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VOLATILE ORGANIC COMPOUNDS- CONCEPT AND ITS ROLE IN AIR POLLUTION

Engineering

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ABSTRACT

Air pollution became a real problem with industrial revolution. Today over two billion pounds of pollutants are released to the atmosphere each year. VOCs are emitted from a myriad of chemical industrial processes. Large quantities of volatile and semi-volatile organic compounds (VOC, SVOC) are emitted into the atmosphere because of both natural and anthropogenic activities. This paper focuses on volatile organic compounds as a air pollutant, its basic concept, its sources of emission, properties etc. The basic concept will be useful while doing work on prevention or removal of VOCs from air stream

KEYWORDS

Index Terms: VOCs, Air Pollution,

1. INTRODUCTION

Air pollution's origin can be traced to the discovery of fire. Sub micron particles in the form of smoke were emitted from incomplete combustion. However, air pollution did not become a real problem until the industrial revolution. Today, over two billion pounds of pollutants are released to the atmosphere each year.

Within the past 40 years, the medical and scientific communities have begun to comprehend the deleterious chronic effects of air pollution. Whether it is volatile organic compounds (VOCs) acting as catalysts for smog formation, chlorinated compounds depleting ozone layer, or odorous compounds becoming a human nuisance, the need to control and treat air pollution has become an urgent environmental and medical concern. The urgency of the matter is clearly evident in the numerous global, national. And regional environmental air pollution control regulations developed to maintain healthful air quality.

Emissions of traffic contribute to a large extent to the health effects of air pollution. It is still uncertain how much of these effects are due to aerosols and whether chemical composition or just the number of particles are important. Large quantities of volatile and semi-volatile organic compounds (VOC, SVOC) are emitted into the atmosphere because of both natural and anthropogenic activities. These compounds then will interact through complex mechanisms with other chemical compounds in the atmosphere, a process in which UV radiation from sunlight plays an important role. This will result in effects like for example photochemical air pollution, changes in stratospheric ozone and acid deposition. Rapid changes in the gas-particulate phase partitioning occur in the first minutes after emission from most sources.

1.2 Definition of VOC

Any chemical compound based on carbon chains or rings (and also containing hydrogen) with a vapour pressure greater than 2mm of mercury (0.27 kpa) at 25° C, excluding methane. These compounds may contain oxygen, nitrogen and other elements. Substances that are specifically excluded are: carbon dioxide, carbon monoxide, carbonic acid, carbonates salts, metallic carbides and methane. [17]

Volatile organic compounds (VOCs) include mainly,
(1) Chlorinated solvents and
(2) Fuel components

1.2. 1 Chlorinated Solvents: -

They are widely used in industry and in common household products. These chemicals are or have been used as degreasing fluids for many different purposes such as dry-cleaning clothes, de-caffeinate coffee, cleaning metal machinery, and dissolving grease build up in septic tanks. Some chlorinated solvents are found in such household products as spot removers, typing correction fluids, adhesives, automotive cleaners, inks, and wood furniture cleaners. Vinyl chloride is used to make plastic materials, such as vinyl and plastic wrap, and water pipes. E.g. carbon tetrachloride, 1, 2-dichloroethane, 1, 1-dichloroethylene, cis-1, 2-dichloroethylene, trichloroethylene vinyl chloride

1.2.2 Fuel Components:-

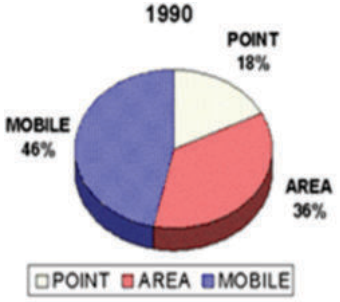
They are chemicals that are ound in products such as gasoline, kerosene, and heating oil. For example, methyl tertbutyl ether (MTBE) is added to gasoline as an octane-booster and as an "oxygenator" (or "oxyfuel") to reduce carbon monoxide emissions. Benzene, toluene, and xylenes (or BTX) are or have been used as solvents in the workplace and are components of some household products, such as glues, paints, and cleaners. Benzene is found in cigarette smoke and car exhaust. MTBE is also used as a laboratory chemical and in medicine to remove gallstones. E.g. benzene, methyl tert-butyl ether, toluene, xylenes

List of Some VOCs: -

Table 1 Lists of VOCs [17]

Name Of VOC	Name Of VOC
Carbon Tetrachloride	Benzene, ,
1,2-Dichloroethane	Methyl Tert-Butyl Ether
1,1-Dichloroethylene	Toluene
Vinyl Chloride	Xylenes
Tri-Chloroethylene	Acrylic Acid
Cis-1,2-Dichloroethylene	Acrylonitrile (2-Propenenitrile
Trans-1,2-Dichloroethylene	Ethylbenzene
Methylene Chloride	Formaldehyde (Methyl Aldehyde)
Tetrachloroethylene	Glutaraldehyde
Acetaldehyde	Acetone
Acetic Acid	Ethyl Butyl Ketone
Acetonitrile	Toluene (Methylbenzene
Ethyl Acetate	Xylenes (Individual Or Mixed Isomers
2- Ethoxyethanol	Cyclohexane
2- Ethoxyethanol Acetate	Methyl Methacrylate
Ethanol	1,1,2- Trichloroethane
Cumene (1-Methylethylbenzene)	Trichoroethylene
Styrene (Ethenylbenzene)	Aniline (Benzenamine)
Chloroform (Trichloromethane)	Methyl Isobutyl Ketone
Chloroethane (Ethyl Chloride)	1,2- Dibromoethane
Tetrachloroethylene	1,1,1,2- Tetrachloroethane
1,2- Dichloroethane	2- Methoxyethanol
Methyl Ethyl Ketone	2- Methoxyethanol Acetate
1,3 – Butadiene	N- Hexane
Ethylene Oxide	Methanol

1.2.3 VOCs Percent Distribution For All Sources: 1990 & 2005[14]



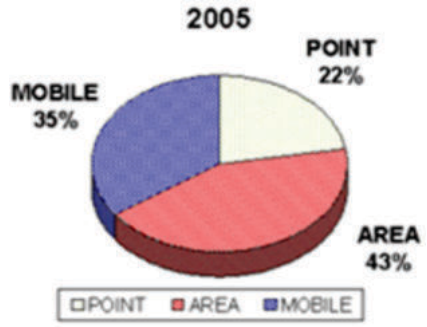


Figure 1.VOCs Percent Distribution for all sources: 1990 & 2005

II. Sources Of Emissions [17]

- Industry sources
- Diffuse sources, and industry sources (included in diffuse emissions data)
- Consumer products which may contain TVOCs
- Transport sources
- Natural sources

1.Industry Source

VOCs are released from a wide range of industrial process. Processes involving solvents, paints or the use of chemicals will likely be the most significant sources. The major point sources of VOCs in Australian cities are petrol refining and fuel storage, and manufacturing industry

2 Diffuse Sources and Industry Sources

They will be released from painted surfaces, fabrics, carpets, and printed paper and material and fibre board products. Petrol stations are significant emitters of VOCs.

3 Consumer Products

These may contain TVOCs. They will be emitted from some fabrics, carpets, fibre board, plastic products, glues and solvents; some spray packs and some printed material, paints, varnishes, wax, cleaning products, disinfectants, cosmetic, degreasing products, hobby products, fuels. The rate of emission may decrease over time as the volatile components are depleted.

4 Transport Sources

These are emitted from vehicle exhausts and from fuel tanks.

5 Natural Sources

There are significant non-anthropogenic sources of VOCs, since in most some area state capitals are adjacent to areas of bush which emit volatile oils. In the Brisbane area, for instance, such sources contribute (and are expected to continue to contribute) 60% of the observed VOCs.

VOC Emissions by Source for 1993 & 2008[14]

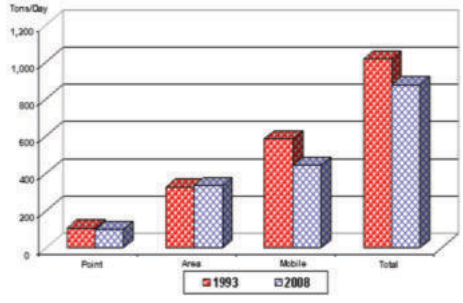


Figure 2 VOCs Emissions by Source for 1993 & 2008

III. Chemical Properties Of Vocs [3]

Why Chemical Properties Are Important? [3]

The primary function of most environmental control measures is to separate unwanted compounds from compounds that are either desired or of no concern

The method of this separation can be physical. If the compounds are in different phases or have different particle sizes.

If the compounds are dissolved in either gases or liquids, them the separation must be chemically based. The difference in chemical properties of the target compounds from the other compounds in solution determines the available methods to effect this separation.

Chemical Properties [3]:-

1. Vapour Pressure:-

Knowledge of the volatility of a compound greatly affects the options for VOC control.

Air Pollution Significance: -

If the gaseous contaminant is condensable at 90 ^{0}F then condensation using water whish is generally available at temperature of 80 ^{0}F or less is applicable. The range of application of condensation can be extended by the use of chilled water, heat transfer compounds or refrigerants. This technology usually finds application where it is worthwhile to recover a volatilized solvent. The volatility of a compound is critical in determining the effectiveness of many treatment systems.

2. Solubility In Water:-

Water solubility is defined as the concentration in the aqueous phase that is in equilibrium with the pure component phase

Air Pollution Significance:

The ability of a compound to dissolve in water is the critical factor in determining whether the compound is suitable for control by liquid scrubbing. The relative solubility of a compound will determine,

- If the compound can be controlled by water scrubbing alone
- If the compound can be controlled by an aqueous solution that is chemically enhanced to improve solubility
- If the compound will adsorb and react with a liquid phase oxidant

3. Ionization: -

Ionization is very important because it allows many compounds (hydrogen sulphide, ammonia) to have very concentrated solutions, far beyond their pure-water solubility. Acids and bases (and their salts0 will ionize in aqueous solution.

Air Pollution Significance:-

If a compound will ionize in solution, then the performance and economics of liquid scrubbing systems can generally be enhanced. For example, the removal of ammonia and hydrogen sulphide in gas stream is very dependent on the fact that these gases will ionize in solution. The addition of either acid or caustics greatly increases the ability of liquid scrubbers to remove these compounds.

4. Reactivity: -

Some of the compounds of concern are highly stable, and others are very reactive. The reactivity of a compound can be used as a tool for control if the products of the reaction are easier to control than the reactants.

Air Pollution Significance:-

Reactivity is very important in the selection of air pollution control equipment. Compounds that are not biodegradable can not be removed in biological systems. When there are mixtures of gases, and some gases are reactive and others are not then the gases can be separated.

Liquid scrubbers that use caustic alone will sorb both hydrogen sulphide and carbon sulphide and carbon dioxide in large quantities. If an oxidant is used, the sorption of carbon dioxide can be reduced to essentially zero, saving on chemical costs. The oxidant makes the scrubber selective for hydrogen sulphide because it is reactive and carbon dioxide is not.

IV Health Effects Of Vocs [17]

The health effects depend on the specific composition of the VOCs present, the concentration and the length of exposure. High concentrations of some compounds which may occur when working with materials or processes that emit VOCs could have serious health effects. These should be considered under the effects of the specific component. General effects of lower concentrations include eye, nose, and throat irritation; headaches, loss of coordination, nausea; damage to liver, kidney, and central nervous system. Some VOCs can cause cancer in animals; some are suspected or known to cause cancer in humans. Build ups of VOCs in indoor environments have been associated with 'sick building syndrome'.

Health Effect of Chlorinated Solvents: -

Chlorinated solvents are easily absorbed through the digestive tract (if swallowed) and the lungs (if breathed in). Once absorbed, they move throughout the body in the blood. For a short time, they can collect in the liver, kidneys, brain, or fatty tissues. In the liver, chlorinated solvents change into other substances and eventually pass out of the body. In general, most of these substances are eliminated from the body in a matter of days after the exposure has ended.

High amounts of chlorinated solvents were found to cause dizziness, reduce the ability to concentrate and remember, damage the nervous system, and produce an irregular heartbeat in people who are exposed in the workplace and in laboratory animals.

Some chlorinated solvents (trichloroethylene, tetra chloro ethylene, Methylene chloride, carbon tetrachloride, vinyl chloride, and 1, 2-dichloroethane) at high doses have caused cancer in laboratory animals. Vinyl chloride has also caused liver cancer in people who use this chemical at work.

Health Effect of Fuel Components: -

Fuel components are easily absorbed through the lungs (if breathed in) and the digestive tract (if swallowed) these chemicals are then carried rapidly throughout the body by the blood, mostly to the brain and nervous system. Fuel components can also build up temporarily in the fatty tissues, bone marrow, liver and kidneys. The liver changes these chemicals to other substances (for example, benzene is changed to phenol) so that they can be excreted through the urine.

Fuel components can cause drowsiness, dizziness and headaches at high doses. Long term exposure to high levels of toluene or xylenes may lead to liver and kidney damage. Benzene is the most toxic of the fuel components and can seriously affect the blood cells. Industrial workers exposed to high levels of benzene in the air were at higher risk of developing a type of anemia and of developing a type of having a low white blood cell count than other unexpected workers.

Leukemia, a form of cancer of the white blood cells, was more likely to occur in industrial workers as compares to other workers. There is also limited evidence that benzene can injure the fetus or cause miscarriage. Some people exposed to high levels of MTBE in the air have reported nose and throat irritation kidney and liver damage occurred in laboratory animals exposed to high levels of MTBE. Exposure of animals to very high levels of MTBE has caused tumors in several organs of the body.

V. Summary

Volatile organic compounds (VOCs) comprise various organic chemicals which are released as gases from different liquids or solids. The nature and impact of the health effects are dependent on the VOCs concentrations and, also, on the exposure time. They are found in various products that easily vaporize and reach in the environment under normal conditions. VOCs have increased volatility, mobility and they are resistant to degradation, being able to be transported to long distances in the environment. The most common exposure pathways to VOCs from contaminated waters were identified as drinking, bathing, food, swimming or laundries. With above study it is advisable to remove the VOC from air stream before releasing into atmosphere to prevent the harmful effect on living and non living things.

REFERENCES:

1. D. Hoon Lee, "development of an alternative biofilter system for odor treatment"
2. Environmental protection agency "air pollution technology flow sheet"
3. H.Rafson, "Odor and VOC control Handbook", Mcgraw Hill Handbook
4. J. Devinny, M. Deshusses, Todd S. "Biofiltration for air pollution control" Webster, LEWIS PUBLISHERS
5. L.Wang, N.Pereird, " ait pollution control engineering Volume 1"Handbook of Environmental Engineering, Humana Press, Totowa, New Jersey.
6. M. Deshusses "Recent developments in biological techniques for air pollution control and integration into sustainable development", University of California
7. R. Govind "Biofiltration: an innovative technology For the future" professor of chemical engineering University of Cincinnati
8. R. Govind "Biotreatment of Organic and Inorganic Odours" Professor, Department of Chemical Engineering, University of Cincinnati, Cincinnati,
9. R. Zerbonia , J. Spivey, S. Agarwal, A. Damle C. Sanford "Survey of Control Technologies for Low Concentration Organic Vapor Gas Streams" Research Triangle Institute
10. "Volatile Organic Compounds (VOC) Recovery Seminar", Air Pollution Prevention and Control Division, Air Pollution Prevention and Control Division, U.S. Environmental Protection Agency, Cincinnati.
11. Z.Shareefdeen, A.Singh "biotechnology for odor and air pollution control" Springer
12. Z. Wang, R. Govind "Review of Biofiltration - Effect of Support Media on Biofilter Performance" Department of Chemical Engineering , University of Cincinnati
13. www-dfiu.wiwi.uni- karlsruhe.de/abgeschlossen/ Platform/website/ Guidelines/ Abatement/IFARE_bioscrubber.PDF
14. http://www.epa.gov/air/oaqps/bluebook/vocsum.html
15. http://www.epa.gov/eogapti1/module6/voc/control/control.htm
16. http://www.frtr.gov/matrix2/section4/4-56html
17. http://www.npi.gov.au/index.html
18. http://www.ppcbio.com/ppcbiotechpapersme nu.htm
19. http://www.rpi.edu/dept/chemeng/BiotechEn viron/MISC/biofilt/biofiltration.htm
20. http://www.usedincinerators.com/