WWF DETOX CAMPAIGN

# Factsheet

## Chain of Contamination: The Food Link

# Synthetic musks

## Background

Synthetic musks are man-made chemicals produced in large quantities and used extensively in a vast array of scented consumer products, including detergents, cleaning products, air fresheners, perfumes, aftershaves, cosmetics and personal care products (Tanabe, 2005). They were created to replace the rare and more expensive natural musks obtained from musk deer and musk ox. They are of two general types: the nitro musks and the polycyclic musks. Musk xylene (MX) and musk ketone (MK) are the only two nitro musks of commercial importance today. Nitromusks have been used for many decades, but due to concerns about their distribution, fate and behaviour in the environment and their toxicological effects, their production and use is now greatly reduced in Europe (Greenpeace, 2005, Peck and Hornbuckle, 2004). The polycyclic musks galaxolide (HHCB[1]) and tonalide (AHTN[2]) are the mostly widely used and have in recent years become the most important commercial synthetic musks (Luckenbach & Epel, 2005, Tanabe, 2005). MK, MX, AHTN and HHCB account for 95% of the European market for synthetic musks (OSPAR 2004). Other polycyclic musks include celestolide (ADBI), phantolide (AHMI), and traesolide (ATII).

From 1995 to 2000, the total worldwide combined usage for musk xylene and musk ketone declined from 300 tons to 200 tons (Salvito, 2005). In 2000 the worldwide use of polycyclic musks was approximately 4,000 tons (Salvito, 2005). The most widely used polycyclic musk is HHCB - defined by the U.S. EPA as a high production volume chemical (<1 million lb produced or imported per annum) - followed by AHTN (Rimkus, 1999). Production of HHCB and AHTN in Europe was about 1,800 tons in 2000, whereas production of other polycyclic musks was < 20 metric tons (Kupper et al. 2004, Rimkus 1999).

Synthetic musks are structurally and chemically different to the compounds they were designed to replace (the natural musks). In fact, the physical and chemical properties of synthetic musks have more in common with man made persistent, bioaccumulative chemicals that are known to biomagnify (increase in concentration) through the food chain, such as PCBs and organochlorine pesticides (Tanabe, 2005, Peck & Hornbuckle, 2004). As a result of these properties, synthetic musks are widespread environmental contaminants, particularly in freshwater and marine ecosystems (Tanabe, 2005, Rimkus, 1999). They have been measured in rivers, lakes, sediment, soil, sewage sludge and effluent from wastewater treatment plants in Canada, the US, UK and Europe (Kupper et al. 2004, Peck & Hornbuckle, 2004, Ricking et al., 2003, Stevens et al., 2003, Simonich et al., 2002, Fromme et al., 2001a, Fromme et al., 1999, Rimkus, 1999, Yang & Metcalfe, 2006). Recent research has shown that levels have increased dramatically in North American lake sediments over the last 15 years, consistent with increased US consumption of the fragrance chemicals in consumer products (Peck et al., 2006). Synthetic musk compounds have also been detected in outdoor air (Peck & Hornbuckle, 2004) and indoor air (Fromme et al., 2004) due to their use in numerous consumer products.

Studies in Europe, North America and Japan have reported bioaccumulation of synthetic musks in a wide range of aquatic wildlife species including cetaceans, sharks, fish, crustaceans and shellfish (Bester et al., 1998, Duedahl-Olesen et al., 2005, Fromme et al., 2001b, Fromme et al., 1999, Gatermann et al., 2002, Gatermann et al., 1999, Kafferlein & Angerer, 2001, Kannan et al., 2005, Nakata, 2005, Yamagishi et al., 1983).

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[1] HHCB = 1,3,4,6,7,8-hexahydro-4,6,6,7,8-hexamethylcyclopenta-γ-2-benzopyran
[2] AHTN = 7-acetyl-1,1,3,4,4,6-hexamethyl-1,2,3,4-tetrahydronaphthalene

Nitromusks and polycylic musks have also been found in human blood, adipose (fat) tissue and breast milk (Duedahl-Olesen et al., 2005, Eisenhardt et al., 2001, Hutter et al., 2005, Kafferlein & Angerer 2001, Kannan et al., 2005, Liebl, 2000, Liebl & Ehrenstorfer, 1993, Muller et al., 1996, Rimkus, 1999, Rimkus & Wolf, 1996).

HHCB and AHTN along with other polycyclic and nitro musks are listed on the US EPA's Toxic Substances Control Act (TSCA) Inventory (TSCA, 2003). The use of musk xylene and musk ketone in cosmetics is now restricted under the EU cosmetics directive, due to their tendency to build up in the environment. Polycyclic musks are under review. The use of synthetic musks in consumer products is being phased out by many retailers e.g CO-OP retail in the UK.

## Major uses

Synthetic musks are used in a wide variety of scented consumer and personal care products such as perfumes, aftershaves, soaps, toiletries, cleaning products, air fresheners, laundry detergents and fabric softeners (Greenpeace, 2005, Tanabe, 2005, Stevens et al., 2003). However, musks are invariably not listed on the ingredients of these products, and are simply covered under the terms "parfum" or "fragrance" on product labels.

## How do synthetic musks get into the environment (and food chain)?

Widespread use of synthetic musks in consumer products means that large amounts wash down the drain after being applied to skin, hair, and clothing. They enter sewage and wastewater systems and find their way into the aquatic environment via effluents and waste waters, principally those from sewage treatment works (Ricking et al., 2003, Stevens et al., 2003). Once in the aquatic environment, synthetic musks can enter the food chain, being taken up by wildlife such as fish and shellfish.

Following wastewater treatment, sewage sludge is digested, dewatered and then the resulting "biosolids" are commonly applied to agricultural land. Synthetic musks in the sludge that have not been degraded during digestion are therefore introduced to the terrestrial ecosystem by entering the soil (DiFrancesco et al., 2004, Stevens et al., 2003). Due to their use in numerous consumer products, musks can also escape into air and dust (Fromme et al., 2004).

## How are people exposed to synthetic musks?

The main exposure route for musks is through the skin (dermal absorption) as they are present in personal care products such as perfumes, cosmetics, soaps and body lotions which are applied directly onto the skin (Duedahl-Olesen et al., 2005, Ford et al., 1999, Greenpeace, 2005, Hawkins et al., 2002, Hutter et al., 2005, Kafferlein & Angerer, 2001, Reiner and Kannan, 2005, Rimkus & Wolf, 1996). Absorption through the skin is also important from fragrances left on clothes from laundry detergents. Inhalation is also a route of entry into the body (Fukayama et al., 1999), since fragrances by their very nature are airborne (air fresheners, perfumes etc.) and have been detected in air (Fromme et al., 2004).

## Musks in food

Exposure to synthetic musks can also occur through the diet, but information on levels in food is limited. Most information regarding synthetic musk residues is on fish and shellfish species as the freshwater and marine ecosystems receive the greatest inputs of these compounds (from sewage and wasterwater discharges). In contrast to other persistent and bioaccumulative compounds e.g. PCBs, the diet is not considered to be the major source of human exposure to synthetic musks.

| Food item(s) | Reference(s) | Comments |
|---|---|---|
| Trout | Duedahl-Olesen L, et al. (2005). Chemosphere, 61(3), pp422-31. | Analysis of nitro musk and polycyclic musks in Danish farmed trout. HHCB dominated in trout samples. Levels of musk xylene in trout shown to be decreasing. |
| Freshwater fish – Eel, perch, common bream, roach and pike | Fromme et al. (2001a). Water Res., 35(1), pp121-8. | HHCB, AHTN, ADBI, AHMI and ATII analysed in 341 fish samples taken from Berlin waterways. HHCB detected at highest levels, followed by AHTN. Other musks detected only at low concentrations. |
| Eel | Fromme et al. (1999). Chemosphere, 39(10), pp1723-35. | Musk xylene, musk ketone and HHCB detected in edible parts of the eel (Anguilla anguilla) from Berlin waters. |
| Fish and shellfish - American eel, lobster, winter flounder, lake trout, clams and mussels. | Gatermann et al. (1999). Chemosphere, 38 (14), pp3431-3441. | Analysis of seafood species in Canada. Samples from densely populated, industrialised areas showed higher concentrations of musk ketone and HHCB. Samples from sparsely populated areas exhibited lower levels. |

## What health effects are associated with exposure to synthetic musks?

Very little is known about the human health effects of synthetic musks. Synthetic musks have been shown to have endocrine disrupting properties – that is, they are capable of interacting with hormone systems. Research has found that both AHTN and HHCB can bind to oestrogen receptors in cells and can be both oestrogenic and anti-oestrogenic, depending on the type of cell and the type of oestrogen receptor involved (Schreurs et al., 2002). HHCB and AHTN have been shown to be weakly oestrogenic (mimicking the action of the hormone oestrogen) in experiments with human cell lines (Seinen et al., 1999) and are anti-oestrogenic (impairing the activity of oestrogen) in fish (Schreurs et al., 2004). In *in vitro* tests, musk xylene, musk ketone, a major metabolite of musk xylene (p-amino-musk xylene), and the polycyclic musk fragrance AHTN have been shown to increase the proliferation rate of human MCF-7 breast cancer cells, which demonstrates their oestrogenic activity (ability to mimic oestrogen) (Bitsch et al., 2002).

Nitromusks and polycyclic musks have been shown to inhibit the activity of “multidrug efflux transporters” in the gills of the marine mussel *Mytilus californianus* (Luckenbach and Epel, 2005). This inhibition continued even after direct exposure to the musk had ended. The efflux transporters are responsible for pumping out pollutants from cells and protecting them from damage. Inhibiting these pumps therefore means that foreign chemicals may then be able to enter the cell, resulting in their continued accumulation. The authors suggest that human exposure to synthetic musks could have similar effects in human cells, increasing exposure to normally excluded pollutants.

Although a causal relationship has not been established, musk xylene and musk ketone concentrations in women’s blood have been correlated to several different clinical parameters of the endocrine system, including higher rates of miscarriage in women with higher musk xylene concentrations (Eisenhardt et al., 2001).

AHTN has been shown to cause acute liver damage in laboratory rodents (Steinberg et al., 1999) but it is not known if this finding is relevant to humans. Musk xylene is classified as a category 3 carcinogen by the EU, and a similar classification for musk ketone is being considered (SCHER, 2006).

## How can exposure to synthetic musks be reduced?

It is difficult to avoid all exposure to synthetic musks, due to their very widespread use in the products mentioned above. It is possible, however, to minimise exposure by using fragrance-free products, avoiding products with “parfum” or “fragrance” on the label and by choosing products containing natural scents or those fragranced with natural oils. Simple actions like opening a window or using pot-pourri to freshen a room can be good substitutes to using air fresheners containing musks.

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