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Gas and Vapor Exposure Assessment Methods

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Developing methods for making exposure assessment measurements for gases and vapors is a well-developed, active research field. Industry, academia, and government agencies have worked in this field for several decades, resulting in many sampling and analytical methods for gases and vapors for use in occupational, environmental, and indoor air applications. Consensus groups such as the International Standards Organization (ISO) and the American Society for Testing and Materials (ASTM) have contributed to the standard (methods) bank as well.

There is much being done and much remaining to be done in methods development for gases and vapors. Additionally, consideration is now being given to issues like exposure to mixtures (noise and solvent vapors), mixed exposures (asphalt, diesel exhaust), and ethical acceptability—areas that before were, for a variety of reasons, largely ignored.

This presentation focuses on method availability for exposure assessment, on research opportunities relative to gas and vapor analytical methods, and on avenues for accomplishing such work, and discusses some of the newer considerations for developing methods for exposure assessment.

Keywords Exposure Assessment Methods, Gas and Vapor Methods, Methods Compendia

Occupational exposure assessment includes developing a sampling strategy; obtaining representative samples; reliably analyzing the samples, the blanks and the quality control samples; and properly interpreting the results to arrive at a reasonable estimation of a worker's exposure to the subject toxic substance. Although the concept of exposure assessment is much broader than this, the sampling and analysis of gases and vapors is a large sub-discipline within exposure assessment.

BACKGROUND

In the 1970s the National Institute for Occupational Safety and Health (NIOSH) began the Standards Completion Program which had as one of its goals the development of a number of sampling and analytical methods for substances on the Permissible Exposure Limit (PEL) list but for which there were no methods. Today NIOSH has, with the first supplement to the Fourth edition of the *NIOSH Manual of Analytical Methods*,[1] 264 methods for over 425 substances. Most of the analytes are gases or vapors. This manual has been distributed to a variety of users on four continents and the second supplement was published in 1998. Similarly, the Occupational Safety and Health Administration (OSHA)[2] has approximately 112 methods for inorganic compounds and 105 methods for organic compounds. The Environmental Protection Agency (EPA),[3,4] has 34 methods useful for the determination of airborne organics and inorganics. The American Society for Testing and Materials (ASTM)[5] lists 101 test methods, practices, and guides for the sampling and analysis of atmospheres. The International Standards Organization (ISO)[6] has developed several standards under ISO/TC 146 Air Quality, SC 2, Workplace Atmospheres. There are more methods if you consider the other subcommittees of TC 146 that write standards for ambient atmospheres and indoor air. The point is, there are many gas and vapor exposure assessment methods. For some compounds there are multiple ways to sample and analyze. So with all of these methods, what is left to do, what still needs to be developed, and why does the method I need, you need, or one of our industrial hygienists need, not exist in one of the aforementioned compendia of sampling and analytical methods?

CHANGING STATE OF THE ART

To answer some of the questions, we need to look at the changing state of the art. When most of this methods development work was in its infancy, the kinds of problems we were considering were, for example, benzene or toluene or the xylenes on charcoal—systems that are now well-studied and well-understood. But now we have evolved. We have available myriad sorbents and samplers (both active and passive). We're dealing with problems of mixtures like asphalt, and metal working fluids (MWF). We are looking at the synergistic effects of mixed exposures of otherwise unrelated agents like noise and solvents, we are wrestling with ethical issues related to gas and vapor

exposure assessment, and we are still grappling with the ability to obtain instantaneous, real-time results. So the problems and issues have become more complex and more diverse. Where do the challenges lie in gas and vapor exposure assessment methods? Anytime a method is developed a number of factors need be considered. NIOSH has published criteria[7] used for methods development/evaluation. Many of the individual criteria are self-evident and could easily taken for granted:

- Accuracy and Precision
- Sensitivity (how low can you measure/quantitate?)
- Practicality (e.g., ease of use, portability, intrinsic safety, field worthiness)
- Reliability (Is the method fail-safe?)
- Cost
- Validity (Does the sample represent the exposure?)
- Sample integrity (tamper-resistant or tamper-evident)
- Ethical acceptability

NEEDS IN EXPOSURE ASSESSMENT METHODS

Some needs in gas and vapor methods, and some peripherally related methods areas, deserve consideration. The following list is taken from one compiled by the National Occupational Research Agenda (NORA) Exposure Assessment Methods Team.

The first suggested need is improved and evaluated methods for assessing workplace microbial contamination and worker exposure to microbes and microbial toxins. There can be gas and vapor issues with bioaerosol sampling. This category would include research to address effective sampling and analytical methods for non-aerosolized microbes, for bioaerosols, and for associated vapors. It includes methods that address the issues of sample transport, sample stability, and sample viability. It includes methods that allow for real-time, or at least on-site, determination of microbial contamination, and methods that can identify exposures to bioaerosol mixtures. For example, in the second supplement to the *NIOSH Manual of Analytical Methods*, you will find an air monitoring method for *Mycobacterium tuberculosis*.

There are needs for improved and evaluated biological monitoring methods. This is closely related to gas and vapor exposure assessment because biological monitoring can be done for gases and vapors. Specifically, we can look for evidence of exposure to gases and vapors in biological fluids. We need methods to evaluate dermal exposures; biological monitoring methods that are inexpensive, less invasive, and easier to use; methods that determine correlation among measurements from different matrices; methods for measuring appropriate biomarkers; methods that address issues of sample transport, sample storage, and sample stability; real-time methods for on-site use, and methods that can measure exposure to mixtures of classes of compounds, such as chlorinated solvent mixtures.

There is still a need for new, evaluated methods for accurately assessing exposure to chemicals in the workplace, that is, needs still exist in traditional gas and vapor exposure assessment. These needs include accurate and precise methods for characterizing low-level exposures, for example, in indoor environmental quality; methods for on-site analysis; methods that provide measurement of NO_2, SO_2, H_2S, and CO at ceiling levels in real-time, in a continuous mode, and that are based on an accurate calibration of sensors for the respective gas; methods to minimize sampling bias caused by samplers worn in moving air streams; methods that characterize exposure to mixtures; methods for "new" chemicals (new standards, new classifications); more real-time methods; additional evaluated methods for diffusive samplers, and research into immunochemical methods. One of the papers in this session addresses the use of diffusive samplers, and it is of note that the Proficiency Analytical Testing Program will soon include diffusive samplers. Those are some of the research opportunities that exist for gas and vapor exposure assessment methods. In short, we are still looking for faster, better, and cheaper methods.

I mentioned ethical acceptability—what does that have to do with gas and vapor exposure assessment methods? It is well beyond the scope of this discussion to answer questions with ethical implications, but I would like to give some indication of what is meant by "ethical issue" so as not to leave you hanging, and because all exposure assessment can involve some ethical issues, particularly with increased biological monitoring. As an example, if you are developing a biological monitoring method for a gas or vapor, and you find you require 50 mL of blood and the worker must first drink some "non-toxic" substance so you can assess phenotype variability, do you accept such an invasive method or do you find another approach?

Within these method areas, there are some recurring themes: the need for on-site, direct-reading methods/instruments, the need to sample and analyze for mixtures, the need to understand the transport, storage, and stability of samples, and the need for methods to be evaluated and kept up-to-date. One of the things NIOSH is doing is revisiting its methods that use gas chromatography as the analytic finish and replacing, if appropriate, the use of traditional packed columns with capillary columns.

All of the work that needs to be done on gas and vapor exposure assessment methods is a massive undertaking. No single entity, whether government agency, academic institution, or private industry has the resources (people, money, time, facilities) to do all the work that needs to be done. We need to think and act in terms that recognize a more global industrial hygiene community. Cooperation, collaboration, and partnering are all viable research concepts for the end of this century and the beginning of the next. Everyone needs to pool and collateralize their resources as we move forward in solving these more difficult methodological issues. How do we cooperate, collaborate, and partner?

From NIOSH's perspective, NORA is a perfect vehicle. It allows for grants, cooperative agreements, and new intramural projects with extramural components. Cooperative research and

development agreements are another possibility. Meetings such as this one, along with the American Industrial Hygiene Conference and Exhibition (AIHCE), are excellent opportunities for networking and finding those with needs similar to your own to cooperate on research efforts.

To that end, the following series of papers address various aspects of gas and vapor exposure assessment methods. In terms of policy and performance, Dr. Richard H. Brown presents two new European Directives and how they relate to methods performance criteria and standardization, and Martin Harper describes protocols for evaluating and using diffusive samplers. Regarding more applied exposure assessment methodologies, Lori Todd presents work on mapping the air in real-time for the purpose of gas and vapor flow visualization, Tom Klingner addresses isocyanate exposure monitoring, and Martin Harper presents a potential universal sorbent for air sampling, Anasorb 747. Each of these papers address some aspect of the needs outlined in this paper.

Each reader needs to consider the research opportunities, consider the following papers and how the papers' topics relate, and then, perhaps most importantly, consider how the reader might help meet the needs in gas and vapor exposure assessment methods.

REFERENCES

1. National Institute for Occupational Safety and Health: NIOSH Manual of Analytical Methods, 4th ed., DHHS (NIOSH) Publication No. 94-113, First Supplement (1996), Second Supplement (1998). NIOSH, Washington, D.C. (1994).
2. Occupational Safety and Health Administration: OSHA Analytical Methods Manual, Publication 4542, OSHA, Salt Lake City, Volumes 1,2,3 (1990), Volume 4 (1993).
3. Environmental Protection Agency: Methods for Assessing Exposure to Chemical Substances. Office of Toxic Substances, EPA-560/5-85/002, NTIS PB 86-107067, EPA, Washington, D.C. (1985).
4. EPA: Validation Methods for Chemical Exposure and Hazard Assessment Models. EPA/600/d-85/297, Environmental Research Laboratory, Office of Research and Development, EPA, Athens, GA (1985).
5. American Society for Testing and Materials, Annual Book of ASTM Standards, vol. 11.03. ASTM, West Conshohocken, PA (1997).
6. International Organization for Standardization, ISO Technical Program. ISO, Geneva (1998).
7. Kennedy, E.R.; Fischbach, T.J.; Song, R.; et al.: Guidelines for Air Sampling and Analytical Method Development and Evaluation. NIOSH Technical Report. DHHS (NIOSH) Publication No. 95-117. NIOSH, Washington, D.C. (1995).