Review Article
Volume 4:5, 2021

Journal of Pollution

ISSN: 2684-4958 Open Access

Characteristics of Methyl Ter-Butyl Ether (MTBE), a Pollutant, in Drinking water: A Review

Shumaila Javed*

Department of Chemistry, The Islamia University, Bahawalpur, Pakistan

Abstract

As MTBE is another safer possible substitute of diethyl ether, MTBE is extensively used in industry as the Tert-Butyl group avoids MTBE from forming potentially explosive peroxides. In the methodology of contact dissolution therapy, MTBE is injected directly into the gallbladder to dissolve gallstones. Certain bacterial strains have been degenerated MTBE under strongly toxic conditions, particularly at the aerobic fringes of petroleum hydrocarbon plumes which can describe that large MTBE groundwater plumes are generally not experienced. Acute exposure of humans to high concentrations of MTBE can result in nausea, vomiting, dizziness, and sleepiness. Animal studies have shown that MTBE is rapidly absorbed following oral or inhalation exposures. Animal studies indicate that MTBE is rapidly distributed in the blood to all parts of the body including the brain. Animal studies have shown that MTBE is rapidly excreted following oral or inhalation exposures. Animal morbidity knowledge indicate that MTBE is low in acute toxicity. Information on the developmental or reproductive toxicity of MTBE in humans was not found in the available secondary sources. In animal studies, high concentrations of MTBE produced developmental and reproductive toxicity in mice and rats. Treatment of alkyl group Tert-Butyl Ether from contaminated surface and groundwater provides presents specific challenges thanks to the chemical science properties of MTBE that rely powerfully on its hydrophilic nature. Separation Methyl-tert-butyl ether is one of the most challenging processes in the chemical industry.

Evaporation is the selective evaporation of one component of a liquid mixture through a non-porous membrane, which is in direct contact with the liquid mixture. The separation mechanism in PV is not based on the relative volatility of components, but on the difference in sorption and diffusion properties of the feed substances as well as perm-selectivity of the membrane. As because a much more energy efficient process can be obtained compared to distillation, wherein all components are evaporated. Thus, the replacement of distillation with concentration or a hybrid method combining the 2 can have vital benefits with regard to energy consumption, yield, and merchandise quality. To lower these effects, we can use different techniques like pervaporation, adsorption, GAC, air stripping and ozonation. Air stripping and ozonation are best methods to remove MTBE from municipal water. We can also replace MTBE with other oxygenates. Other oxygenates are the main potential alternatives to MTBE. Oxygenates have a number of benefits, including high octane and the ability to replace conventional gasoline toxic components. Much more studies are required to get knowledge about adverse health effects of MTBE on humans and to replace it by other oxygenated compounds.

Keywords: MTBE • Tert-butyl ether • Evaporation • Membrane

Introduction

Anthropogenic activities associated with intensive urbanization, agricultural practices, industrial enterprise, and population growth have diode to water quality deterioration in several components of the planet. There are many factors that polluting water including the physical disturbance of land due to construction of houses, industries, roads, etc.; chemical pollution from industries, mines, etc.; inadequate sewage collection and treatment; increase in fertilisers to grow more food. This leads to a rise in nutrients within the water that causes increased plant growth. When this stuff dies and decays the microorganism uses the element within the water. This lowering of oxygen levels results in the death of other water life that needs oxygen to survive, e.g. fish, etc. This process is called eutrophication; litter, which causes disease and has a negative visual impact. MTBE is a chemical compound that is produced by the chemical reaction of methanol and isobutylene. MTBE is a volatile, flammable and colorless liquid that dissolves partially in water at room temperature. Methyl Tertiary Butyl Ether (MTBE) is oxygen containing compounds.

***Address to correspondence:** *Shumaila Javed, Department of Chemistry, The Islamia University, Bahawalpur, Pakistan, Tel: 9203490563276; E-mail: talhajaved3835@gmail.com*

Received: 02 August, 2021; **Accepted:** 16 August, 2021; **Published:** 23 August, 2021

When MTBE is added to gasoline, then it has reduced certain pollutants and pollutant precursors in automobile exhaust by assisting a more complete combustion of fuel [1].

Methyl Tertiary Butyl Ether (MTBE) had been firstly familiarized in the Islamic Republic of Iran in the end of 2001 as gasoline octane enhancer. Ordinary, reformulated gasoline contains 11-15% of MTBE. MTBE production has been rising exponentially in the world about 35 million tons per year due to its low cost of production and best blending quality. MTBE plants can be retrofitted to produce iso-octane from isobutylene. Methyl Tetra-Butyl Ether (MTBE) is substituted with tetra-ethyl lead to enhance combustion efficiency and to reduce air pollution and it is also anti-knocking agent that has been added to gasoline since 1970s. As MTBE is another safer possible substitute of diethyl ether, MTBE is extensively used in industry (which is commonly used in academic research) as the tetra-butyl group avoids MTBE from forming potentially explosive peroxides. It is not so much commonly used as that of diethyl ether, but It is also utilized as solvent in academic research. MTBE forms azeotropes with water 96.5% methyl-tetra butyl ether and with methanol containing 68.6% MTBE. In the methodology of contact dissolution therapy, MTBE is injected directly into the gallbladder to dissolve gallstones [2].

MTBE had offered low water solubility, low reactivity and low volatility that enable refiners to avoid the handling problems associated with alcohol oxygenates when it was compared to alcohols. So, most refiners have confined their choice to use MTBE over other oxygenates primarily for its blending characteristics and for economic reasons. In terms of solubility parameters of two components, methanol is rather polar while MTBE is a much non-polar component. The addition of Methyl Tetra-Butyl Ether (MTBE) to gasoline had resulted in public uncertainty concerning the continued reliance on biological processes for gasoline remediation. By using pure and mixed cultures with half-lives, MTBE is effectively degraded in the laboratory under aerobic conditions. The half-life is ranging from 0.04 to 29 days. MTBE concentrations have also been observed to decrease under anaerobic conditions; however, these rates are not as well defined. Certain bacterial strains have been degenerated MTBE under strongly toxic conditions, particularly at the aerobic fringes of petroleum hydrocarbon plumes which can describe that large MTBE groundwater plumes are generally not experienced. Bacteria will preferentially degrade other more easily metabolized hydrocarbons first. In cases where biologic degradation does occur, toxic degradation products such as Tertiary-Butyl Alcohol (TBA) and Tertiary-Butyl Formate (TBF) can be formed.

General Properties of MTBE

Identity

Methyl tertiary-butyl ether is usually observed as MTBE. Methyl Tertiary-Butyl Ether (MTBE) is a chemical compound made from a chemical reaction of methanol and isobutylene. At just one occasion, MTBE was produced in very large quantities and was used primarily as a fuel additive in gasoline. The Chemical formula of Methyl tetra-butyl ether is $C_5H_{12}O$. MTBE is quickly absorbed by all routes except dermal which the most important routes of excretion square measure via invalid air and excreta. MTBE exists in the atmosphere in the gas phase. The dominant atmospheric loss process for MTBE is by reaction with the hydroxyl (OH) radical. Based on this reaction, the atmospheric half-life and lifetime of MTBE are estimated to be approximately 3.5 days and 5 days, respectively. The products of the OH radical reaction include tert-butyl formate, formaldehyde, methyl acetate, and acetone.

Chemical properties

MTBE is a relatively volatile chemical and is moderately soluble in water. It is very soluble in some organic solvents such as alcohol and ether. Oil refiners mix MTBE into fuel to satisfy needs for aerated fuels. Gasoline containing MTBE has become recognizable by its pungent odor. MTBE is burnable and may be a moderate hearth risk. One of the most vital characteristics of MTBE is its objectionable taste and odour from a drinking water perspective. It is unstable in acid solution, and emits acrid smoke and irritating fumes when heated to decomposition. The smell is like that of ethers and turpentine and has a low odor threshold. Methyl tetra-butyl ether is miscible with gasoline and is soluble in water, alcohol, and other ethers. The combustion by-products of pure MTBE are evaluated in previous laboratory studies, however very little attention has been paid to the combustion by-products of MTBE as a part of gasoline [3].

Environmental fate of MTBE

MTBE is resistant to microbial as well as chemical decomposition in water. In surface water, MTBE can usually be removed very quickly due to its high volatility and stability. In groundwater, it can be more constant than in surface water because its volatilization to air is reduced or eliminated than that of water.

MTBE level in air and water

Indoor air was the most important source, presumably since there is very little commuting in vehicles at this age. A mean MTBE concentration of 35 ng/litre was detected in tap water from Frankfurt am Main. MTBE has been found in a few drinking water sources statewide. The primary source of MTBE in subsurface water is leaking underground storage tanks. All underground tanks must be upgraded.

Total estimated exposure of MTBE

The chief source of exposure of MTBE to human is to be from inhalation of air not from oral ingestion. Drinking water ingestion by non-breast-fed infants can contribute up to 10% of total exposure but in other age ranges, the contribution is only about 2% (Health Canada, 1999). Because of its volatility, there is potential for exposure in the home to airborne MTBE release from severely contaminated groundwater. Recently, MTBE has been, the second most frequently detected contaminant in drinking water supplies. In small mammalian animals, respiratory exposure has an adverse effect on the nervous system and on fetus development and can lead to kidney damage. Furthermore, there are suggestions supporting the role of MTBE as a possible human carcinogen [4].

Production of MTBE

Methyl Tetra-Butyl Ether (MTBE) is one of the largest growing chemicals in the last 10 years and will probably be in the next 10 years. There area unit 3 forms of MTBE production plants: (1) butene, made as a by-product in refinery chemical change nuts and in organic compound gas plants, is reacted with methyl alcohol to supply MTBE. (2) Merchant plants isomerize normal butane to isobutane, dehydrogenate isobutane to isobutylene, and then react the isobutylene with methanol to produce MTBE. (3) Tertiary Butyl Alcohol (TBA) is a byproduct of the propylene oxide production process. TBA is reacted with methanol to produce MTBE. Very few plants use this process.

Applications of MTBE

Roughly three-quarters of all wood spirit is employed within the production of methanol, carboxylic acid and a spread of alternative chemical intermediates that kind the muse of the many secondary by-product. The remainder of wood spirit demand is within the fuel sector, mainly within the production of MTBE. Methanol is one of the most promising fuels for fuel cell applications. Methanol is a lot of environmentally benign than typical liquid fuels. It has fewer potential environmental impacts and offers a greater degree of environmental protection. MTBE is a special ether that contains an oxygen atom, in gasoline promotes more complete combustion of the gas in the engine by increasing the temperature at which gas burns; thus, decreasing the amount of Carbon monoxide (CO) produced during combustion. MTBE is the second largest end use of methanol. This additive was designed to reduce smog forming anti toxic pollutants and increase the octane content to prevent engines from knocking.

Health Effects

The use of MTBE has been increased rapidly due to great use of lead-free gasoline in recent years. The predominant use of MTBE has led to its introduction into environment, resulting from spill and leakage of underground storage tanks or petroleum pipelines. MTBE is biologically and chemically stable, poorly adsorbed by soil and has a high solubility in water, making it very persistent in the environment. MTBE can result in dyspnea, asthma, headache, dizziness, insomnia and rash, and also classified it as a possible human carcinogen. Acute exposure of humans to high concentrations of MTBE can result in nausea, vomiting, dizziness, and sleepiness. Direct exposure to the skin and eyes can cause drying and irritation. Animal studies have shown that MTBE is rapidly absorbed following oral or inhalation exposures. Animal studies indicate that MTBE is rapidly distributed in the blood to all parts of the body including the brain. The major metabolites of MTBE are Tertiary Butyl Alcohol (TBA) and formaldehyde. The methanal is probably going additional metabolized to acid and CO2, with the possible formation of methanol as well. 2-Methyl-1,2-propanediol and a-hydroxy iso-butyric acid have also been identified in the urine of MTBE-exposed animals. Animal studies have shown that MTBE is rapidly excreted following oral or inhalation exposures.

Animal morbidity knowledge indicate that MTBE is low in acute toxicity. The main organ of acutely harmful doses of MTBE is that the systema nervosum. If acute symptoms are being caused by MTBE, they appear to be mild and transient. Intravascular haematolysis and kidney failure have occurred following unintended extravasation of an outsized bolus of MTBE. In animals, symptoms of inhalation exposure include nervous system effects, as well as inflammation of the nasal mucosa and trachea. MTBE conjointly causes gentle skin irritation and moderate eye irritation. Information on the sub-chronic and chronic toxicity of MTBE to humans was not found in the secondary sources searched. Laboratory rodents exposed to high doses or concentrations of MTBE exhibit blood chemistry changes and kidney abnormalities. Information on the potential carcinogenicity of MTBE in humans is lacking. The genotoxicity of MTBE has been evaluated in microbial mutation assays, a Sister Chromatid Exchange (SCE) assay, a mouse lymphoma assay, and in a Drosophila sex-linked recessive lethal test. Information on the developmental or reproductive toxicity of MTBE in humans was not found in the available secondary sources. In animal studies, high concentrations of MTBE produced developmental and reproductive toxicity in mice and rats [5].

Environmental Effects

MTBE has low acute toxicity to aquatic organisms; deadly concentrations ar typically larger than one hundred mg/L. In rana tempooraria, a concentration of 200 mg/L was not lethal, and a concentration of 100 mg/L resulted in accelerated tadpole development and marked increases in body weight of tadpoles and frogs that had undergone metamorphosis. The chemical wouldn't be acutely virulent to terrestrial animals unless gift in terribly high concentrations. Although MTBE is added to gasoline to improve air quality by enhancing combustion and reducing emissions of carbon monoxide and benzene, emissions of other pollutants, such as formaldehyde may increase. MTBE is a Volatile Organic Compound (VOC) substance. As a VOC, MTBE can contribute to the formation of photochemical smog in the presence of other VOCs.

Treatments for Elimination of MTBE

Treatment of Methyl Tetra-Butyl Ether (MTBE) from contaminated surface and groundwater supplies presents specific challenges due to the physicochemical properties of MTBE which depend strongly on its hydrophilic nature.

Separation of methyl-tetra-butyl

Separation Methyl-Tetra-Butyl Ether (MTBE) is one of the most challenging processes in the chemical industry. Pervaporation is the selective evaporation of one component of a liquid mixture through a non-porous membrane, which is in direct contact with the liquid mixture (Sridhar et al., 2004). The separation mechanism in PV is not based on the relative volatility of components, but on the difference in sorption and diffusion properties of the feed substances as well as perm-selectivity of the membrane. As because a much more energy efficient process can be obtained compared to distillation, wherein all components are evaporated. Thus, the (partial) replacement of distillation with concentration or a hybrid method combining the 2 can have vital benefits with regard to energy consumption, yield, and merchandise quality.

Technologies for removing MTBE

Although the procedures are often difficult and time consuming, MTBE can be removed from soil and water using existing technologies, e.g., Soil Vapour Extraction (SVE), air stripping, Granular Activated Carbon (GAC) and selected zeolites. Adsorption is one of the most utilized and effective processes for the removal of some pollutants from water and wastewater. Activated carbon, clay mineral, resin and zeolite are usually used as adsorbents for adsorption of MTBE. In the adsorption process, many factors, such as pore volume, pore structure, aperture size, ratio of composition, adsorption time and temperature, and initial MTBE concentration, could play an important role. The GAC treatment techniques include pumping contaminated water through a bed of C to get rid of organic material compounds. However, as MTBE does not adsorb well to organic fractions, its effective removal requires the repeated passing of enormous water volumes through a GAC system.

Municipal water filtration plants that believe standard water treatment techniques like clotting, sedimentation, precipitative softening, filtration and chlorination have been unsuccessful in reducing concentrations in drinking water. Air uncovering is employed for removing MTBE from drinkable sources in locations across the US. However, MTBE is stripped from water at a comparatively low rate. Air stripping is a process in which contaminated water is passed through a column filled with packing material and an upward-flow of air removes the chemicals from the water. Also, in this case the vapours are not released directly into the air before the appropriate treatment. In order to avoid MTBE loss by air stripping, zonation experiments were carried out in batch mode. Advanced oxidation technologies are based on oxidation of contaminants using appropriate combinations of Ultraviolet (UV) light, chemical oxidants and catalysts. Advanced oxidation using UV and hydrogen peroxide has also been successful. Resins are available that have a much higher adsorbent capacity for MTBE relative to activated carbon. This technology relies on the generation of electrons and hydroxyl radicals that rapidly oxidize chemicals in water. Bioreactors use activated carbon to support microbial growth so that contaminants are either adsorbed onto the carbon or destroyed by resident microbes as the contaminants pass through the activated carbon unit.

Conclusion

Methyl Tetra-Butyl Ether (MTBE) is substituted with tetra-ethyl lead to enhance combustion efficiency and to reduce air pollution and it is also anti-knocking agent that is added to gasoline. MTBE is very important due to its unique physio-chemical properties like low volatility, flammability and colorlessness. This Study concluded that although the Methyl Tetra-Butyl Ether (MTBE) is beneficially used to lower toxicity or air pollution caused by Carbon monoxide (CO), produced if incomplete combustion, because it promotes complete combustion of gasoline but also have many health effects on animals and environment. To lower these effects, we can use different techniques like pervaporation, adsorption, GAC, air stripping and ozonation. Air stripping and ozonation are best methods to remove MTBE from municipal water. We can also replace MTBE with other oxygenates. Other oxygenates are the main potential alternatives to MTBE. Oxygenates have a number of benefits, including high octane and the ability to replace conventional gasoline toxic components. The other ethers were used less widely than MTBE. They seem to have similar, but not identical, chemical and hydrogeological characteristics to the extent that they have been studied. The Panel recommends accelerated study of these compounds ' health effects and groundwater characteristics before they can be put into widespread use.

Despite the active reporting of MTBE detections in groundwater and drinking water, only a few studies have tried to assess whether drinking water exposures to MTBE are likely to affect human health at current environmental concentrations.For instance, Stern and Tardiff found that no threats to public health are likely to be associated with tap water chronic and subchronic human exposures to MTBE based on estimated water concentrations resulting from the atmospheric deposition of MTBE or leaks and spills of gasoline containing MTBE. In order to conduct a more quantitative evaluation of alternative oxygenates or fuel blends, additional data are needed on the following issues in particular. Measured (or modeled) data on air contaminant concentrations before and after the introduction of oxygenated fuels over time, including the oxygenates themselves(or potential photochemical breakdown products)and contaminants that are not subject to federal emission reduction requirements, and that account for other factors that may affect air quality (e.g., meteorological conditions or fleet turnover).

Measured (or modeled) data on drinking water contaminant detections, including MTBE, ethanol, benzene, and other gasoline constituents or byproducts, and concentrations before and after the introduction of oxygenated fuels over time; Analyses of the uncertainties in biological effects or toxicity of the oxygenates and their byproducts at relevant environmental exposure levels; and Quantitative data on the lifecycle impacts associated with the production, distribution, and transportation of MTBE, ethanol, or alternative oxygenates or fuel blends. Additional research on these topics will enable a more comprehensive quantitative analysis of alternative fuel options for risk-benefit. Assessing the risks and viability of using and handling these options will also better inform decision-making. These types of assessments are necessary to ensure that those who are more thoroughly unknown are replaced by "unknown" hazards.

References

1. Achten, Christine, Kolb Axel, and Puttmann Wilhelm. "Occurrence of Methyl Tetra-Butyl Ether (MTBE) in Riverbank Filtered Water and Drinking Water Produced by Riverbank Filtration. 2." *Environ Sci Tech* 36 (2002): 3662-3670.
2. Alkaram, Uday F, Mukhlis Abduljabar A, and Al-Dujaili Ammar H. "The Removal of Phenol from Aqueous Solutions by Adsorption using Surfactant-Modified Bentonite and Kaolinite." *J Hazard Mater* 169 (2009): 324-332.
3. Chen, Wen-Janq, and Martin Charles R. "Highly Methanol-Selective Membranes for the Pervaporation Separation of Methyl Tetra-Butyl Ether/ Methanol Mixtures." *J Membr Sci* 104 (1995): 101-108.
4. Fortin, Nathalie Y, and Deshusses Marc A. "Treatment of Methyl Tert-Butyl Ether Vapors in Biotrickling Filters. 1. Reactor Startup, Steady-State Performance, and Culture Characteristics." *Environ Sci Tech* 33 (1999): 2980-2986.

5. Franklin, Pamela M, Koshland Catherine P, Lucas Donald, and Sawyer.Robert F, et al. "Evaluation of Combustion by-Products of MTBE as a Component of Reformulated Gasoline." *Chemosphere* 42 (2001): 861-872.

How to cite this article: Javed, Shumailas. "Characteristics of Methyl Ter-Butyl Ether (MTBE), a Pollutant, in Drinking water: A Review." *J Pollu*4 (2021) : 103