GLYCOL ETHERS AS GROUNDWATER CONTAMINANTS

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Abstract

Ether derivatives of dihydroxy alcohols, which are formed from ethylene or propylene, comprise an important group of groundwater contaminants known as glycol ethers. Compounds in this group are used as solvents, cleaning agents, and emulsifiers in many chemical products and manufacturing operations. Glycol ethers have been associated with a variety of toxic effects, and some compounds in the group are relatively potent teratogens. The limited information available suggests that glycol ethers are common contaminants in groundwater, especially in anaerobic plumes emanating from disposal of mixed industrial and household waste. Most methods used to analyze groundwater samples cannot adequately detect μg/l (ppb) concentrations of glycol ethers, and the existing methods perform worst for the most widely used and toxic species. A new method capable of analyzing μg/l concentrations of glycol ethers was recently developed, and its use is recommended for groundwater samples where glycol ethers are likely to be present.

INTRODUCTION

Glycol ethers are a widely used class of chemicals that are detected often in contaminated groundwater when library searches are made. Their high toxicity and propensity to migrate rapidly in ground water make them significant groundwater contaminants. However, these compounds are difficult to analyze, they are not included in standard lists of target analytes, and their health effects have not been widely publicized. Consequently, the presence and behavior of glycol ethers in groundwater have not attracted the attention they deserve.

This paper reviews available information about the properties of glycol ethers, their occurrence in groundwater, analytic methods for detecting them, and
their health effects. Groundwater scientists should take account of this information when selecting analytic methods and interpreting analyses that report glycol ethers.

**PHYSICAL AND CHEMICAL PROPERTIES**

Glycol ethers are colorless liquids with a faint odor. As the name implies, they are ethers derived from glycols. The glycols are usually monomers or dimers of ethylene or propylene glycol. At least one of the two hydroxyl groups is replaced with an ether linkage to an alkyl or aryl group. Esters of glycol ethers are also generally included in the classification. The glycol ethers that are mentioned in this paper are listed in Table 1, and the structural formulas of some common glycol ethers are shown in Figure 1.

Ethylene glycol monobutyl ether:

\[
\text{HO-CH}_2\text{CH}_2\text{O-CH}_2\text{CH}_2\text{CH}_2\text{CH}_3
\]

Diethylene glycol diethyl ether:

\[
\text{CH}_3\text{CH}_2\text{O-CH}_2\text{CH}_2\text{O-CH}_2\text{CH}_2\text{O-CH}_2\text{CH}_3
\]

Propylene glycol monomethyl ether:

\[
\text{CH}_3\text{CHCH}_2\text{O-CH}_3
\]

Figure 1. Structural formulas of some typical glycol ethers, showing the system of nomenclature.

Glycol ethers are referred to by a variety of names (Table 1), and analytical chemists often report glycol ethers by using IUPAC names or similar structure-based names.

Glycol ethers are hydrophilic. Partition constants between water and air and between water and olive oil for six glycol ethers, measured by Johanson and Dynesius (1988), are summarized in Table 2. The partition constants in Table 2 were measured at 37°C using a saline solution; measurements with distilled water at a lower temperature might give substantially smaller values. Generally, the glycol ethers become more hydrophilic (that is, they have smaller oil/water partition constants) with a decreasing number of carbon atoms in either the glycol or the alkyl group. In addition, ethylene glycol monoethyl ether is more hydrophilic than its acetate ester.

**USE**

Glycol ethers are used in industry and in chemical products in large amounts and for a wide variety of purposes. They are often used as solvents for cellulose esters, dyes, resins, lacquers, varnishes, and stains. They are also present in varnish removers, cleaning solutions, products for treatment of leathers and textiles, and in jet fuel as a de-icing additive.

The extent of the use of glycol ethers in products can be seen from a data base of the declared contents of chemical products maintained by the Swedish Chemical Inspectorate. The results of a search of this data base for widely used glycol ethers are summarized in Figure 2. (The data base only includes ingredients considered hazardous by the manufacturer or importer. Some products containing glycol ethers, especially those of higher molecular weight, may not have been declared.)

Some idea of the extent to which glycol ethers are used in manufacturing can be obtained from the Toxics Release Inventory of the U.S. Environmental Protection Agency. This data base shows the amount of various organic and inorganic chemicals reported to have been released into air, water, or the subsurface by U.S. manufacturers. The only glycol ethers included in this inventory are the ethylene glycol monomethyl and monoethyl ethers; others need not be reported by the manufacturer.