**Managing Volatile Organic Carbons at Workplace**

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*Abstract: VOCs are emitted as gases by several organic solids or liquids and present a significant occupational health and safety (OHS) challenge due to their deleterious health effects. Though widely present outdoor as well as indoor, the later poses a major health hazard at workplaces where these are extensively used or applied. Analytical chemistry laboratories, industrial scale application workplaces, especially those dealing with substantial quantities of organic chemicals, have VOCs as important pollutants that may affect the indoor air quality index and pose major OHS risk. Therefore, it is important to make proper quantitative and qualitative assessment of VOCs and adopt proper mitigative strategies after evaluating their concentrations against the standards.*

*Key words: Volatile Organic Compounds (VOCs), occupational health and safety (OHS), Indoor air quality, VOC measurement, VOC mitigation*

**Introduction:**

Volatile organic compounds (VOCs) refer to organic chemical compounds that have significant vapor pressures and which can adversely affect the environment and human health.1 Volatile organic compounds (VOC) are defined in various ways. The most generalised definition, frequently used for indoor air quality (IAQ) standards, describes them as organic chemical compounds which evaporate under normal indoor atmospheric temperature and pressure. Since the volatility of organic compounds is generally defined by their boiling points, the European Union and defines VOCs as any organic compound having an initial boiling point less than or equal to 250° C measured at a standard atmospheric pressure of 101.3 kPa.2 For indoor VOCs, volatility or boiling point are the only defining criteria.

The World Health organisation classifies the VOCs (in the context of broad definition of indoor volatile organic compounds) under three categories as given in the Table1.3

**Table 1** WHO classification of VOCs

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| --- | --- | --- |
| Class  | Boiling Point Range (0C) | Common Compounds |
| Very Volatile (gaseous) Organic Compound (VVOC) | <0 to 50-100  | Propane, butane, methyl chloride |
| Volatile Organic Compound (VOC) | 50-100 to 240-260  | Formaldehyde, d- Limolinene, toluene, acetone, ethanol, isopropyl alcohol |
| Semi-Volatile Organic Compound (SVOC) | 240-20 to 380-400 | Pesticides (DDT,chlordane), plasticizers(phthalates), fire retardants (PCBs, PBB)) |

**Sources of VOCs**

VOCs can be emitted from natural as well as anthropogenic sources. Naturally occurring VOCs or the biogenic volatile organic compounds are released into the atmosphere from vegetation.4 Anthropogenic organic chemical compounds are present in both indoor and outdoor environments due to their widespread use in many products and materials. Outdoor anthropogenic VOCs could be released into the air during manufacture of products, use of common products, evaporation of construction ingredients of buildings and road surfaces and from vehicular emissions. Indoor VOCs are typically released into the air through household, industrial and consumer products such as paints, solvents, repellents and aerosol sprays etc. The workplaces such as chemical analysis laboratories, synthesis laboratories, medical and biological labs and occupational spaces and industrial set-ups where extensive quantities of organic chemicals are used present a special challenge due to frequent and copious use and storage of organic chemicals.5

Indoor air may contain a wide range of VOCs simultaneously in varying concentrations and different chemical, physical and biological properties. The indoor VOC concentrations mainly depend on the factors like total space volume, the production and removal rates, air exchange rate with the outside atmosphere, and also on the outdoor VOC concentration.6 It is a common practice to report the total VOC (TVOC) levels instead of individual values of specific VOC since the concentration of individual VOCs is variable (temporally and spatially) in any given environment that also depends upon potential emission sources.6,7

Figure 1 shows relative distribution of VOC groups of compounds among all identified and quantified VOCs in the Indoor air of typical buildings where occupancy resulted into adverse health effects seemingly proportionate to the time spent in the building, although specific disease or a cause could not be identified.8



**Figure 1.** Distribution of various VOC groups among all identified and quantified VOCs8

**Health effects:**

The ability of organic chemicals to cause health effects varies greatly from no visible health effects to highly toxic effects. The extent and nature of the health effects depends on many factors including type (of VOC), concentration and duration of exposure. The adverse effects of VOCs can be simple symptoms like headache, eye (conjunctival), nose, and throat irritations, allergic skin reaction, nausea, dyspnoea, fatigue, dizziness and loss of coordination etc that are likely to be experienced immediately after the exposure of certain VOCs. The severe health effects could be asthma, cancers, chronic pulmonary disorders, and serious damage to the kidney, liver and central nervous system generally after long exposures.

**Regulation:**

Indoor Air Quality (IAQ) standards and guidelines from different global, national or regional agencies do not have a uniformity over the VOC candidates as Indoor Air Pollutant and their limiting or recommended values. Many international organisations such as Greenguard, BIFMA (Business and Institutional Furniture Manufacturers), NIOSH (National Institute for Occupational Safety and Health.), EPA (Environmental Protection Agency) and WHO (World health Organisation) have established their VOC standards for IAQ. The acceptable limits given by Greenguard for TVOC is ≤ 0.5 mg/m3 and for formaldehyde is ≤ 0.05 ppm.9 The threshold Limit Values (TLVs) range from 0.1 and 0.5 for Formaldehyde and Benzene respectively to 50 and 100 for Dichloroemethane and Xylenes respectively by various agencies. The VOC Solvents Emissions Directive is the main policy instrument for the reduction of industrial emissions of volatile organic compounds (VOCs) used by the European Union. The WHO working group, while developing the guidelines for indoor air defined the following criteria in 2010 for VOCs to qualify as Indoor Air Pollutant.10

(i) Existence of indoor sources.

(ii) Availability of toxicological and epidemiological data.

(iii) Indoor levels exceeding the levels of health concern.

on the basis of above criteria VOCs such as Formaldehyde, benzene, trichloroethylene, tetrachloroethylene and polycyclic aromatic hydrocarbons have been included by WHO to establish their indoor air guidelines. Nevertheless, the IAQ guidelines and standards for VOCs are not given in terms of specific VOCs but referred to in terms of Total Volatile Organic Compounds (TVOCs). Different countries regulate varied assortment of organic compounds as part of their indoor air quality regulations with respect to TVOCs.

**Measurements:**

VOCs are qualitatively and quantitatively analysed by gas chromatography (GC) as this allows the separation of gaseous components. Gas Chromatography in conjunction with a flame ionization detector (FID) can detect hydrocarbons as low as the PPT levels. GCs can also be used for the estimation of organohalide in conjunction with electron capture detectors. The other widely used technique for VOC analysis is mass spectrometry usually in conjunction with GC. For fast detection and accurate quantification of VOCs, direct injection mass spectrometry techniques are often employed. For temporal measurements where one requires the continuous concentration recording and averaging over entire period of sampling, gas chromatography analysis (with various detectors) of VOCs sampled on solid adsorbents is useful.

A comparative study on three most common analytical techniques for continuous monitoring of VOC in indoor air viz., flame ionization detection, nondispersive infrared spectrometry and Fourier transform infrared spectrometry found the applicability of flame ionization detection and nondispersive infrared spectrometry for temporal patterns of VOC and TVOC levels. 11 These techniques, therefore can be utilized to identify sources and sinks and of VOCs that can be utilized to device their dilution mechanisms. The study also found flame ionization detection to have better applicability than nondispersive infrared spectrometry in most cases. Fourier transform infrared spectrometry is found to be very suitable for monitoring and identifying specific VOCs and their sources. However, indirect techniques where the ambient air concentrations are essentially utilized to monitor the exposure often underestimate the personal exposure.

**Mitigation:**

The mitigation strategies for indoor VOCs include preventive measures such astheir control at source and proper storage ventilation. The simplest way to remove toxic VOC pollutants from indoor air is to reduce the number of products and usage to include fewer toxic products. There are various technologies such as adsorption, catalytic and thermal oxidation and photocatalysis are available to remove the VOCs from indoor air. Techniques using activated carbon air purifiers and filters are the most rudimentary but readily available methods for the removal of VOCs from the indoor air. Sorption remains as one of the most effective and affordable strategies for the removal of volatile organic compound (VOC) and VOC sorption by biochar has been proposed as an alternative sorbent for the removal of VOCs.12

When dealing with mitigative processes utilizing VOC oxidation, three major aspects viz., no release of toxic by-products, low power consumption and long life of process must be considered simultaneously. 13 A literature study to find the feasibility of biofilters and biotrickling filters for the treatment of complex waste air containing volatile organic compounds found lower VOC removal efficiencies for these filter types.14

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