

USE OF POLYFLUORINATED COMPOUNDS IN CONSUMER ARTICLES IN DENMARK

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Introduction

During the past ten years a growing concern has arisen on a new type of persistent organic pollutants – the polyfluorinated compounds (PFCs) – containing an alkyl chain typically between 4 and 12 carbon atoms, where all or most of the hydrogen atoms have been replaced by fluorine. The carbon-fluorine bond makes the chain very stable and practically non-degradable in the environment. These compounds also contain a more reactive functional group which may be an alcohol, a carboxylic acid, a sulfonic acid, a phosphoric acid or derivatives. OECD's "Preliminary lists of PFOS, PFAS, PFOA and related compounds and chemicals that may degrade to PFCA" contain almost thousands of these polyfluorinated compounds.¹ Most PFCs are surface active substances that repel water, grease, and dirt and are increasingly used as impregnating agents in numerous industries and consumer articles under various trade names.²

The growing environmental concern about these potentially harmful compounds, especially perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) is caused by the discovery of these chemicals as wide spread globally in the environment including in wildlife in remote areas as the Arctic.³ In addition, in many countries PFOS, PFOA and other related substances have been observed in human blood samples from the general population.⁴

Materials and methods

A survey was conducted in 2007 with the purpose to estimate the use of fluorinated compounds in impregnating agents for textiles, carpets, leather, paper and cardboard, cleaning agents for glass, wax, floor polish, paint and impregnated articles such as carpets, all-weather clothing's, sunshades, footwear and other consumer articles in Denmark.⁵ An earlier survey was carried out in 2001-2002, however, that survey mainly covered PFOS and PFOS-related compounds.^{6,7}

Information about the use of PFCs in consumer articles in Denmark was obtained by several instruments:

1. A search of all fluorochemicals on the OECD list was carried out in the Danish Product Register to determine the present registered use of fluorinated substances in articles in Denmark. The Product Register is the authorities' confidential database of the ingredients of chemical products for occupational use of more than 100 kg per year in Denmark. Chemical products must be notified (registered) if they contain dangerous substances in a concentration of at least 0.1% or 1% (depending on the substances). The database can only be assessed by authorised individuals.
2. Supplemental information on the content of fluorinated compounds in various consumer articles was obtained from Internet sites and technical literature.
3. Several companies in Denmark, as well as foreign producers/suppliers of fluorinated substances, were contacted in order to obtain information on the consumption of fluorinated chemicals in consumer articles in Denmark.

This obtained information was combined with official Danish statistics on the supply of different impregnating agents or impregnated consumer articles containing these substances in order to calculate a total estimate of the total use/consumption of PFCs in Denmark. The calculations were performed by multiplying the Danish supply of

different relevant consumer articles with information about the content of polyfluorinated substances in different consumer articles. The content of polyfluorinated substances for e.g. carpets was estimated and refined by contacting the industry in order to identify the percentage of the carpets on the market that actually are impregnated with polyfluorinated substances and also by identifying the recommended amount of e.g. DuPont's Zonyl® products for impregnation of carpets.

Results and discussion:

Uses of polyfluorinated substances registered in the Danish Product Register

Confidential information about commercial use in 2007 of 92 of these fluorinated substances was identified in the Danish Product Register. Of these, 11 fluorinated substances were registered with a total annual amount of more than 100 kg, and 48 substances were registered with a very low consumption (below 1 kg or "zero"). As companies using fluorinated substances are the source of the data in the Product Register, an annual consumption of zero may indicate the companies' failure to report the used amounts or may indicate a pause in the production or importation.

The registered amounts in the Product Register are for chemical products for occupational use. These chemical products may, however, afterwards be used in the production of consumer articles, why it is assumed that most of the registered amount can be found in consumer articles afterwards.

Figure 1: Used amount and number of fluorinated substances in different OECD categories registered in the Danish Product Register

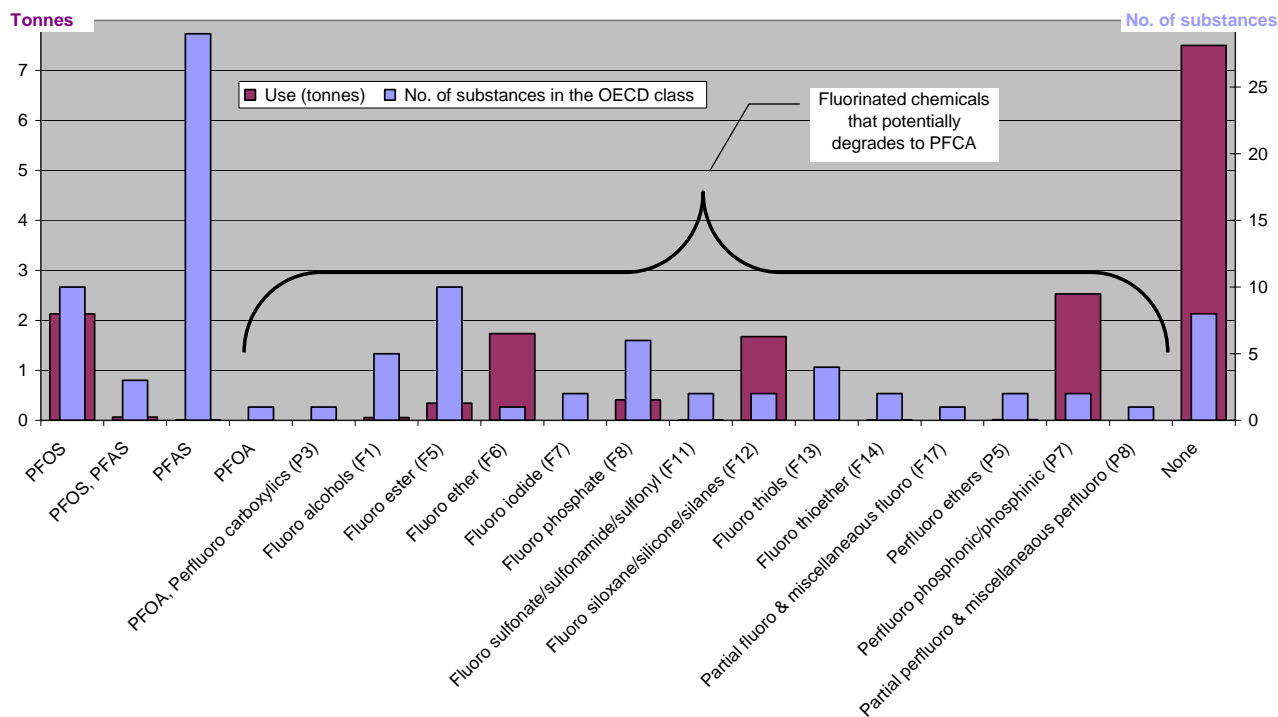
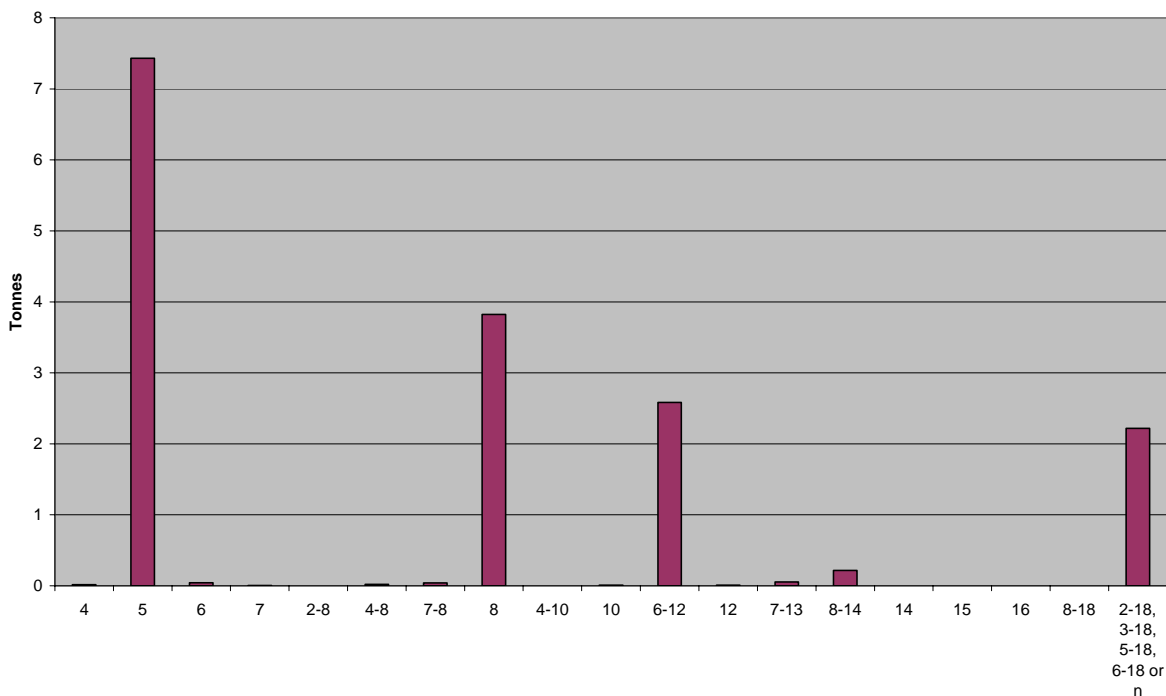


Figure 1 shows how the fluorinated substances found in the Danish Product Register search are distributed between different OECD categories both with respect to the number of substances and the amount registered. 46% of the substances were either PFOS or PFAS related substances, 46% were fluorinated chemicals that potentially could degrade to PFCA, and 9% were substances not appearing on the OECD list. These non-OECD substances were, however, found in the former survey of PFOS and PFOS-related substances carried out in 2001-2002.

The search showed that significant amounts of PFOS-related substances were still registered in 2007 in the Danish Product Register. The largest amount, about 7.2 tonnes, was registered for a substance not on the current OECD's list. This polyfluorinated substance was used as releasing agents, which may for example be used for non-stick coatings in consumer articles.

We examined the length of the fluorinated carbon chain for the PFCs registered in the Danish Product Register. It showed that most substances (about 70%) had a fluorocarbon chain length of C₈ or below. However, Figure 2 shows that significant amounts of PFCs with a longer fluorocarbon chain are still in use. Polyfluorinated substances presently used for consumer articles, such as impregnated carpets and clothing's, are mostly related to fluorotelomer alcohols (FTOHs) with a fluorocarbon chain length of 6 or 8 and 10.⁸

Figure 2: Total used amount of fluorinated compounds registered in the Danish Product Register depending on the fluorocarbon chain length. Some products are mixtures of compounds with different fluorocarbon chain length.



Calculations of the use of polyfluorinated substances consumer articles in Denmark

The calculations based on statistics on supply combined with known amounts of polyfluorinated substances in impregnated or impregnation products showed that the most important use areas in 2007 were: Carpets, releasing agents (e.g. for use in non-stick surfaces), impregnated clothing's, paint and lacquers, glue (or glued articles) and surfactants (e.g. for use in cleaning agents). The estimated figures are shown in Table 1.

Based on all information, the annual consumption of fluorinated compounds in consumer articles in Denmark was estimated to be from about 14 tonnes to more than 38 tonnes. The actual amounts are, however, most likely much higher. This estimate is quite uncertain, because some figures are calculated with a use of educated guesses based on information from industry and literature. The amounts found by the search in the Product Register must for most uses be regarded as minimum values as only chemical products with a content of substances classified as dangerous in a concentration of at least 0.1% or 1% (depending on the substances) are registered in the Danish Product Register. Further, contents of fluorinated chemicals in consumer articles only are not registered.

Table 1: Total estimated amount of polyfluorinated compounds in articles in Denmark in 2007

Use area	Min. amount (kg)	Max. amount (kg)
Releasing agents	7,200	7,200
Paint and lacquers	100	3,500
Printing inks	15	15
Glue	2,500	2,500
Surface active substances	1,100	1,100
Cleaning agents	100	100
Polish and care products	171	420
Carpets	745	18,000
Impregnated clothing	400	3,500
Impregnating agents	170	340
Galvano-technical products	760	760
Inhibitors	400	400
Pesticides	180	180
Soldering agents	280	280
Total	≈ 14 tonnes	> 38 tonnes

For comparison, the Norwegian Pollution Control Authority estimated a use of perfluoroalkyl substances of about 26 tonnes in 2002.⁹

Acknowledgements

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