Overview

Volatile organic compounds (VOCs) are an empirically defined group of compounds that: (1) typically have a low molecular weight, small specific gravity, low water solubility, and low boiling point; (2) include chemical classes such as aliphatic and aromatic hydrocarbons, halocarbons, aldehydes, ketones, and alcohols; and (3) are commonly analyzed using purge-and-trap gas chromatography coupled with mass spectrometry. Acetaldehyde, benzene, carbon tetrachloride, chloroform, propane, and vinyl chloride are but a few examples of VOCs. They are used extensively by many industries and are ingredients in many consumer products, such as fuels, paints, aerosols, cosmetics, disinfectants, refrigerants, and pesticides.

Many VOCs can adversely affect human health and the environment. Twenty-five VOCs, such as benzene, carbon tetrachloride, and chloroform, are known or suspected carcinogens; concentrations of these compounds in public water supplies are regulated by the U.S. Environmental Protection Agency (USEPA) and various state regulatory agencies. Public health concerns related to releases of VOCs into the atmosphere include depletion of the atmospheric ozone layer and, as a consequence, an increase in the incidence of human skin cancer, an increase in the mutation or die-off of plants and animals, and a decrease in food crop production. Accidental spills of VOCs, such as methyl isocyanate, have been known to be extremely disastrous to humans and animals. Because of their widespread use, their toxicity, and their environmental effects, VOCs are scrutinized closely by regulatory agencies, the scientific community, and concerned citizens.

VOCs have been detected in municipal and industrial wastewater discharges, the atmosphere, surface and ground waters, soil and landfills, municipal sewage sludge, and some foods. Their presence in the environment has been widely reported in scientific journals, the mass media, and in special technical reports. The concentrations of VOCs in urban air are of particular concern and, in March 1994, the USEPA issued stringent regulations aimed to reduce current VOC emissions by 80%. VOCs such as multihalogenated benzenes have been detected in shrimp in the United States. Xylene has been detected in tissue from fish in areas as remote as the Arctic Region.

VOCs are known to migrate into shallow and deep aquifers. VOCs, especially xylene from petroleum hydrocarbons and gasoline, have been detected in many shallow ground-water systems. After the prolonged flooding during the summer of 1993 in Iowa, many VOCs were detected in water from more monitoring wells (number of wells): benzene (1), carbon tetrachloride (1), dichloroethane (1), ethylbenzene (3), tetrachloroethylene (1), and xylene (6). The depths of these wells ranged from 9 to 48 m below land surface. Methyl tert-butyl ether is an oxygenated fuel additive for air-quality improvement mandated by the Clean Air Act Amendments of 1990. According to a 1993–1994 survey of national shallow ground water from 211 wells in 8 urban areas and 524 wells in 20 agricultural areas, this compound was detected in 27% of urban wells and 1.3% of the agricultural wells. Concentrations ranged from less than the detection level of 0.2 μg/L to as high as 23 000 μg/L.

Many VOCs currently are regulated in drinking water, industrial and municipal effluents, solid and hazardous wastes, and air quality programs by Federal and state agencies. For example, 33 of 126 chemicals regulated under the Safe Drinking Water Act, 29 of 297 toxic substances regulated under the Clean Water Act, and 77 of 418 toxic substances regulated under the Resource Conservation and Recovery Act can be classified as VOCs. Other statutes

that are the basis for regulation of VOCs include the Toxic Substances Control Act and the Occupational Safety and Health Act.

VOCs in air are regulated by provisions of the Clean Air Act. More than 50 of 189 toxic substances in air are classified as VOCs. According to the regulation, each industry is required to release less than maximum air toxic concentrations, the so-called technology-based criteria on the basis of maximum achievable control technology. Many states have adopted air toxic regulations more stringent than the Federal regulations. For example, South Carolina has mandated that 257 compounds should meet air quality standards—a large number of them are VOCs.

The unique characteristic of all VOCs in the environment is their volatility, which makes the study of VOCs more challenging than all other types of contaminants. It is difficult to close mass balance calculations and recovery of VOCs are low. There is a distinct negative bias in monitoring VOC concentrations. For example, the conventional grab sampling method, for obvious reasons, is inadequate. VOC samples need an environment in which there is no opportunity for volatilization into air. Alternatively, VOCs can be captured in a solvent for later analysis. In addition, VOC studies involve complex questions such as their distribution, source(s), transport, and fate in the environment. Other equally important issues include ecological and health risk assessments, control, and environmental remediation strategies. The number of studies related to VOCs in the environment has been increasing steadily in recent years as public awareness of the occurrence and potential hazards of these compounds has increased.

As part of the effort to increase the understanding of VOCs in the environment, an International Symposium on Volatile Organic Compounds in the Environment was sponsored by the Committee E47 on Biological Effects and Environmental Fate, American Society for Testing and Materials (ASTM). The purpose of the Symposium was to bring together scientists, engineers, regulators, and concerned citizens in an open forum to exchange information on VOCs. The objectives were to evaluate the current information and to help guide future research directions. The Symposium was intended to be an international forum because the transport of VOCs is not restricted by national boundaries and the understanding of VOCs has international applications.

The Symposium was held 11–13 April 1994, in Montreal, Canada, and included contributions from attorneys, scientists, engineers, and environmental managers from Austria, Brazil, Canada, Czech Republic, Great Britain, Korea, and the United States. The keynote address, given by Professor Yoram Cohen of the University of California, Los Angeles, set the tone of the Symposium by describing the multimedia perspective of VOCs. Professor Cohen's presentation was followed by a lecture by Carol Boman, an attorney formerly with Howard, Rice, Nemerovski, Canady, Robertson and Falk of San Francisco, on the international regulation of VOCs, with special reference to the North American Free Trade Agreement.

The Symposium was divided into sessions that focused on regulation and assessment, air quality, environmental fate, environmental measurement, environmental monitoring, and control and remediation of VOCs. The ultimate objective of VOC research is to improve environmental quality through control or remediation, both of which were heavily emphasized in this Symposium.

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