is not yet ready for population studies.

A Personal Particle Speciation Sampler

Susanne Hering, Nathan Kreisberg, and Walter John

HEALTH EFFECTS INSTITUTE

Charlestown Navy Yard
120 Second Avenue
Boston MA 02129 USA

+1-617-886-9330
+1-617-886-9335 fax

pubs@healtheffects.org
www.healtheffects.org