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Chlorinated hydrocarbons

apropos

CHCs

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Definition

CHC (chlorinated hydrocarbon) is a generic designation for all aliphatic* and aromatic* hydrocarbons in which one or more hydrogen atoms have been replaced by chlorine atoms. This gives a multitude of possible compounds which can be used in the most diverse fields of application.

Examples:

○ solvents	aliphatic CHCs
○ dry cleaning (textiles)	aliphatic CHCs
○ anaesthetics (e.g. formerly chloroform)	aliphatic CHCs
○ insecticides (e.g. DDT, dieldrin, lindan)	aromatic CHCs
○ heat exchanger, refrigerant and insulating fluids	aromatic CHCs
○ plastics (e.g. PVC)	vinyl chloride as base material

The following article will deal in detail only with the aliphatic chlorinated hydrocarbons, as these are the ones normally associated with the concept of CHCs in the public debate.

CHCs differ from the CFCs (chlorinated fluorocarbons) used e.g. as propellant gases for spray cans in that in the latter some of the chlorine atoms are substituted by fluorine atoms. The problems associated with CFCs will be dealt with in the context of the ozone problem.

The most common aliphatic CHCs are:

Dichloromethane	CH_2Cl_2
Chloroform	$CHCl_3$
Tetrachloromethane	CCl_4
Trichloroethene	C_2HCl_3
Tetrachloroethene (Perchloroethylene)	C_2Cl_4
Trichloroethane	$C_2H_3Cl_3$
Tetrachloroethane	$C_2H_2Cl_4$

Fields of application

CHCs are very versatile. They are widely used especially in the chemical industry, in the metal working industry (for cleaning and degreasing), in dry cleaning, in the textile industry and in the manufacture of paints and enamels. Further users include printers, renderers, tanners, the foodstuffs industry and electrical engineering. In these industries they are used especially for cleaning, drying, preserving, extracting and as solvents.

On average every 10th industrial and commercial business uses CHCs on a regular basis, nearly all businesses and households use CHCs at least occasionally.

Manufacture and economic importance

Aliphatic chlorinated hydrocarbons are manufactured in a process involving the reaction of aliphatic hydrocarbons with chlorine at temperatures between 250 and 400° C or in the presence of light.

In the former West Germany alone, 1 to 2 million tonnes of organic solvents were manufactured per year, of which chlorinated hydrocarbons accounted for about 260,000 tonnes (data from 1987).

Properties

Most chlorinated hydrocarbons are colourless liquids with a slightly sweet smell. Their density is greater than that of water (> 1.3 kg/l), and they are virtually insoluble in water. One characteristic is their relatively high volatility; their vapours are heavier than air. Because of their low surface tension – by comparison with water – they are able to permeate a number of substances (including concrete).

* Conventional classification of organic compounds according to their molecular structure

Hazard potential and effects

Effects on human beings

CHCs can be inhaled, absorbed through the skin, or orally ingested. Due to their good liposolubility, they primarily affect the skin but may also irritate the eyes. CHCs act on the central nervous system, having a more or less pronounced narcotic effect. Persons working in an environment with an airborne CHC concentration above the allowable limits may suffer loss of concentration, nervousness, headache, sleeplessness, and even permanent damage to the central nervous system.

Some CHCs can also cause severe liver and kidney damage. In Germany, some are classified as "carcinogenic substances" or as "substances reasonably suspected of having a carcinogenic potential".

Ecological impact

Because of their long-term stability and toxicity, CHCs are particularly hazardous to the environment. Being only weakly biodegradable, they can readily accumulate in the soil, ground air and groundwater via the airborne transmission path as a result of gradual or accidental emissions.

Since 70% of the drinking water supply in Germany is obtained from the groundwater, CHCs constitute a particular hazard potential. A further complicating factor is that, because CHCs are heavier than water, surface skimming methods cannot be used, making it extremely difficult to separate the CHCs from the groundwater.

Limits

The maximum allowable workplace concentrations valid in Germany depend on the toxicity of the various compounds and lie between 1 ppm (for tetrachloroethane) and 200 ppm (for 1,1,1,-trichloroethane and 1,2-dichloroethane).

In Germany, the maximum allowable workplace concentrations (MAK) are airborne concentration values for a maximum daily exposure of 8 hours for healthy persons of working age.

Most CHCs are classified as water pollutants (German water hazard class 3). Given the pollution limit for drinking water (10 micrograms/l) established in the EC Directive on the Quality of Drinking Water for Human Consumption dated 15th July 1980, 1 litre of CHCs would theoretically be enough to contaminate about 125,000 m^3 of drinking water. This corresponds to the annual private water consumption of about 3000 persons (average consumption figures for Germany).

Analysis

Water samples have to be conditioned and/or concentrated. Quantitative analysis is then performed by means of gas chromatography. Gas chromatography methods are likewise used to analyse air and ground air samples. In Germany, costs lie between DM 120 and DM 280 per analysis, depending on the number of substances present.

Substitutes

In view of the environmental hazard potential of CHCs, it is necessary or at least desirable to change over from CHCs to alternative and if possible to closed-cycle processes. Aqueous and other organic solvents have been substituted for CHCs for some purposes. In extraction applications for instance, CHCs have been replaced by mechanical ejection processes or by gaseous extraction using CO_2, in metal cleaning applications by the use of ultrasonic baths, and for cold paint stripping by alkaline aqueous solutions. However, substitution of CHCs by other substances

with a lower water hazard classification may enhance the overall process risk, since some substitute substances have a higher fire and/or explosion potential than CHCs.

Where CHCs are indispensable, engineered safeguards must be used to minimise the hazard. Such safeguards may be, for example, CHC-retaining pallets, containers, floor sumps, drip trays, or compartment and surface linings made of plastic-coated stainless steel to prevent the pollutants from penetrating the concrete and the subsoil, and extractor fans to prevent airborne contamination.

Tips for the underwriter

Casualty insurance

Apart from the potential environmental hazard (due to accidental release or gradual pollution) there is also a considerable hazard potential for persons who have to handle CHCs regularly in the course of their work. About 100 to 200 persons per year receive compensation for health impairment due to such exposure under occupational illness regulations in Germany.

Decontamination

Statutory requirements in Germany specify that soil, ground air and groundwater that have become contaminated with CHCs must be restored to their original condition.

CHCs can be removed from the soil and the ground air by ground air extraction backed up by further optimised processes such as air or vapour stripping. These two processes can also be used to decontaminate polluted groundwater.

The ground air extraction facility consists essentially of a shaft which is driven through the soil down to the groundwater level. A vacuum is applied to draw off the ground air with entrained CHCs and transport it to the surface for decontamination (as a rule by adsorption in an active carbon filter). This reduces the CHC content in the subsoil in the course of time.

Biological decontamination of CHC-polluted areas is currently under development, and initial results are available from field trials. A further possibility is thermal decontamination.

Investigation and decontamination costs (Germany 1991)

Bore holes	180 to 200 DM/m
Probes	50 to 70 DM/m
Experts' reports	80 to 190 DM/h
Samples	20 to 50 DM/sample
Ground air extraction	10 to 60 DM/tonne of soil

(depending on the amount of pollutant present)

Property insurance

Some CHCs form explosive mixtures with air and are readily combustible. In the event of an occurrence of this kind, the cost of cleaning up the CHC contamination would have to be added to the cost of the physical damage.

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