

A SMALL DOSE OF SOLVENTS - II

Biological Properties

From a biological perspective the most important properties of solvents are their volatility, high fat solubility (lipophilicity), and small molecule size. Solvents with these characteristics are termed volatile organic compounds (VOCs). Under normal working conditions solvents readily evaporate into the air, from where they enter the lungs. The high lipid solubility and small molecule size means they are quickly absorbed across lung membranes and enter the blood supply. Blood from the lung moves directly to the brain and other body organs before reaching the liver, where metabolism of the solvent occurs. With ongoing exposure, equilibrium is reached between the amount in the body and the concentration of the solvent in the air.

Solvents are also well absorbed following oral or skin exposure. Most solvents are quickly absorbed from the gut, although the presence of food may delay absorption. Alcohol is a good example of a solvent typically consumed orally. The skin offers little barrier to solvents. Skin exposure to solvents can result in local irritation and increased blood levels of the solvent.

Solvents are eliminated from the body by metabolism or exhalation. The more volatile and fat-soluble the solvent, the greater its concentration in exhaled air. Exhaled air can be used to estimate solvent concentrations in the blood, as in breath analysis for alcohol exposure. Metabolism of solvents occurs primarily in the liver by P450 enzymes. In most cases the metabolism results in reduced toxicity and increased elimination of the resulting products. For example, the toxicity of toluene is reduced when liver enzymes change the compound so that it does not readily cross cell membranes. However, the toxicity of benzene is increased when it is changed to a compound that can attack the blood-forming cells of the bone marrow, causing leukemia.

There is considerable variability in people's ability to metabolize solvents. Subtle genetic differences can increase or decrease an individual's ability to metabolize certain solvents, resulting in increased or decreased toxicity. The liver is also prone to damage by some solvents, such as carbon tetrachloride (CCl₄). This damage can actually be made worse by prior exposure to alcohol.



Products that are mostly solvent:

Gasoline
Diesel fuel
Charcoal lighter fluid
Lantern fuel
Lubricating oils
Degreasing agents
Paint strippers
Paint thinner
Turpentine
Nail polish remover
Rubbing alcohol

Products that are partially solvent based:

Glues
Adhesives
Oil-based paints
Furniture polishes
Floor polishes and waxes
Spot removers
Metal and wood cleaners
Correction fluid
Computer disk cleaner
Varnishes and shellacs
Wood and concrete stains

Health Effects

The majority of us are exposed to low levels of solvents every day. Millions of workers around the world are exposed on a daily basis to high levels of solvents that can adversely affect health. Workers often come in contact with more than one solvent during a day's work. Health hazards from solvent exposure range from mild to life-threatening depending on the compound involved and the level and duration of exposure. It should also not be forgotten that many solvents are highly flammable.

Acute effects often involve the central nervous system because of the rapid absorption of the solvent from the lungs and direct distribution to the brain. The immediate effects may result in drowsiness or mild impairment of judgment . In most situations these effects are not serious and will end quickly once

exposure stops. In some circumstances a slight lapse of judgment could be disastrous. A person responding to a hazardous materials spill or perhaps a fire must take appropriate precautions to limit exposure to any solvents that could impair her or his judgment and thus increase risk of injury.

Chronic exposure to solvents can result in a range of organ-system effects. Damage to the peripheral nervous system results in a tingling sensation and loss of feeling in the hands and feet, increased reaction time, and decreased coordination. Reproductive effects included decreased and damaged sperm, which causes a loss in fertility. Liver and kidney damage is possible from a range of solvents. Cancer is also caused by a number of different solvents, such as benzene and carbon tetrachloride.

There is no doubt that repeated exposure to high levels of solvent can result in permanent damage to the nervous system. These changes may result in impaired learning and memory, decreased attention spans, and other psychological effects. There is also considerable data indicating that chronic low-level exposure to solvents can result in a cluster of symptoms variously referred to as painter's syndrome, organic solvent syndrome, or chronic solvent encephalopathy. The painter's syndrome was first described in Scandinavia in the late 1970s and became a recognized occupational disease in these countries. The cluster of symptoms includes headache, fatigue, sleep disorders, personality changes, and emotional instability, which progress to impaired intellectual function and ultimately, dementia. Early symptoms are often reversible if exposure is stopped.

Health Effects of Solvents

Reproductive hazard	methoxyethanol, 2-ethoxyethanol, methyl chloride
Developmental hazard	alcohol (Ethyl Alcohol)
Liver or kidney damage	Toluene , carbon tetrachloride, 1,1,2,2-tetrachloroethane, Chloroform
Nervous system damage	n-hexane , perchloroethylene, n-butyl mercaptan
Carcinogenic	carbon tetrachloride, Trichloroethylene , 1,1,2,2-tetrachloroethane, perchloroethylene, Methylene Chloride , Benzene
Visual system hazard	methanol

The easy availability of solvents in commercial and household products, combined with the rapid onset of nervous systems effects, encourages the use of solvents as an intoxicating drug. The recreational inhalation of solvents can produce euphoria, visual and auditory hallucinations, and sedation. As mentioned above, repeated exposure to high levels of solvents results in permanent brain damage. Children who accidentally drink furniture polish or other solvent-based household products are vulnerable to nervous system effects and possibly pneumonitis.

Reducing Exposure

From a health perspective there are few redeeming features of solvents except for their use as anesthetics. Clearly the simple recommendation is to avoid exposure unless administered for some medical reason. In the workplace, appropriate ventilation and personal safety equipment should be in place at all times. There are numerous national and international regulations on solvent exposure in the workplace. Substitution of less-toxic solvents in processes and products can reduce the risk of injury.

Regulatory Standards

In workplaces, standards and exposure recommendation are complex because they must address both level and duration of exposure. Below are some of the common terms used in establishing exposure recommendations.

STEL - Short term exposure limits (15 minute exposure) -protects against loss of consciousness or loss of performance, allows short-term exposure in emergency situations

TLV - Threshold Limit Value

TWA - Time Weighted Average (acceptable for 8-hr day, 40-hr week)

TLV-C - Threshold Limit Value-C (ceiling not to be exceeded)

Recommendation and Conclusions

Solvents are common around the home and workplace. As with most toxic substances, the best policy is to substitute less-toxic products whenever possible, and to reduce exposure through ventilation or protective equipment when substitutes are not available. Inhalation of solvents is particularly dangerous because of the rapid exchange in the lungs and quick access to the nervous system. Solvent inhalation produces predictable short-term effects but the long effects of repeated solvent exposure are not well characterized.

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