

apropos Benzene

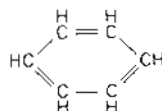
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The concept/origin

Benzene is an aromatic hydrocarbon compound. A highly dangerous water pollutant, it is a combustible, carcinogenic organic compound in which 6 carbon atoms are joined in a benzene nucleus (see illustration below).



Chemical formula: C_6H_6

Benzene occurs naturally, for example in crude oil, and is generated when organic substances are burned (e. g. forest and scrub fires).

Benzene is released into the environment during production, storage and transport, but above all as a result of incomplete combustion processes, especially in motor vehicles, power plants and industrial furnaces.

Fields of application/
industrial uses

As a basic chemical substance benzene has a wide variety of industrial uses. It is used particularly as a solvent, as an antiknock compound to raise the octane number of motor fuels and as an input material for the production of plastics, rubber coatings, aniline, carbolic acid, styrene and nitrobenzene.

Annual worldwide production of benzene measures about 22 million tonnes, 25% of which is manufactured in the EC. The greater part of benzene emissions is accounted for by motor vehicles; in Germany alone some 41,200 tonnes were released into the atmosphere in 1989.

Production

Benzene is either distilled or extracted from mineral oil, coaltar or coke oven gas. By far the greater part (90%) is generated in the production of automotive fuels from heavy oil fractions in processes that employ catalysts to crack or reform long-chain molecules. Benzene is then distilled from the end products of the cracking process.

Properties

At normal temperatures benzene is a colourless liquid, solidifying at temperatures below $5.5^\circ C$. Its physical properties may be summarised thus:

- o Density: 0.879 kg/m^3
- o Melting point: $5.5^\circ C$
- o Boiling point: $80.15^\circ C$
- o Ignition point: $555^\circ C$

Hazard potential and
effects
Human beings

Benzene is a hazardous substance which can cause cancer. Inhalation of benzene fumes by humans causes dizziness, vomiting, loss of consciousness or narcotic states, but can also lead to respiratory paralysis. Changes in the genotype have also been observed. Concentrations in excess of 60 mg/l inhaled air can have fatal effects after only a few minutes.

Incorporation of benzene damages the liver and impairs the central nervous system.

If ingested, benzene can, among other things, impair formation of the blood. The leucocyte count is reduced, thus weakening the body's immune system.

Benzene can also be absorbed through the skin and therefore should not be used as a solvent or cleanser. Measurements carried out indoors have revealed an average benzene concentration of $5 \mu\text{g}/\text{m}^3$ air. Some probable sources of this are not only the glues used to attach floor coverings but also heaters burning wood or coal. In the liver benzene is transformed into carboic compounds and, after bonding with glycuronic acid, is excreted through the kidneys.

Ecological behaviour

Motor vehicle emissions are the main cause of benzene entering the environment. Further emissions stem from the manufacture, storage and transport of benzene itself.

Open-air samples taken in rural areas show an average benzene concentration of $0.7 \mu\text{g}/\text{m}^3$, whereas the concentrations in large urban areas are up to 10 times higher. Peak readings taken along busy roads have even been as high as $30 \mu\text{g}/\text{m}^3$.

Benzene decomposes very easily in the atmosphere, breaking down under the influence of UV rays within 3–14 days. As yet no studies have been carried out to assess the danger to humans posed by the products of this decomposition process.

In water – and thus in groundwater, too – light concentrations of benzene are biodegradable. However, locations in which intensive use has been made of benzene are demonstrably in need of decontamination.

On the site of one former refinery in Germany, for instance, benzene concentrations of 10 mg/litre groundwater were recorded. In view of the fact that the German regulations governing the purity of drinking water do not specify any limit for benzene, the World Health Organisation's current recommended limit of $10 \mu\text{g}/\text{litre}$ drinking water is usually taken as a yardstick. Latest scientific research suggests an average daily intake of benzene of around 600 μg per person, the greater part of which is inhaled through second-hand smoke; this constitutes a particular danger for non-smokers. The second largest contributing factor is benzene emissions indoors, with outdoor air presenting the lowest hazard.

Limits in Germany

In the German ordinance concerning flammable liquids (VbF) benzene is classified A I, i. e. with a flash point below 21°C . Benzene is a highly dangerous water pollutant, a fact reflected in the German authorities' classification of it under water hazard class 3 "WGK 3". Its water-solubility is 1800 mg/l.

As a carcinogenic substance, benzene's permissible volume concentration under the German "TRK" (technical standard concentration) is set at $5 \text{ml}/\text{m}^3$ air, while no maximum allowable workplace concentration ("MAK-Wert") is specified.

The usual limit for the incidence of benzene is that recommended by the WHO. Benzene is not mentioned in the German ordinance on drinking water.

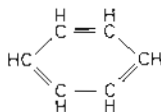
Analysis

The detection level for benzene is about $0.1 \mu\text{g}/\text{l}$ in water and $0.01 \mu\text{g}/\text{kg}$ in soil. Gas-chromatography analyses of ground-air samples can be made using a flame ionisation detector (FID) and a mass spectrometer (MS). The detection level for ground-air samples is $0.2 \text{mg}/\text{m}^3$.

The average costs of a water or soil analysis in Germany run at about DM 160 per sample; those of analysis of ground-air or gas at around DM 120. These prices can fluctuate considerably depending on the conditions prevailing in the market. However, the price should not be the only deciding factor. It is also important whether the laboratory involved carries out quality assurance. This is almost always the case with those laboratories that participate in "round robin" testing with other laboratories.

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Third-party liability/
Accident insurance

Benzene can potentially cause damage to public property. During industrial processes it can enter the subsoil either gradually or as a result of a sudden accident and from there can pose a threat to the soil, ground-air and water. The main threat to human health is via the air, with the greatest exposure to benzene occurring through emissions indoors, at the workplace and in road traffic. During 1993 50 cases of occupational disease resulting from benzene were acknowledged by German employers' liability insurance associations.

The product liability risk, e.g. from benzene in floor adhesives, must also be considered high, particularly as regards the direct/indirect export of such products to the USA and Canada.

Decontamination/
disposal

Benzene contamination usually occurs in conjunction with toluene and xylene and is thus often abbreviated in expertises to BTX (after the initials of the three contaminants). Most reported cases involve waterbody and soil contamination, with relatively few instances of ground-air contamination being observed.

Possible decontamination methods include excavation and subsequent treatment of the soil in biological beds, soil washing and on-site techniques such as high-pressure soil washing, microbiological transformation or hydraulic decontamination including stripping.

The costs of such methods (including analyses) largely depend on the individual market situation, the cost estimates are subject to wide fluctuations. In the event that decontamination is unavoidable, it is wise to compare estimates or call for tenders so as to be better able to make an adequate price-performance comparison.

Property insurance

Benzene is flammable and can become electrostatically charged when flowing. The latter poses an additional fire risk. This is why all procedures involving the transfusion, storage, transport or processing of benzene should be properly earthed. Over and above the property damage caused by fire, allowance must also be made for the costs of the subsequent clean-up and decontamination.

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