



2-Butoxyethanol and 2-Methoxyethanol

Current Use Patterns in Canada, Toxicology Profiles of Alternatives, and the Feasibility of Performing an Exposure Assessment Study

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Executive Summary

Environment and Health Canada have assessed 2-butoxyethanol and 2-methoxyethanol and have proposed that they are added to Schedule 1 of *CEPA, 1999* (as published in *Canada Gazette I*, August 19, 2000). As a consequence, Health and Environment Canada require up to date information on; current use patterns in Canada, the toxicology profiles of alternatives, the technical efficacy and relative cost of alternatives, and an assessment of the feasibility of performing an exposure modelling study - this report provides the required background information on these aspects.

2-Butoxyethanol (2-BE) and 2-Methoxyethanol (2-ME) are volatile organic compounds (VOCs), and both are highly water-soluble colourless viscous liquids. They are members of a class of chemicals commonly referred to as "glycol ethers". Glycol ethers are categorised as E-series glycol ethers (based on ethylene oxide) or P-series glycol ethers (based on propylene oxide) - both 2-BE and 2-ME are E-series glycol ethers. The main uses for glycol ethers are as solvents for formulations such as paints, inks and cleaning fluids. Glycol ethers combine the solubility characteristics of both ethers and alcohols, as both functional groups (ether and hydroxyl [or carboxyl]) are present in the molecule. Non-solvent applications for glycol ethers include use as anti-icing agents in jet fuel, decontamination agents, as fluids for hydraulic systems and as chemical intermediates for plasticizers, and other compounds.

There is no domestic production of either 2-BE or 2-ME in Canada currently and the majority of imports into Canada are from the United States.

The primary use of 2-Butoxyethanol is in paints and coatings and it is found in consumer, professional, and in industrial products. 2-BE is also used in cleaning products, in printing inks, and in other products including pesticides and hydraulic fluids. Most consumer uses of 2-BE are in cleaning products (primarily general purpose cleaners and window cleaners), with the second largest consumer use being in paints and coatings.

The primary uses for 2-Methoxyethanol appear to be associated with anti-icing agents for fuels and military decontamination agents. To a lesser extent it is used as a chemical intermediate, and in specialty coatings, pharmaceutical manufacturing, electronics manufacturing, other minor industrial solvent uses, and as a minor component in hydraulic fluids.

There has been a significant increase in the global demand for glycol ethers over the past decade. This trend is largely due to the growth of the coatings industry and the technical importance of glycol ethers in a wide range of coatings formulations. In 1990, approximately 85% of the glycol ethers produced globally were E-series glycol ethers (based on ethylene oxide). In the last decade, however, P-series glycol ethers (propylene oxide-based) have gained an increasing share of the glycol ethers market. This trend is expected to continue into the next decade for two main reasons; (1) E-series glycol ethers will continue to be increasingly replaced with P-series glycol ethers, and other alternative solvents, and (2) paints and coatings products, and other product types, will continue to trend towards lower VOC and zero-VOC formulations.

There is now only one manufacturer of 2-ME in North America. There are several North American suppliers of 2-BE and other glycol ethers.

The main substitutes for 2-BE and 2-ME are alternative E-series and P-series glycol ethers. These alternative glycol ethers would be expected to constitute >65% of substitutes for 2-BE and 2-ME if these chemicals were subjected to management measures that resulted in a reduction in uses.

The toxicity profiles of the main alternatives to 2-BE and 2-ME were examined. Key points to consider in terms of the general toxicity associated with glycol ethers include; (1) the principal clinical signs of acute intoxication in animals exposed to glycol ethers are consistent with the non-specific central nervous system (CNS) depression commonly seen with organic solvents; (2) the glycol ethers that cause haemolytic effects (e.g. 2-BE) have lower LD₅₀ and LC₅₀ values than other glycol ethers; (3) consistent with the solvent properties of these materials, prolonged or repeated exposure to these materials can cause moderate to severe skin irritation; (4) they are not appreciably irritating on acute exposure; (5) there is no evidence from animal experiments or human observations that any glycol ethers are skin sensitizers; (6) the weight of evidence indicates that glycol ethers do not pose a significant genotoxic risk to humans; (7) metabolism plays a key role in explaining the differing toxicological effects observed with structurally related glycol ethers; (8) the toxic effects observed correlate with the extent of metabolite formation and subsequent elimination rate; (9) small differences in glycol ether structure can significantly affect toxicity, and (10) comparative assessment of glycol ether toxicity must include consideration of differences in metabolism and well as structural comparisons.

It is important to note that glycol ether acetates are rapidly hydrolysed to their corresponding glycol ethers by carboxylesterases - and the toxicity and patterns of metabolic elimination are virtually identical for glycol ethers and their acetates. Hence the acetates of 2-BE and 2-ME should not be considered viable alternatives to these materials. Testicular toxicity is consistently observed in animal studies with 2-ME, ethylene glycol ethyl ether (EGEE), and their acetates as well as with certain higher molecular weight homologues such as DEGME. For this reason, EGEE and DEGME are not considered suitable for use in consumer products.

The short chain ethylene glycol methyl and ethyl ethers (and their acetates), as well as other glycol ethers capable of being converted to ethylene glycol methyl or ethyl ethers, cause testicular atrophy, teratogenicity/foetotoxicity and bone marrow depression. In contrast, longer chain ethylene glycol ethers (ethylene glycol ether derivatives substituted with alkyl groups that have more than two carbons e.g. ethylene glycol butyl ethers (2-BE), -propyl ether, -isopropyl ether and -phenyl ether) have not been found to cause these effects. However, these longer chain ethylene glycol ethers cause erythrocyte fragility in rats. Haemolytic activity increases as the length of the alkyl chain increases and 2-BE is the most potent of the glycol ethers in this regard. In this regard, it should be noted that human erythrocytes are less sensitive to haemolysis than rodent erythrocytes.

The toxicity of propylene glycol ethers with the alkoxy group at the primary position is quite different to that of the ethylene glycol ethers. None of the effects associated with shorter chain ethylene glycol ethers (e.g. testicular atrophy, teratogenicity/foetotoxicity and bone marrow depression) have been reported for propylene glycol ethers, however, toxicity towards the liver and kidney has been observed. Teratogenic effects (but no testicular or bone marrow effects) have been reported when the primary position is occupied by a hydroxyl group (1-propylene glycol 2-methyl ether or its acetate) - however, neither material is commercially available.

Many of the primary alternatives to 2-BE and 2-ME show similar or lower aquatic toxicity than 2-BE and 2-ME. The available biodegradability data indicate that the primary alternatives to 2-BE and 2-ME would not be expected to persist in the environment. Log Kow values for 2-BE, and its primary propylene glycol ether alternatives, indicate negligible partitioning to soil, sediments, biota. Bioconcentration factors are low for 2-BE, 2-ME and their glycol ether alternatives indicating little potential for bioaccumulation. Based on their physico-chemical characteristics, 2-BE/2-ME and their primary alternatives (alternative E-series and P-series glycol ethers) would partition primarily to water following release into the environment, and it is expected that sorption to soils or sediments would be minimal. In addition, glycol ethers released to air would be rapidly removed by photooxidation. Assessment of the photochemical reactivity of the primary alternatives to 2-BE and 2-ME indicates that no increase in ground level ozone formation would be expected if management actions resulted in some 2-BE/2-ME uses being replaced with these alternatives. This indicates that the assessed primary alternatives to 2-BE and 2-ME represent relatively low risk to the environment.

Total uses of E-series glycol ethers declined between 1989 and 1998 and this trend is expected to continue to 2008 in North America. The decline in use is observed in all product categories in which E-series glycol ethers are used indicating that replacement of E-series glycol ethers can be achieved in all product categories. Depending on the alternatives that are used to replace them, there may be reduced costs, no increase in raw material cost, or there may be increased costs.

The primary alternative to 2-ME is diethylene glycol monomethyl ether (DEGME). The use of DEGME results in cost savings since DEGME is generally sold at a lower price and used at the same concentration.

Although generally carrying a higher price tag, P-series glycol ethers have been demonstrated to be cost-effective replacements for 2-BE in coatings, cleaning products, and inks - which combined comprise over 95% of 2-BE uses. For example, some formulations of cleaning products with P-series glycol ethers (e.g. Propylene glycol n-butyl ether (PnB) and/or Dipropylene glycol n-butyl ether (DPnB)) are actually less expensive than 2-BE-containing formulations at the same performance level, and, at cost parity, blends of P-series glycol ethers with alcohols have been shown to outperform 2-BE as coupling agents in waterborne coating applications. These facts, coupled with the fact that the US producers of 2-BE and 2-ME and their Canadian subsidiaries, are also actively involved with the chemicals most likely to replace them, indicates that the decline in 2-BE and 2-ME use is unlikely to adversely impact solvent market dynamics, or the output, profitability, or employment of the producers of these chemicals, their Canadian operations, or the primary industries formulating with these chemicals.

However, industries involved with pesticide products and disinfectants/sanitizers currently containing 2-BE may face significant costs since re-registration is often necessary following re-formulation of these types of products. It should be noted that these products represent a relatively small fraction of the market for 2-BE in Canada currently.

Hence, it appears that cost-effective alternatives exist for 2-BE and 2-ME. These are primarily alternative glycol ethers - both alternative ethylene-based (E-series) and propylene-based (P-

series) glycol ethers. Some of the main alternatives for 2-BE and 2-ME appear to have more favourable human health and environmental profiles than 2-BE and 2-ME based on available information. However, some potential alternatives, including the acetates of 2-BE and 2-ME, and EGEE and DEGME, should be not considered viable alternatives for consumer products based on toxicity.