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Project Summary

Characteristics, Deposition and Fate of Inhaled Particulate Matter

David Armentrout and Barbara Locke

Accurate estimates of deposition and fate for particulate matter in the respiratory tract are difficult to make because of complexities in particle composition and morphology. Several deficiencies in information further complicate the ability to make accurate estimates. Available models for making estimates range from simple models based on assumed particle size distribution to more complex models based on a variety of parameters. Most work in the area of estimating particle fate following inhalation has been done on aerosols of known composition. Additional work is needed to categorize properties of inhalable particles with respect to compositon in addition to morphology. Additional research is needed to define the effects of pulmonary disease on particle clearance from the lung. Additional research also is needed to better explain the mechanics of clearance from the pulmonary region of the lung.

This Project Summary was developed by EPA's Office of Health and Environmental Assessment, Washington, DC, 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

Site- and/or situation-specific exposure assessments often require incorporation of new procedures and new information. One area where additional information is needed is that of exposure assessments dealing with the fate of inhaled particulate matter. The purpose of this report is to present information available for use in estimating the fractions of inhaled particles that are absorbed by the lung and for estimating the fate of these particles following absorption.

The final project report, summarized herein, includes the following specific areas of investigation:

- Summary of current information on types and characteristics of inhalable particulate matter. The final report defines the commonly used terms for classes of particulate matter, and also summarizes size and chemical composition of particulate matter from the most common broad categories of combustion and process emissions sources.

- Summary of information that may be useful in describing current techniques for estimating absorption of particulate matter. The final report summarizes current information on deposition and clearance of particles developed from a survey of studies identified through a literature search.

- Determination of the influence of various physical parameters on regional distribution and retention of particles within the respiratory tract. Summary of information on breathing patterns, age, effects of pulmonary disease, and the general influence of physical and chemical particle characteristics relative to depositon of particulate matter.

- Description of lung damage caused by particulate matter and the relation-

ship of the damage to altered retention characteristics. A discussion of the type of information available is presented.

- Provision of information on the distribution of particulate matter to target organs of the body following lung absorption or absorption through the gastrointestinal tract following elimination from the lung. A discussion of the problems associated with the pollutant-specific nature of the available information is included.

An extensive literature search was conducted to determine the availability of data in each subject area and the applicability of the data to improving current risk estimating techniques. The literature search produced a list of 405 references, the most pertinent of which are included in the final report.

Similarly, a large volume of information is available for use to improve the current method of estimating the fate of inhaled particulate matter; unfortunately, this information is not in summary forms that can be readily applied. Additional work is needed to develop adequate particulate matter classifications and data summaries. Because of the volumes of data involved, the development of useful summaries would require an effort beyond the scope of the present effort.

Discussion

Existing models can predict particle deposition and retention in the respiratory tract. These models are based primarily on the behavior of particle classifications according to size and solubility. Literature searches identified several of those models which show reasonable correlation with predicted results.

More is known about deposition and clearance mechanisms in the extrathoracic and tracheobronchial region than in the pulmonary region. More studies are needed to provide better definition of the mechanics of macrophage clearance from the pulmonary region as well as the mechanics of clearance through the lymph system. This research is critical to providing accurate estimates of total dose, including dose to target organs resulting from absorption of inhaled particles.

Summaries of gross classifications of particles based on size distribution and solubility characteristics are included in the final report. These summaries were taken primarily from two sources published in 1982 and in 1967. Expanded summaries more adequately characterizing common aerosols are probably now available, and a new literature search may reveal better data regarding aerosol composition and physical and chemical characteristics. Existing industry-specific studies provide more in-depth characterization of emissions from industrial processes. Compound-specific aerosol data may provide a better basis for estimating probable particle size distribution in cases where the particle size distribution is not known.

Studies have shown the importance of age, breathing patterns, physical and chemical properties of particles, and pulmonary disease on particle deposition. Relatively few studies have been performed, however, regarding the effects of age and pulmonary disease, and significantly more research is needed in those two areas. With respect to physical and chemical properties, a number of studies have been conducted concerning the influence of electrostatic charge, particle morphology, hygroscopic properties, surface coating, and toxicity on absorption. For example, numerous studies have attempted to characterize the effects of inhalation of various sulfates. Data are also available to characterize the physical and chemical properties of classes of organic and metal compounds. These data are not considered in available exposure models, but they are important for assessing the clearance and distribution characteristics of metal and organic compounds. Summaries of data useful for exposure assessments are not available in the present references; compilation of such data is beyond the scope of this report. Classification and summarization of data on specific organic and metal compound classes from the voluminous available data should significantly enhance the capability for making exposure estimates.

In conjunction with classifying and summarizing available data on the chemical and physical properties of inhalable particulate matter, a comparison of the assumptions used in the most commonly available exposure models would be useful in assessing the state of the art for estimating exposure. Literature sources discuss experimental results related to specific models, but a comparison of assumptions and parameters used in the various models has not been documented.

The most immediate needs for improving exposure assessment techniques are the development of an improved classification system for estimating particle size distribution and a compilation of pollutant-specific or compound class-specific chemical and physical characteristics. These would improve the basis for estimating clearance and distribution over what is available from current summaries. The basic data needed to accomplish this may be available from existing sources. Assembly of a usable data base is needed.

The needs for expanded information on the mechanics of clearance from the pulmonary region and for information on the effects of pulmonary disease are equally critical to the development of an improved risk-assessment methodology. These areas, however, will require significant resources and time, as they would involve extensive laboratory and clinical testing.

David Armentrout and Barbara Locke are with PEI Associates, Inc , Cincinnati, OH 45246.
***Michael H. Shapiro** is the EPA Pr ıect Officer (see below)*
The complete report, entitled "Ch ıracteristics, Deposition and Fate of Inhaled Particulate Matter," (Order No. PB 87-214 854/AS; Cost: $13.95, 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:

Office of Health and Environmental Assessment
U.S. Environmental Protection Agency
Washington, DC 20460

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