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Study of some Volatile Organic Compounds

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ABSTRACT

More than one hundred volatile organic substances were identified by gas chromatography and mass spectrometry (GC/MS) in the indoor and outdoor air. Volatile fatty acids (acetic, propanoic, butanoic and pentanoic acids) and their esters dominated along with aldehydes (butanal, pentanal and hexanal) and 4-methylphenol in the indoor and outdoor air. Road dust and soil samples contained mainly volatile aromatic compounds (toluene, benzene, ethylbenzene, styrene and xylenes), aliphatic hydrocarbons (largely n-alkanes), dichloromethane and carbon disulphide.

VOLATILE ORGANIC COMPOUNDS (VOCs)

Volatile organic compounds (VOCs) are organic chemicals that have a high vapor pressure at ordinary room temperature. Their high vapor pressure results from a low boiling point, which causes large numbers of molecules to evaporate or sublimate from the liquid or solid form of the compound and enter the surrounding air. For example, formaldehyde, which evaporates from paint, has a boiling point of only -19 °C (-2 °F). VOCs are numerous, varied, and ubiquitous. They include both human-made and naturally occurring chemical compounds. Most scents or odours are of VOCs. VOCs play an important role in communication between plants, and messages from plants to animals. Some VOCs are dangerous to human health or cause harm to the environment.

Anthropogenic VOCs are regulated by law, especially indoors, where concentrations are the highest. Harmful VOCs typically are not acutely toxic, but have compounding long-term health effects. Because the concentrations are usually low and the symptoms slow to develop, research into VOCs and their effects is difficult.

Biologically generated VOCs

Not counting methane, biological sources emit an estimated 1150 teragrams of carbon per year in the form of VOCs. The majority of VOCs are produced by plants, the main compound being isoprene. The remainder are produced by animals, microbes, and fungi, such as molds.

The strong odor emitted by many plants consists of green leaf volatiles, a subset of VOCs. Emissions are affected by a variety of factors, such as temperature, which determines rates of volatilization and growth, and sunlight, which determines rates of biosynthesis. Emission occurs almost exclusively from the leaves, the stomata in particular. A major class of VOCs is terpenes, such as myrcene. Providing a sense of scale, a forest 62,000 km2 in area is estimated to emit 3,400,000 kilograms of terpenes on a typical August day during the growing season. Induction of genes producing volatile organic compounds, and subsequent increase in volatile terpenes has been achieved in maize using (Z)-3-Hexen-1-ol and other plant hormones.

Anthropogenic sources

Anthropogenic sources emit about 142 teragrams of carbon per year in the form of VOCs.

Specific components

Paints and coatings :

A major source of man-made VOCs are coatings, especially paints and protective coatings. Solvents are required to spread a protective or decorative film. Approximately 12 billion litres of paints are produced annually. Typical solvents are aliphatic hydrocarbons, ethyl acetate, glycol ethers, and acetone. Motivated by cost, environmental concerns, and regulation, the paint and coating industries are increasingly shifting toward aqueous solvents.

Chlorofluorocarbons and chlorocarbons :

Chlorofluorocarbons, which are banned or highly regulated, were widely used cleaning products and refrigerants. Tetrachloroethene is used widely in dry cleaning and by industry. Industrial use of fossil fuels produces VOCs either directly as products (e.g., gasoline) or indirectly as byproducts (e.g., automobile exhaust).

Benzene :

One VOC that is a known human carcinogen is benzene, which is a chemical found in environmental tobacco smoke, stored fuels, and exhaust from cars. Benzene also has natural sources such as volcanoes and forest fires. It is frequently used to make other chemicals in the production of plastics, resins, and synthetic fibers. Benzene evaporates into the air quickly and the vapor of benzene is heavier than air allowing the compound to sink into low-lying areas. Benzene has also been known to contaminate food and water and if digested can lead to vomiting, dizziness, sleepiness, rapid heartbeat, and at high levels, even death may occur.

Methylene chloride :

Methylene chloride is another VOC that is highly dangerous to human health. It can be found in adhesive removers and aerosol spray paints and the chemical has been proven to cause cancer in animals. In the human body, methylene chloride is converted to carbon monoxide and a person will suffer the same symptoms as exposure to carbon monoxide. If a product that contains methylene chloride needs to be used the best way to protect human health is to use the product outdoors. If it must be used indoors, proper ventilation is essential to keeping exposure levels down.

Perchloroethylene :

Perchloroethylene is a volatile organic compound that has been linked to causing cancer in animals. It is also suspected to cause many of the breathing related symptoms of exposure to VOCs. Perchloroethylene is used mostly in dry cleaning. While dry cleaners recapture perchloroethylene in the dry cleaning process to reuse it, some environmental release is unavoidable. Studies show that people breathe in low levels of this VOC in homes where dry-cleaned clothes are stored and while wearing dry-cleaned clothing.

MTBE :

MTBE was banned in the US around 2004 in order to limit further contamination of drinking water aquifers primarily from leaking underground gasoline storage tanks where MTBE was used as an octane booster and oxygenated-additive.

Indoor air :

Since many people spend much of their time indoors, long-term exposure to VOCs in the indoor environment can contribute to sick building syndrome. In offices, VOC results from new furnishings, wall coverings, and office equipment such as photocopy machines, which can off-gas VOCs into the air. Good ventilation and air-conditioning systems are helpful at reducing VOC emissions in the indoor environment. Studies also show that relative leukemia and lymphoma can increase through prolonged exposure of VOCs in the indoor environment.

The aromatic VOC compound benzene, emitted from exhaled cigarette smoke is labeled as carcinogenic, and is ten times higher in smokers than in nonsmokers.

The concentrations of VOCs in indoor air to be found 2 to 5 times greater than in outdoor air and sometimes far greater. During certain activities indoor levels of VOCs may reach 1,000 times that of the outside air. Studies have shown that individual VOC emissions by themselves are not that high in an indoor environment, but the indoor total VOC (TVOC) concentrations can be up to five times higher than the VOC outdoor levels. New buildings especially, contribute to the highest level of VOC off-gassing in an indoor environment because of the abundant new materials generating VOC particles at the same time in such a short time period. In addition to new buildings, we also use many consumer products that emit VOC compounds, therefore the total concentration of VOC levels is much greater within the indoor environment.

VOC concentration in an indoor environment during winter is three to four times higher than the VOC concentrations during the summer. High indoor VOC levels are attributed to the low rates of air exchange between the indoor and outdoor environment as a result of tight-shut windows and the increasing use of humidifiers.

VOC Sensors :

VOCs in the environment or certain atmospheres can be detected based on

different principles and interactions between the organic compounds and the sensor components. There are electronic devices that can detect ppm concentrations despite the non-selectivity. Others can predict with reasonable accuracy the molecular structure of the volatile organic compounds in the environment or enclosed atmospheres and could be used as accurate monitors of the Chemical Fingerprint and further as health monitoring devices.

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