

# Chapter Five

## Organic Solvents Toxicity

- Aromatic hydrocarbons
- Alcohols and Glycols

# brainstorming

- ❖ The difference b/n aliphatic and aromatic hydrocarbon?
- ❖ What are organic solvents?
- ❖ What are the properties of organic solvents?

- *Solvents* are liquid organic chemicals with variable lipophilicity and volatility
- small molecular size, and lack of charge.
- Solvents undergo ready absorption across the lung, skin, and gastrointestinal (GI) tract.
- In general, the lipophilicity of solvents increases with increasing molecular weight, whereas volatility decreases.

- Solvents are classified largely according to their molecular structure or functional group.
- Classes of solvents include
  - aliphatic hydrocarbons; aromatic hydrocarbons; alcohols; ethers; esters; aldehydes; ketones;
- Subtle differences in chemical structure can translate into dramatic differences in toxicity.

# 1. Aromatic Hydrocarbons

- The “ aromatics” are composed of one or more six-carbon (phenyl) rings
- The simplest member of the class are:
  - Benzene, phenyl compounds (alkyl benzenes) and then the aryl- and alicyclic-substituted, multi ring benzenes
  - Diphenyl and polyphenyl compounds, includes the polynuclear aromatic hydrocarbons (PNAs or PAHs), such as naphthalene, which are common as constituents of petroleum fuels
  - Benzene and the alkyl benzenes are common as raw materials and solvents in the ink, dye, oil, paint, plastics, rubber, adhesives, chemical, drug, and petroleum industries

## Aromatic hydrocarbons cont'd

- Aromatic hydrocarbons typically cause more tissue irritation than aliphatic or alicyclic
- These phenyl compounds may cause primary dermatitis and defatting of the skin
- Conjunctivitis and corneal burns cause by benzene or its alkyl derivatives when splashed into the eyes
- If the aromatics are reaspirated into the lungs after ingestion (e.g., following vomiting), they cause pulmonary edema, chemical pneumonitis, and hemorrhage

## Aromatic hydrocarbons cont'd

- Inhalation of high concentrations can result in conditions ranging from bronchial irritation, cough, and hoarseness to pulmonary edema
- Once absorbed and in systemic circulation, the hydrocarbons are more toxic than aliphatic and alicyclic

## Polycyclic Aromatic Hydrocarbon (PAH) Compounds

- Aromatic hydrocarbons that consist of fused [aromatic rings](#)
- This includes many members, all of which are cyclic-substituted benzenes
- Many of the PAHs are common components of petroleum fuels and some solvent mixtures

## Aromatic hydrocarbons cont'd

- The PAHs are nonpolar, lipid-soluble compounds that may be absorbed via the skin, lungs, or digestive tract
- Once absorbed, they can be concentrated in organs with a high lipid content
- Naphthalene is the simplest member of the PAHs and is a common fuel component, as well as a commercial moth repellent
- Naphthalene inhalation at sufficient concentration may cause headache, confusion, nausea, and profuse perspiration
- Severe exposures may cause optic neuritis and hematuria

## **Aromatic hydrocarbons cont'd**

- At high, acute doses, PAHs are toxic to many tissues and degenerative changes may ultimately be observed in the kidney and liver
- The thymus and spleen are particularly sensitive to acute effects

## 2. Alcohols and Glycols

### Alcohol Compounds: R–OH

- Alcohols are more powerful CNS depressants than their aliphatic analogs
- Tertiary alcohols with multiple substituent OH groups are more potent than secondary alcohols, which, in turn, are more potent than primary alcohols
- The alcohols exhibit irritant potential and are stronger irritants than similar organic structures that lack functional groups (e.g., alkanes).
- The alcohols are much less irritating than the corresponding amines, aldehydes, or ketones

## Alcohols and Glycols cont'd

- Alcohols and glycols (dialcohols) rarely represent serious hazards in the workplace, because their vapor concentrations are usually less than the required irritant levels, which, in turn, prevents significant CNS effects as well.
- Methanol , also known as methyl alcohol or wood alcohol, is the simplest structural member of the alcohols.
- It is widely employed as an industrial solvent and raw material for manufacturing processes.

## Alcohols and Glycols cont'd

- It is also used as one of several possible compounds to “denature” ethyl alcohol, which is used for cleaning, paint removal, and other applications
- Methanol intoxication typically exhibits one or more of the following features:
  - CNS depression, similar to or greater than that produced by ethyl alcohol (ethanol)
  - Metabolic acidosis, caused by degradation of methanol to formic acid and other organic acids
  - Ototoxicity, specific toxicity to retinal cells caused by formaldehyde, an oxidation product of methanol

## Alcohols and Glycols cont'd

- Acute methanol poisoning is characterized by headache, vertigo, vomiting, upper abdominal pain, back pain, dyspnea, restlessness, cold or clammy extremities, blurred vision, ocular hyperemia, and diarrhea
- Visual disturbance can proceed to blindness
- The pulse may slow in severely ill patients, and coma can develop rapidly

# Alcohols and Glycols cont'd

## Other Simple Alcohols

- High concentrations of propanols (propyl alcohols; structural variants including isopropanol, *n*-propanol) may cause intoxication and CNS depression
- Ethyl alcohol (ethanol) in high concentrations acts as a mild to moderate local irritant, having the ability to injure cells by precipitation and dehydration
- The CNS typically is affected more markedly than other systems
- Isopropanol [(CH<sub>3</sub>)<sub>2</sub>CHOH] generally is less toxic than *n*-propanol [CH<sub>3</sub>(CH<sub>2</sub>)<sub>2</sub>OH], but both substances are more acutely toxic than ethanol

## Alcohols and Glycols cont'd

- In humans, several hundred parts per million of isopropanol in air generally causes mild irritation of eyes, nose, and throat
- *n*-Butanol (C<sub>4</sub>H<sub>9</sub>OH) symptoms may include eye, nose, and throat irritation; vertigo; headache; drowsiness; contact dermatitis; and corneal inflammation
- Allyl alcohol may cause severe burns of the eye, lacrimation, photophobia, blurring vision and skin irritation
- It is metabolized by the liver to allyl aldehyde, a potent hepatotoxin

# Alcohols and Glycols cont'd

## Glycols

- The larger alkyl-chain glycols (e.g., some of the dihydroxy alcohols) typically exhibit a lower degree of acute oral toxicity in comparison to the monohydroxy alcohols
- They are not significantly irritating to eyes or skin, and have vapor pressures that are sufficiently low so that toxic air concentrations are not usually observed at ambient temperature (e.g. 60–80 °F)

## Alcohols and Glycols cont'd

- Ethylene glycol is a common example that may be used to represent the glycol family
- A single oral dose of 100 mL is lethal in humans, because of its metabolism to oxalate (or oxalic acid) may cause obstructive renal failure from formation of oxalate crystals

# References and Suggested Reading

- Phillip L. Williams, Robert C. James, and Stephen M. Roberts, eds., *Principles of toxicology: environmental and industrial applications*, 2nd ed., A Wiley-Interscience, New York, 2000.
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