

MTBE Background-1

- Member of the ether chemical group.
- $C_5H_{12}O$
 - Produced from isobutene
- Colorless and inflammable (high volatility)
- Additive in gasoline
 - Originally used as an octane booster after Pb-phaseout
 - Now used as an oxygenate

MTBE, a Gasoline Additive

Joshua Penrod

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Oxygenated Gasoline

- Promotes cleaner combustion and cleaner air
- Mandated under Clean Air Act
- Mandatory areas: LA, NYC, Balt., Chi., Milwauk., Houston, San Diego
- Other areas may opt in: DC, Philadelphia, Maine

MTBE –Background 2

- Use in gasoline started in Europe in 1970s then spread to North America
 - Ease of mixture and distribution
 - High octane
 - Beneficial dilution in gasoline

MTBE – Background 3

- Highly water soluble, more so than other gasoline compounds
- Can and will leach into groundwater and reservoirs
- Represents potential problems for drinking water supplies.

MTBE – Background 4

- Listed as a hazardous substance under CERCLA
- Accounts for 10-15% of gasoline by volume
- United States uses 250,000 barrels of MTBE per day
- Strong, distinctive odor
- Bad taste in very low concentrations in drinking water.

MTBE -- Major Sources in Environment

- Most sources consist of leaking underground petroleum storage tanks (USTs)
- Also:
 - Accidental transportation spills
 - Leaking watercraft fuel
 - Leaking pipelines

MTBE – Minor Sources in the Environment

- Stormwater run off
 - MTBE does not easily adsorb to soils
 - Easily transports to groundwater
- Evaporation
- Refueling activities
- Manufacture and transportation

MTBE -- Exposure

- Dermal pathway
- Ingestion pathway
- Inhalation Pathway
- *Common problem in MTBE studies is that they focus on MTBE without really approximating environmental exposure: MTBE plus thousands of other compounds in gasoline!*

MTBE – Dermal Exposure

- Has not been well studied or documented
- Swimming in surface waters
- Direct contact with gasoline
- Washing or bathing in water contaminated by MTBE

MTBE Studies' Focus

- Liver
- Kidneys
- CNS
- Toxicokinetics for inhalation and ingestion are both simple and complicated

MTBE -- Metabolism

- Major metabolites are formaldehyde and tertiary butyl alcohol (TBA)
- Minor metabolites include:
 - Alpha-hydroxyisobutyric acid
 - 2-methyl-1,2 propanediol
 - Methanol
 - At least two other unknown metabolites
- Liver's cytochrome P-450 apparatus is engaged in MTBE metabolism.

MTBE – Ingestion

- CNS effects seen in animals at 1200mg/kg/day
- Kidney effects seen at 300 mg/kg/day
- Certain rat studies showed tumors (see carcinogenetics, below)
 - Studies have not been duplicated
 - Saturation of pathways have been suspected as the reason for this
 - Same studies were not duplicated in mice

MTBE -- Inhalation

- Respiratory mucus membranes may be a reservoir for extended exposures.
- Reversible rat and mouse CNS effects seen at 8000ppm.
- Liver and kidney effects observed at 3000ppm.
- Decreases in organ weight (liver, kidneys, spleen, brain)
- Interstitial testicular adenomas at 3000ppm with extended exposure.

MTBE – Two Paths to Bodily Elimination

- Exhalation
- Oxidative Demethylation

MTBE -- Oxidative Demethylation

- MTBE metabolized to TBA and formaldehyde with other minor metabolites
- MTBE's half-life in the blood has been estimated at 30 minutes
 - Half-life throughout the body has ranged from 2.6-5.3 hours
 - More studies need to be done on mucosal accumulation; may affect this figure

Oxygenated Demethylation, cont'd.

- One study did show that 69% of MTBE metabolites can be recovered from the urine.
- Has not been duplicated.
- Other studies have recovered MTBE from fatty tissues in human abdominal wall after therapeutic use of MTBE on gallstones.

TBA

- Causes does-related nephropathies in rat and mouse studies.
- Has a longer half-life than MTBE
- Is not genotoxic
- Used as a reliable biomarker for MTBE exposure

Formaldehyde

- CAS No. 50-00-0
- Possible carcinogen to humans
- Genotoxic on its own and as a metabolite
- Decomposes to carbon dioxide
- Cytotoxic effects

MTBE -- Acute effects; Drunken Rodents

- Nausea
- Headaches
- Vomiting
- Disorientation
- Dizziness
- Staggering

MTBE – Specific, Observed CNS effects

- Depression
- Ataxia
- Reduced muscle tone
- Duck-walk gait

Chronic Effects

- Rat studies showed reduced brain weight.
- Some animal studies have shown endocrine system repercussions
 - Reduced uterine weight
 - Reduced pituitary weight

MTBE – Carcinogenic?

- Difficult to parse carcinogenicity of MTBE from carcinogenicity of its metabolites.
- Alpha-2u globulin nephropathy
 - Specific to rats!!
- NOAEL for rats at 400-800ppm (inhalation)
- Various tumors in animal (rat) studies
 - Testes, leukemias, lymphomas, uterine sarcomas

MTBE -- Regulation

- MTBE and oxygenated fuel is past, current, and future battleground.
 - State level
 - Federal level
 - Ongoing source of tort and environmental litigation
- MTBE has been banned in several states, even with confusing evidence
- Future of MTBE and oxygenated gasoline is uncertain.
 - Questions of cost vs. benefit for all oxygenates