

# Preface

Fatty alcohols are widespread in the environment coming from a range of natural sources including bacteria, plants and animals. These compounds are also manufactured by industry from natural fatty acid sources or from petroleum-derived carbon. This book presents their environmental occurrence, fate and behaviour. The principal focus of past research has been on their natural production, which occurs in all living organisms from bacteria to humans, and the profiles and concentrations of these compounds in water, soils and sediments. Their relatively non-polar nature means they are principally associated with solid phases in aquatic systems (*e.g.* sediments) rather than dissolved in water. The major biological synthetic pathway is from the reduction of fatty acids, through aldehyde intermediates, to fatty alcohols and in many organisms to esters with fatty acids to form waxes. These waxes are used by organisms for a variety of purposes, from the prevention of desiccation in the terrestrial environment to energy reserves in the marine environment. They are ubiquitous and occur in most environments around the world, including the deep ocean and in sediment cores.

Due to the nature of the synthetic pathway using acetyl-CoA, most fatty alcohols are of an even chain length. Terrestrial plants utilise fatty alcohols as a waxy coating, dominated by long chain moieties with chain lengths from C<sub>22</sub> to C<sub>32</sub>. In contrast, marine organisms synthesise smaller compounds with peak chain lengths of C<sub>14</sub> to C<sub>16</sub>. Bacteria also produce fatty alcohols but these can also be odd chain lengths and contain branches. This aspect of their occurrence enables them to be used as biomarkers for organic matter sources. As well as their natural production and occurrence, fatty alcohols are also utilised in detergent formulations, principally as sulfates or polyethoxylates.

The analytical method preferred by contemporary environmental scientists used to measure the concentration of the ethoxylates involves direct derivatisation with a pyridinium complex and quantification *via* LC-MS (liquid chromatography–mass spectrometry). This technique will detect free fatty

alcohols as well as the ethoxylates, but will not detect any of the bound alcohols such as the waxes. To detect this latter group, a saponification step is required. This second method, frequently using GC-MS (gas chromatography–mass spectrometry), in combination with the LC method will detect all of the ethoxylates and may be considered as giving a good measure of the total fatty alcohols present in a system.

The concentration of individual fatty alcohols in the environment ranges from low values in old deep cores and the open ocean floor (undetectable to  $12 \text{ ng g}^{-1}$  dry weight (DW) for  $\text{C}_{16}$ ) to high values near natural sources and especially in suspended particulate matter ( $2.7 \times 10^6 \text{ ng g}^{-1}$  DW for  $\text{C}_{16}$ ); this is almost a factor of  $10^6$  difference in their concentrations. The short chain compounds are more readily degradable than the longer chain compounds and, in many cases, are removed first as a preferred food source for bacteria. The longer chain compounds may also degrade to short chain compounds with time but, in general, the  $>\text{C}_{20}$  class of alcohols degrades more slowly in sediments and soils than the  $<\text{C}_{20}$  class.

The different compound profiles for each source has made them suitable as biomarkers and the use of multivariate statistical methods can clearly distinguish compounds from each potential source as well as sites. Principal component analysis (PCA) is particularly useful in this regard. Signature analysis using partial least squares (PLS) analysis has been used successfully to discriminate between samples that are impacted by marine *versus* terrestrial sources. However, due to the commonality of fatty alcohol detergent formulations and the natural environmental alcohols, source partitioning on the basis of compounds alone is not as successful. When ascribing proportions to such sources, a different approach such as stable isotopes may be more appropriate.

Based on the toxicity and ecotoxicity testing of fatty alcohols, they are relatively benign in the environment due to low environmental exposures. Free fatty alcohols have been shown to undergo very rapid and complete biodegradation. Fatty alcohols lack effects on genotoxicity and reproductive and developmental toxicity, and carcinogenicity. Health studies for oral, ingestion and inhalation exposure have all shown good margins of safety for human health and are, therefore, unlikely to lead to effects on the aquatic ecosystem.