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Foreword

Special issue on the environmental risk assessment of alcohol ethoxylate nonionic surfactant

Alcohol ethoxylates (AEs) are a class of nonionic surfactants produced and used globally. The primary route to the environment is through down-the-drain disposal following use in consumer products. More than 1 million metric tonnes of these materials are consumed yearly. Their environmental safety is largely a function of their removal in wastewater treatment plants and lack of availability in the aquatic environment. Scientific assessment techniques have evolved through time, and awareness of important fate and effect processes were identified as research evolved.

A milestone for AE environmental risk assessment was achieved in the 1990s when an extensive review of the environmental safety of surfactants used in the Netherlands market was performed (AISE and CESIO, 1996). The review was conducted jointly by government scientists in the Netherlands (RIVM, Dutch National Institute of Public Health and the Environment), regulators (VROM, Dutch Ministry of Housing, Physical Planning and Environment), trade associations (NVZ, Dutch Soap Association), and industry scientists representing individual companies. Four surfactant classes, linear alkylbenzene sulfonate (LAS), AE, alcohol ethoxysulfate (AES), and soap had been prioritized for environmental risk assessment. The assessments were published as a series of research papers and concluded that the use of the four major surfactants on the Dutch market posed negligible risk and were acceptable for continued use (Feijtel et al., 1999; Matthijs et al., 1999; van de Plassche et al., 1999). However, further work was still indicated for countries other than the Netherlands, and a commitment to further the risk assessment of surfactants was taken up by the European trade association ERASM (European Risk Assessment and Management).

Since 1996, the global detergent industry, represented by formulators and suppliers, continued research on understanding the environmental fate, exposure, and effects of high-priority surfactants. The nonionic surfactant group of AEs was considered the group that was in greatest need of additional research and a series of task forces under the auspices of ERASM were formed to meet this need. The papers that follow summarize the primary findings of a new approach for the environmental risk assessment of complex mixtures of AEs.

The new risk assessment methodology is based on the development of a more sensitive and specific analytical method that is capable of detecting a greater range of homologs at higher sensitivity than previously (Dunphy et al., 2001). AEs in commercial products (technical mixtures) and in the environment are complex mixtures of homologs that vary in alkyl chain length and degree of ethoxylation. Technical mixtures of linear AEs can be represented by the molecular formula $CH_3(CH_2)_n(OCH_2\ CH_2)_yOH$, of which the major homolog distribution of n is 11–15,17 and y is 0–18. Several monitoring studies have been conducted with this new analytical method on wastewater treatment plant influents and effluents. The studies were intended to be representative of the environmental fingerprints in Europe and North America. Morrall et al. (2006) used this method to describe the removal of AEs in various types of sewage treatment in the US and identified the presence of high amounts of aliphatic alcohol in wastewater treatment plant effluents. Eadsforth et al. (2006) present AE distribution data from several European countries and Canada also indicating the prevalence of aliphatic alcohol. These two papers represent the occurrence of AE fingerprints to be expected in the environment.

Three additional papers develop the scientific methodology to assess exposure to AEs by aquatic life. Most of the alcohol detected by the analytical methodology in the environment is from other sources than AE biodegradation. Wind et al. (2006) experimentally quantified the production of aliphatic alcohol as a result of AE biodegradation. This observation is presented as an “alcohol cap”, the fraction that describes the amount of aliphatic alcohol derived or associated with AE that is considered in the risk assessment. The low contribution of AE-derived alcohols is supported by Federle and Itrich (2006), who demonstrate that half-lives of aliphatic alcohol and AE are extremely short (minutes and less) in the presence of activated sludge. Further, they also demonstrate that alcohol produced by an ether cleavage biochemical pathway is not a dominant route of biodegradation and other mechanisms are involved. Bioavailability is another important consideration in understanding relevant exposure scenarios for biota to these hydrophobic organic compounds. Van Compernolle et al. (2006) summarize the literature on AE sorption and produce regression models that can be used to estimate sorption of all homologs in river water and on to

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effluent solids. In combination with monitoring of environmental fingerprints, the "alcohol cap" and "bioavailability" are important tools to provide the correct exposure context for the later risk assessment of AE.

Because the vast majority of aquatic toxicity studies performed on AEs utilize commercial mixtures, and these commercial mixtures do not resemble the distribution of homologs in environmental effluents, a mechanism is needed to place both into the same context. The first step is the development of structure-activity relationships or SARs. Boeije et al. (2006) describe new chronic aquatic toxicity SARs for *Daphnia magna*, fathead minnows (*Pimephales promelas*), and complex stream mesocosms. These new SARs allow the appropriate interpretation of multicomponent mixtures of AE homologs and their distributions.

In a risk assessment, exposure and effect concentrations are compared and for AEs this approach was applied following the development of the new information. Belanger et al. (2006) synthesize the current analytical, fate, and exposure data with newly constructed SARs, which were used to develop homolog-specific species sensitivity distributions, and combine these with knowledge of effluent distributions of AEs. Through a combination of exposure assessment (using monitored distributions, the "alcohol cap" concept, and bioavailability adjustment) and mixture toxicity based on species sensitivity distributions, a conclusion of low risk to aquatic life from AEs is put forward.

To our knowledge this surfactant risk assessment is the most integrated and comprehensive available and could act as a model for other complex mixtures with comprehensive fate and effects understanding.

Dedication

In memoriam to Dr. Ir. Thomas (Tom) C.J. Feijtel (1959–2005).

This collection of papers is dedicated to the memory of our colleague and friend Tom Feijtel, a visionary, who took on the challenge to produce the original Dutch Risk Assessment and who died tragically on 19 September 2005 in a bicycle accident. Tom's scientific and interpersonal skills ensured technical credibility of surfactant research conducted across the broad environmental community regardless of academic, government, or industry affiliation. We will forever miss his passion, commitment, and skill to blend research into meaningful scientific and social advances.

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S.E. Belanger, G. Boeije, T.W. Federle, D.C. McAvoy, S.W. Morrall, W.S. Eckhoff, J.C. Dunphy, N.R. Itrich, B.B. Price, E. Matthijs
Procter & Gamble Company, Cincinnati, OH, USA
Procter & Gamble, Brussels, Belgium
E-mail address: belanger.se@pg.com (S.E. Belanger)

T. Wind
Henkel KgaA, Dusseldorf, Germany

R. Toy, M.L. Cano, C.V. Eadsforth, R. Van Compernolle, P.B. Dorn, R.J. Stephenson, A.J. Sherren, M. Selby, A. Evans
Shell Global Solutions (UK), Cheshire, UK
Shell Global Solutions US, Houston, TX, USA

S.J. Marshall
Unilever Colworth, Bedfordshire, UK

H. Gümbel, D. Zeller
BASF, Ludwigshafen, Germany