Survey of Chemical Substances in Consumer Products

Survey no. 24 2003

Antibacterial compounds in clothing articles

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Summary

Clothing articles are treated with antibacterial compounds to avoid mal-odour produced by decomposition of sweat. Thus the clothing remains fresher for a longer time. The aim of the present investigation is to acquire the knowledge of antibacterial compounds present in the clothing articles marketed in Denmark, to perform chemical analysis of a series of clothing articles to know the amounts of some selected antibacterial chemicals used in these products, and finally to evaluate the emission of antibacterial compounds when these products are washed.

The Danish clothing manufacturers and importers as well as retailers were contacted to gather the information concerning antibacterial treatment of clothing marketed in Denmark. Besides, an extensive inter-net search was performed. On the basis of the available information, 17 products from the Danish retail out-let were analysed for the content of some selected antibacterial compounds: triclosan, dichlorophen, Kathon 893, hexachlorophen, triclocarbon and Kathon CG.

The contents of the selected antibacterial compounds were determined by high performance liquid chromatography. The detection limits of all of the target compounds in the products was approximately 5 ppm (0.0005%). Five of the products were found to contain 0.0007% - 0.0195% triclosan. None of the other target substances could be detected in any of the investigated product. The content of triclosan found in the clothing articles is much lower than the maximum authorised concentration of this compound in cosmetic products. Thus, the use of clothing treated with antibacterial compounds may not be of concern. Because the triclosan was found in relative small concentration in only few products, it was decided to end the project without investigation of the emission of triclosan from washing of these products.

1 Introduction

The technological developments in the recent years has made it possible to develop textile fibres for various purposes, so that clothing can meet both comfort and functional requirements: wearing qualities (pill- and abrasion durability), protection against strong winds and heavy rains, stretch and fitness properties to give freedom of movement and to reduce muscle fatigue, breathable (moisture management system), etc. Moreover, textile fibres as well as clothing treated with specific chemicals are also available, so that clothes can provide UV protection, they may contain fragrances and they may have antibacterial properties, etc. The function of antibacterial treatment of clothing is to avoid malodour created by bacterial degradation of sweat. Thus, the clothing can remain fresher for a longer period.

The aim of the present investigation is to gather information of use of antibacterial substances in clothing, especially to acquire the knowledge of commonly used antibacterial substances in clothing as well as to make an account of, if possible, the amounts of antibacterial substances that are used in clothing marketed in Denmark. Hereafter, to determine the contents of 2-3 antibacterial substances in a series of clothing articles to know the amounts of these substances in the products, and finally to investigate the loss of target substances from clothing by washing.

The project is divided in three phases: i) to gather information, ii) selection of antibacterial substances and products and perform chemical analysis, and iii) selection of products for washing followed by chemical analysis of the washed products.

Manufacturers/retailers have had an opportunity of commenting on the report before publication.

One manufacturer states that they use triclosan in their sandals in order to reduce odour problems arising from use of the sandals. They are thus able to prolong the life of the product. They states that they do what they can in order to minimise the use of antibacterial substances. This is done by trying to develop materials that do not make the use of antibacterial substances necessary as well as limiting the amount of triclosan used as much as possible.

Another manufacturer states that they use triclosan in their underwear as their products are aimed at a specific group of consumers who have a sanitary problem due to their being incontinent. The alternative to using antibacterially treated products could be the use of disposable products. However, these products do not give the consumer the same level of comfort. The manufacturer is of the opinion that the use of triclosan remedies any odour problems and in their experience reduces the risk of skin problems as well as bacterial and fungal attacks.

2 Information collection

2.1 Market survey

A number of garments- and shoe shops, shops for sports clothing as well as supermarkets were visited to collect the information attached with clothing articles. Special attention was paid to sports clothing of popular brands, because sports clothing are specifically marketed as to have odourless properties. A limited investigation showed that the available information were mainly about the textile fibres used for the clothing, the moisture removal property of the clothing, and in some cases fitness properties of clothing (freedom of movement and low muscle fatigue). A few products were labelled "antibacterial treatment" or "meldew resistant", but there was no information about the antibacterial substance(s) used for the treatment of clothing.

2.2 World Wide Web search

Based on the information collected from the market survey and the information received from Danish EPA, an extensive search for the information related to use of antibacterial chemicals in textile fibres and in clothing articles was performed in the inter-net. The search was made on the commonly used antibacterial compounds, sports clothing, textile fibres, and speciality products for allergic, etc. Because of a large number of cross-references, the Web-search is not exhaustive, but it covers a major part of the antibacterial treated clothing articles available on the global market.

According to the information gathered from the Web pages, antibacterial treatment of clothing belongs to two groups:

1) The antibacterial chemicals are built-in the textile fibres during their manufacture. It is claimed that the antibacterial property of clothing, manufactured using such fibres, lasts during the whole life of the product.
2) The clothing are coated with some antibacterial compound using various techniques.

Followings are often encountered antibacterial textile fibres and antibacterial clothing articles in the Web pages:

ACB® (Allergy control barriers- coating) is used for the manufacture of clothes, bedding, diverse products for household, etc. The information on the antibacterial substance is not available.

Actigard®olefin fibre is used in the production of mattresses (both cover and filling). The antibacterial compound is **1,2,3-benzothiadiazole-7-thiocarboxylic acid-s-methylester (CAS No. 135156-54-2)**. According to www.mcrespi.com allergy line with Actigard® protection is approved by Oekotex Standard 100, class II-IV. (ed. 01/2001 Oeko Tex Zurich).

Amicor* textile fibre is used for the manufacture of clothing for hospital workers, bedding in the hospitals, sports clothing, etc. According to information in www.amicor.co.uk, this fibre is used for the manufacture of sports clothes by Reebok, Fila, Fogarty, Arena and Sure D'orge. The antibacterial compound is **triclosan**.

AM/P2 polyolefin is used in the production of, for example ladies tights and underwear. The information on the antibacterial substance is not available.

Bio-Fresh™ acrylic fibre is used for the manufacture of "activewear" and lingerie. The antibacterial compound is **triclosan.**

Dryz™ antibacterial treatment is used for the manufacture of clothes, shoe, sports clothing, etc. The information on the antibacterial substance is not available.

HELAPSO® Hygienic fibre with antibacterial/deodorant treatment is used for the manufacture of all types of clothing. The information on the antibacterial substance is not available.

Innova®AMP antimicrobial polyolefin is used, for example for the manufacture of "activewear", winter clothing, clothing for water-sport, etc. The information on the antibacterial substance is not available.

Microban® antibacterial treatment is used in sports clothing etc. It is described that an organic compound in the same family as triclosan is used in Microban® antibacterial treatment. Thus, it seems that the active substance may be a chlorophenol derivative. INEOS Acrylics manufacture Leucite® acrylfibre (polymethylene methylacrylat) treated with Microban®. Leucite® acrylfibre are used in the manufacture of articles for use in bathrooms, fibreglass etc.

Microsafe®acetate fibre is used for the manufacture of "activewear", sports clothing, underwear, socks, gloves, armbands, etc. The information on antibacterial substance is not available. However, according to the producer of Microsafe®, the purpose of antibacterial treatment is to manufacture products with resistance to attack by bacteria.

MicroSpreme® acrylic fibre is used for the manufacture of "activewear", which is mildew resistant and free of malodour. The information on the antibacterial substance is not available.

Polartec® Polar Strech® textiles are produced with an "odorless antimicrobial finish". The information on the antibacterial substance is not available.

Sanitized® antibacterial treatment is used in the production of sports clothing, working clothes, socks, tights, etc. The antibacterial components of Sanitized® treatment are **5-chloro-2-(2,4-dichlorophenoxy)-phenol** and **2-N-octyl-isothiazoline-3-one.**

Ultra-Fresh™ antibacterial treatment is used in the manufacture of sports clothing, shoe soles, etc. The information on antibacterial substance is not available. According to the producer of Ultra-Fresh™, the purpose of antibacterial treatment is to manufacture products with resistance to attack by bacteria.

Tinosan® antibacterial treatment is used in the manufacture of textiles. The antibacterial compound is **triclosan**.

Thinsulate™ Lite loft™ og Thinsulate® Ultra, which are used in gloves, caps, sleeping bags, etc., are hypoallergenic and they provide odourless comfort. The information on the antibacterial substance is not available.

Other antibacterial treated textile products, often encountered in the Web pages, are bed linen; filling and cover for pillows and sleeping bags; and carpets (for example Hollofil®og Quallofil® with Allerban®). These products are marketed specially for people with allergy. At home page www.a1allergy.com textile toys for children with allergy are described. These toys are made of textile treated with "ACB® barrier", through which allergens can not penetrate. Other toys treated with antibacterial compounds were also advertised at Web pages, for example Playskool series from Hasbro is treated with Microban®. The manufacturer explained the antibacterial treatment is for the product safety, i.e. the product is resistant to bacterial attack.

No information has been found concerning the use of other well-known antibacterial compounds (Bactnix®, Lexol®, Ster-Zac®, Irgasan®) in clothing articles. Lexol® is used in cleaning products. Ster-Zac® (hexachlorophane according to the manufacturer, but the substance possibly is hexachlorophen) is used in pharmaceuticals and cosmetic products. Irgasan® (triclosan) is used in many product categories, and it is used for the treatment of clothing under the name Tinosan®.

2.3 Conclusions of the information collected

Synthetic fibres for the manufacture of a large number of sports clothing (and many clothes for out-door activities) are produced using a production technology by which a so-called "sweat management system" or "moisture transport system" is incorporated in the fibres. A large number of such synthetic fibres are produced at global scale. These fibres belong to various groups: acetate, nylon, polyolefin, acryl, polyamide, etc. On the basis of the information collected from Web pages, it can be concluded that almost all types of synthetic fibres and the clothing made of synthetic fibres can be treated with antibacterial compounds. Therefore, it may be expected that a considerable number of sports clothing for various purposes (tennis, football, golf, swimming, dance, etc.) may contain antibacterial compounds, even though they are not labelled for the content of antibacterial compound(s). Some manufacturer mention that the purpose of treating the clothing articles with antibacterial compounds is to increase the product safety, i.e. the antibacterial compound(s) is used to incorporate resistance to bacteria and mildew in the product.

Clothing articles, which often contain antibacterial compounds, are as follows:

- Insert in cycle shorts (for example, Airstripe™, Monolith® and Vario-Thick®) are generally treated with antibacterial compounds. According to the manufacturers of Airstripe™ and Monolith®, these are made of polyester fibre especially made for this purpose. Microban® is used in Monolith® insert.
- Thinsulate™ (polyester fibre) lining is often used in winter clothing, especially gloves, caps, socks, shoes, etc. Some of the variants of Thinsulate™

are Thinsulate™ Lite Loft™ and Thinsulate™ Ultra, which according to the manufacturer are hypoallergenic products and provide odourless comfort. Therefore, it is expected that these materials are treated with some anti-bacterial compound.

3 Products for the analysis

3.1 Antibacterial clothing marketed Denmark

On the basis of the knowledge acquired, more than 30 Danish manufacturers and importers of textile fibres and sports clothing as well as sports associations were requested to inform about the antibacterial treated products marketed by them. About half of the companies responded to the request. In general, the impression is that the marketing of antibacterial treated clothing articles is relatively new. However, according to several clothing manufacturers, the growth is eminent in the marketing of fibres treated with antibacterial compounds. The antibacterial treated fibres are relatively expensive and they are to a great extent used only for the manufacture of clothing for physical activities. Only a few of the clothing manufacturers, with the knowledge of antibacterial treated fibres, knew the antibacterial compound(s) used for the treatment of fibres. The clothing retailers knew about the antibacterial treated products mainly by publicity.

3.2 Product selection

As the information obtained from the Danish manufacturers and importers was very limited, the products for the investigation are selected on the basis of the knowledge acquired through the Web-pages as well as the knowledge gained through retailers of clothing articles. Most of the products are selected on the basis of the information that indicated the products were treated with antibacterial compounds or they were mildew resistant. All-in-all 17 products, described in Table 3.1, are analysed in the present study.

3.3 Selection of antibacterial compounds

According to the acquired knowledge, triclosan is often used for the antibacterial treatment of textile fibres and clothing articles. This view is also supported by the EU Scientific Committee (1). A clothing importer sent the information, which described the use of 5-chloro-2-(2,4-dichlorophenoxy)-phenol and 2-N-octyl-isothiazoline-3-one in Sanitized® treatment of clothing articles. Therefor, trichlorsan and 2-N.octyl-isothiazoline-3-one (marker of Sanitized® treatment) were selected for the analysis in all products. In a Norwegian study, dichlorophen was identified in a cleaning sponge (2). Therefore, dichlorophen was also selected for the analysis in all products. It was noted that some other antibacterial compounds (triclocarbon, hexachlorophen and Kathon CG) could also be analysed with the same methods, which were selected for the analyses of the target antibacterial compounds. Therefore, all products were also subjected to screenings analysis for the content of triclocarbon, hexachlorophen and Kathon CG.

Table 1: Clothing articles analysed for the content of antibacterial substances.

NERI No.	Product	Product description	Information on antibacterial treatment	The analysed material
2-0937	Ladies underwear	Underwear with insert	Importer: Sanitized®, Web-pages	Insert as well as insert with textile material
2-0938	Cycle shorts	Cycle shorts with insert, fibre: Lineltex by Fillattice	Retailer	Insert with textile material
2-0939	Cycle shorts	Cycle shorts with Hygenic® insert, fibre: Lycra	Retailer, Web-pages, labelling	Insert with textile material
2-0940	Cycle shorts	Cycle shorts with insert, fibre: polyamid+ Elasthane/Lycra	Retailer	Insert with textile material
2-0941	Cycle shorts	Cycle shorts with insert, fibre: Microfiber and Sandex-ACDX	Retailer	Insert with textile material
2-0942	Underwear (ski)	Ski underwear, fibre/treatment: Power Dry™, antibacterial treatment	Web-pages	Textile material
2-0943	Gents pullover	Pullover, Lifa base layer	Web-pages	Textile material from the arms
2-0944	Ladies bathing costume	Bathing costume, mildew resistant	Labelling	Textile material
2-0945	Ladies cycle shorts	Cycle shorts with insert	Presumed	Insert with textile material
2-0946	Sports sole	Sole for the shoe, blue	Web-pages	Sole
2-0947	Sandals	Sandals	Retailer	Sole
2-0948	Gents jogging shoes	Jogging shoes, DuoTruss treatment	Web-pages	Sole
2-0980	Socks	Socks with "BlisterGuard" treatment	Retailer	Textile material
2-981	Ankle protector	Ankle protector, AEGIS™ treatment	Labelling	Insert
2-1319	Bra-insert for breast-feeding	Bra-insert for breast feeding	Presumed	Insert
2-1320	Bra-insert for breast-feeding	Bra-insert for breast-feeding, woollen	Presumed	Insert
2-1321	Ladies underwear	Underwear, fibre: Lycra, antibacterial treated	Labelling	Textile material

4 Analysis

4.1 Chemicals and reagents

Dichlorophen, hexachlorphen, triclocarbon and triclosan are from BCR, Brussels, Kathon CG is from Rom & Haas, USA and Kathon 893 (2-N-octyl-isothiazoline-3-one) is bought from Fluka, Switzerland. HPLC grade methanol and acetonitrile is from Rathburn, Scotland and all other chemicals of analytical grade are from Sigma-Aldrich, USA.
Phosphate buffer: In a one1 litre volumetric flask, dissolve 125 g $Na_2HPO_4.2H_2O$ in water (MilliQ), add 2.877 g o-phosphoric acid and make up to the volume by water.

4.2 Sample preparation

4.2.1 Extraction in ethyl acetate

2-3 g sample, cut in small pieces, is weighed in a 100 ml dark bottle. 20 ml ethyl acetate is added and the mixture is treated with ultrasound for 15 min. The extract is filtered through a Whatman No.2 filter paper over to a 50 ml volumetric flask. Another 20 ml ethyl acetate is added to the sample and the mixture is again treated with ultrasound for 15 min. The extract is filtered through a Whatman No.2 filter paper in the same volumetric flask as before. The volumetric flask is filled up to the mark with ethyl acetate. 40 ml extract is concentrated to 5 ml using a rotary evaporator at 35 °C. The concentrated extract is analysed by high performance liquid chromatography (HPLC). Two extracts of each sample are prepared.

4.2.2 Extraction in methanol

The products, which were found not to contain any of the target substances (when extracted with ethyl acetate), were extracted with a more polar solvent, i.e. methanol. The same extraction procedure was used as described in 4.2.1, except that ethyl acetate was substituted by methanol.

4.3 High performance liquid chromatography (HPLC)

All sample extracts and calibration solutions are analysed in duplicate by HPLC as described below:

Apparatus

Pump	Gradient pump (Waters 616 pump med 600 controller)
Auto sampler	Auto sampler/Visp (Waters 717)
Detector	PDA detector (Waters 996)
PC-software	Control of HPLC-system by PC using Millennium version 3.2.0 software
HPLC Column	Zorbax C 8, 5µ, 250 x 4,6 mm with a C8 precolumn
Column temperature	40°C

HPLC analysis of Triclosan, dichlorophen, hexachlorophen and triclocarbon

Run	Gradient
Flow	1,5 ml/min
Mobile phase	Acetonitrile (100 %), Phosphate buffer
Injection volume	50 µl
Analysis time	35 min
Datacollection	Range 220 nm-400 nm, 1 spectrum/s, resolution 1.2 nm

Gradient programme

Time	Flow	A	B	C	D	Curve
0	1,5	80	20	0	0	
10	1,5	40	60	0	0	Linear
25	1,5	40	60	0	0	
27	1,5	80	20	0	0	Linear
50	1,5	80	20	0	0	

A: Phosphate buffer, B: Acetonitrile, C: Methanol, D: Water

HPLC analysis of Kathon CG and Kathon 893

Run	Isocratic
Flow	1,0 ml/min
Mobile phase	Methanol : Phosphate buffer (80:20)
Injection volume	50 µl
Analysis time	25 min
Data collection	range 240 nm - 400 nm, 1 spectrum/s, resolution 1.2 nm

4.4 Calibration curves, repeatability and recovery

Five calibration solutions of triclosan (10-300 ppm), dichlorophen (10-250 ppm) and Kathon 893 (5-250 ppm) are analysed to prepare calibration curves of these substances. Repeatability of the analytical methods is determined by the 10 repeated analysis of two solutions of triclosan (24 and 124 ppm), dichlorophen (20 and 100 ppm) and Kathon 893 (23 and 230 ppm). The recovery of triclosan is investigated by the analysis of two products (2-0937 and 2-0980) spiked to concentration levels 50 ppm and 100 ppm respectively with this substance.

4.5 Identification and determination

The data collected is treated to produce a maxplot chromatogram, where all substances eluted through the column show a HPLC peak at their respective λ_{max}. The identification of the target substances in the sample extracts is performed by matching the retention time and UV spectrum of the sample peaks with the retention time and UV spectrum of target substances. The content of the identified substances is performed by using their calibration curves.

5 Results

All samples were extracted in ethyl acetate, because in an earlier investigation maximum extraction of triclosan from a cycle shorts was established (3). The products, which did not contain triclosan, were extracted in a more polar solvent, i.e. methanol - to investigate whether other target substances could be extracted in methanol.

All samples were investigated for the content of triclosan, Kathon 893 (marker of Sanitized® treatment) dichlorophen, triclocarbon, hexachlorophen and Kathon CG. HPLC chromatogram and UV spectra of all of the target substances are shown in Figures 1-4. The detection limits of target substances are in the range 1-3 ppm. Thus, it should be possible to determine the content of these substances in the products, when their content in the products is in the range of 2-5 ppm respectively. The calibration curves of triclosan, dichlorophen and Kathon 893 are linear in the investigated concentration range (Figure 5). The relative standard deviation of the determination of triclosan, dichlorophen and Kathon 893, measured at two concentration levels, is below 4% for all 3 substances (Table 5.1). The recovery of triclosan from two samples (2-0937 and 2-0980) spiked with this substance is 74% and 94% respectively. The recovery of dichlorophen from the same two samples spiked with this substance is 64% and 91% respectively.

The content of the target substances in the investigated products is described in Table 5.2. All four analytical results on each substance as well as the mean content are reported in Table 5.2. The results have not been corrected for the per cent recovery. Five of the investigated products are found to contain 7 ppm -195 ppm triclosan. The HPLC chromatograms of sample extracts and spectrum match with standard triclosan are shown in Figures 6-10. Dichlorophen, Kathon 893, hexachlorophen, triclocarbon or Kathon CG could not be identified in any of the investigated products.

Table 5.1: Repeatability of determination of triclosan, dichlorphen and Kathon 893

Analysis	Triclosan, arealtal		Dichlorophen, arealtal		Kathon 893, areal tal	
	24,2 ppm	124,9 ppm	20,0 ppm	100,2 ppm	23,1 ppm	230,9 ppm
1	1206550	6706341	708903	4177132	847483	10065093
2	1283810	6616496	743627	3895097	840993	10029132
3	1273362	6616836	752966	3942866	860033	9977132
4	1280210	6652222	757613	3966703	834970	10037417
5	1357567	6695759	812551	4021431	*	9999548
6	1384814	6665761	834048	3630149	849488	10040926
7	1370612	6684850	772604	4020516	852926	10027811
8	1361936	6680628	776452	3978029	853050	9986754
9	1317862	6868437	778534	4223604	854218	10052823
10	1316373	6716157	786718	4031252	866601	9970556
Std. afv.	55446,7	71264,6	3512,7	161452,8	9543,5	32974,6
Middel	1315309,6	6690348,7	772401,6	3988676,1	851084,7	10018719
% RSD	4,2	1,1	4,6	4,1	1,1	0,3

* No area count, because of problems with HPLC system.

Table 5.2: The contents of target antibacterial substances in the products. The content is described as a mean of four results (*in italics*)

Product	NERI No.	Indhold % (m/m)					
		Triclosan	Dichloro-phen	Hexachlo-rophen	Triclo-carbon	Kathon 893	Kathon CG
Ladies under-wear	2-0937	0,00155* *0,00156, 0,00149, 0,00160, 0,00156*	i.d	i.d	i.d	i.d	i.d
Cycle shorts	2-0938	0,00094 *0,00094, 0,00094, 0,00094, 0,0094*	i.d.	i.d.	i.d.	i.d	i.d.
Cycle shorts	2-0939	0,00219 *0,00217, 0,00226, 0,00208, 0,00225*	i.d.	i.d.	i.d.	i.d.	i.d.
Cycle shorts	2-0940	i.d.	i.d.	i.d.	i.d.	i.d.	i.d.
Cycle shorts	2-0941	i.d.	i.d.	i.d.	i.d.	i.d.	i.d.
Underwear (ski)	2-0942	0,00074 *0,00060, 0,00076, 0,00078, 0,00080*	i.d.	i.d.	i.d.	i.d.	i.d.
Gents pullover	2-0943	i.d.	i.d.	i.d.	i.d.	i.d.	i.d.
Ladies bathing costume	2-0944	i.d.	i.d.	i.d.	i.d.	i.d.	i.d.
Ladies cycle shorts	2-0945	i.d.	i.d.	i.d.	i.d.	i.d.	i.d.
Sports sole	2-0946	i.d.	i.d.	i.d.	i.d.	i.d.	i.d.
Sandals	2-0947	0,01956 *0,01966, 0,01951, 0,01958, 0,01950*	i.d.	i.d.	i.d.	i.d.	i.d.
Gents jogging shoes	2-0948	i.d.	i.d.	i.d.	i.d.	i.d.	i.d.
Socks	2-0980	i.d.	i.d.	i.d.	i.d.	i.d.	i.d.
Ankle protec-tor	2-0981	i.d.	i.d.	i.d.	i.d.	i.d.	i.d.
Bra-insert for breast feeding	2-1319	i.d.	i.d.	i.d.	i.d.	i.d.	i.d.
Bra-insert for breast feeding	2-1320	i.d.	i.d.	i.d.	i.d.	i.d.	i.d.
Ladies under-wear	2-1321	i.d.	i.d.	i.d.	i.d.	i.d.	i.d.

* The content is determined in the insert (without textile material), which was sent separately by the importer. Triclosan could not be determined in the underwear (insert with textile material).

n.d.: Not detected

6 Discussion

The contents of six selected antibacterial substances (triclosan, dichlorphen, Kathon 893, hexachlorphen, triclocarbon and Kathon CG) has been determined in 17 clothing articles that were bought from the Danish retail out-lets. The products were selected after a market survey and collecting the information from Web pages concerning antibacterial treated clothing articles. According to the available information, 14 of the investigated products should have been treated with some antibacterial agent. The analytical methods for the determination of triclosan, dichlorophen and Kathon 893 are validated before determining their contents in the products. For the content of remaining target substances in the products, only screening analysis has been performed. The detection limit for all of the target substances in the products is approximately 5 ppm (0.0005%)

Triclosan 0.0007% - 0.0195% (7-195 ppm) was present in five of the investigated products. None of the other target substances were identified in any of the products. As most of the products should have been treated with some antibacterial agent, it is expected that either the products contain < 5 ppm of the target substances, or some other antibacterial agents were present in the investigated products.

According to the information from the importer of the ladies underwear (Sample No. 2-0937), the insert in this product should have been treated with Sanitized®. The Sanitized® 5-chloro-2-(2,4-dichlorophenoxy)-phenol og 2-N-octyl-isothiazoline-3-one (Kathon 893) treatment. According to the Material Safety Data Sheet is a mixture of 5-chloro-2-(2,4-dichlorophenoxy)-phenol og 2-N-octyl-isothiazoline-3-one (Kathon 893). In the sample 2-0937, triclosan was found, but not Kathon 893 (marker of Sanitized®). Similar observation was also made in a Norwegian study (2), in which triclosan was identified in a product treated with Sanitized®.

There is no information on the minimum required concentration of triclosan for an optimal antibacterial functionality in clothing articles. Present study demonstrates that very small amounts of triclosan (≤ 7 ppm) are required for the antibacterial property of a clothing article. The investigation further indicated that other target substances (triclocarbon, hexachlorophen, dichlorophen, Kathon 893 and Kathon CG) are either not used as antibacterial agents in clothing, or their content in the products is < 0.0005%. The market survey revealed that antibacterial treatment is performed under various trade names, composition of which is not described. Present investigation demonstrated that triclosan is used in Sanitized® and Hygenic® treatments.

It appears that triclosan is not used in the manufacture of clothing articles in Denmark. In some other EU Member States, several tons of triclosan is used in the manufacture of clothing. As there is free movement of products in the EU Member States, some antibacterial treated clothing will obviously be available in Denmark. According to articles and advertisements in the Web-pages, interest and need of antibacterial treated clothing is increasing, because of hygiene, cleanliness and odourless fresh feelings. For example, the owner of Amicore* treatment writes "*as lifestyle becomes faster and more hectic, Amicor provides a solution to the needs of modern living: health conscious, and functional materials from bed linen, fashion to sportswear round the clock freshness, comfort and cleanliness*". According to the retailers, the number of antibacterial treated clothing in the market has been increasing in the last 2-3 years, but the in-

crease appears not be significant. And there is still not a great demand of antibacterial treated clothing. However, this may be due to a non-aggressive advertisement of these products.

The content of triclosan in the investigated products (0.0007% - 0.0196%) is much lower than the maximum authorised concentration (0.3%) of this substance in cosmetic products, according to Danish Statutory order on cosmetic products (4). Recently an EU Scientific Committee has concluded that there is no basis for changing the maximum authorised concentration of triclosan in cosmetic products (5). Thus, the use of antibacterial treated clothing seems not be of concern according to a direct health consideration.

It was planned to investigate emission of antibacterial compounds to the environment by washing the clothing containing such materials. As only few products were found to contain relatively small amounts of only one substance (triclosan), it is considered that the contribution of such substances from clothing to the environment may be much less than from other sources, for example from cosmetics. Therefore, it was concluded that there was not enough basis for performing the last phase of the project, i.e. to estimate the loss of antibacterial substances by washing the clothes treated with such substances.

7 References

1. SCC. Opinion on Triclosan Resistance adopted by Scientific Steering Committee at its meeting of 27-28 June 2002. EU Commission, Brussels.

2. Norsk undersøgelse 2001 om triclosan i forbruger produkter (oplysninger modtaget fra Miljøstyrelsen).

3. Miljøstyrelsen. Kortlægning nr. 4, 2002: Indholdet af triclosan i forbruger-produkter.

4. Miljø- og Energiministeriets bekendtgørelse om kosmetiske produkter. Bekendtgørelse nr. 594 af 6. juni 2000.

5. Opinion of the Scientific Committe of cosmetic products and non-food products intended for consumers. Opinion concerning troclosan. SCCNFP/0600/02 Final.

8 Annex Figures 1-10

Figure 1: HPLC chromatogram (A) and UV spectra (B) of dichlorophen (0.006%), triclosan (0.005%) and triclocarbon (0.001%)

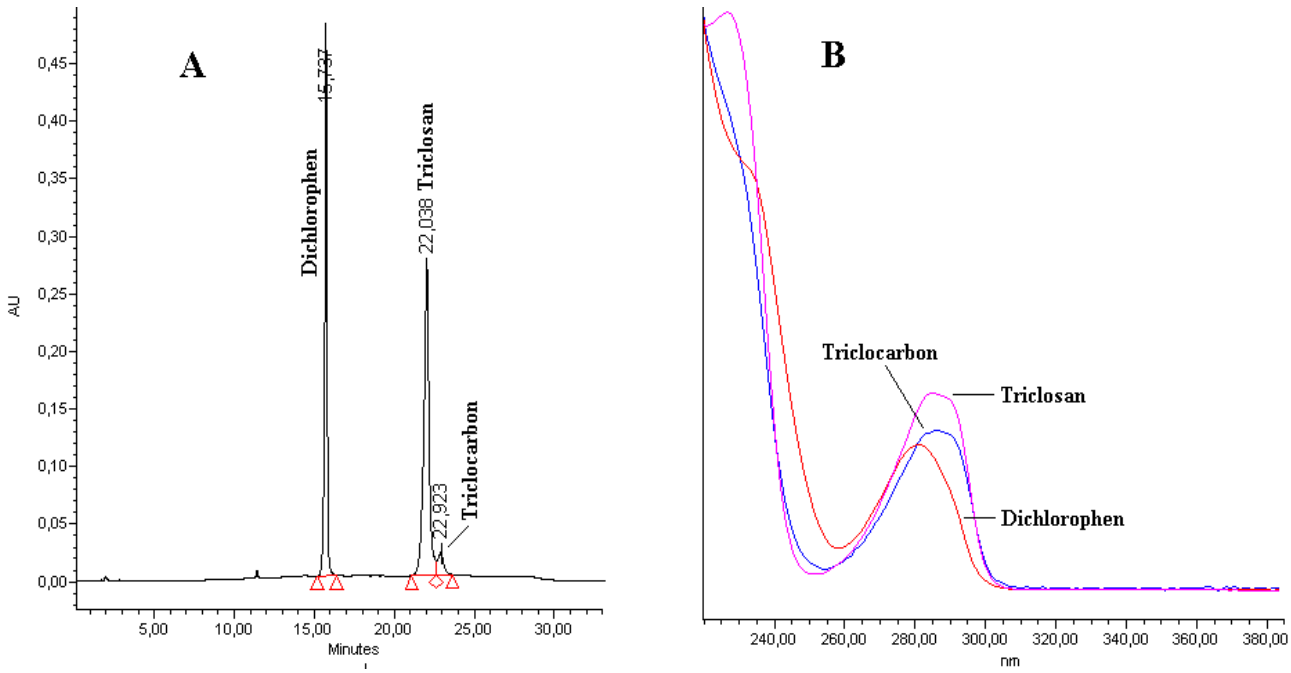


Figure 2: HPLC chromatogram (A) and UV spectra (B) of 0.001 % Kathon CG (methylisothiazolinone and chloromethylisothiazolinone)

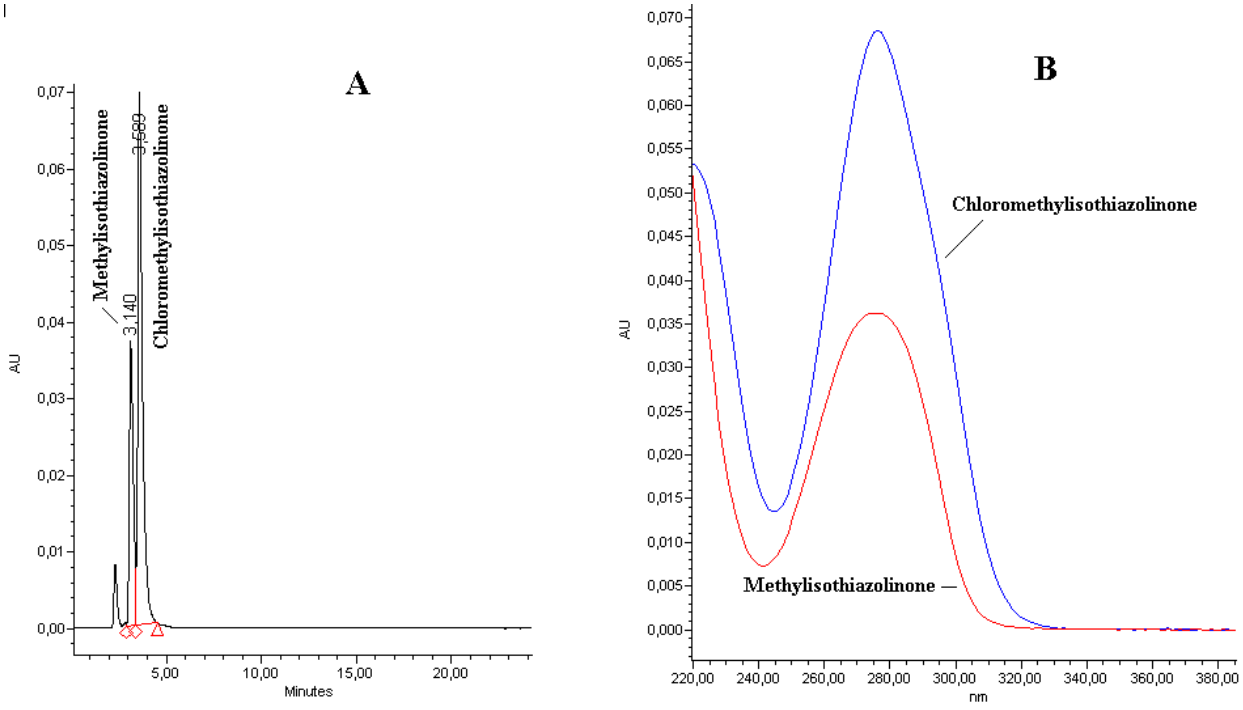


Figure 3: HPLC chromatogram (A) and UV spectrum (B) of 0.001 % Kathon 893

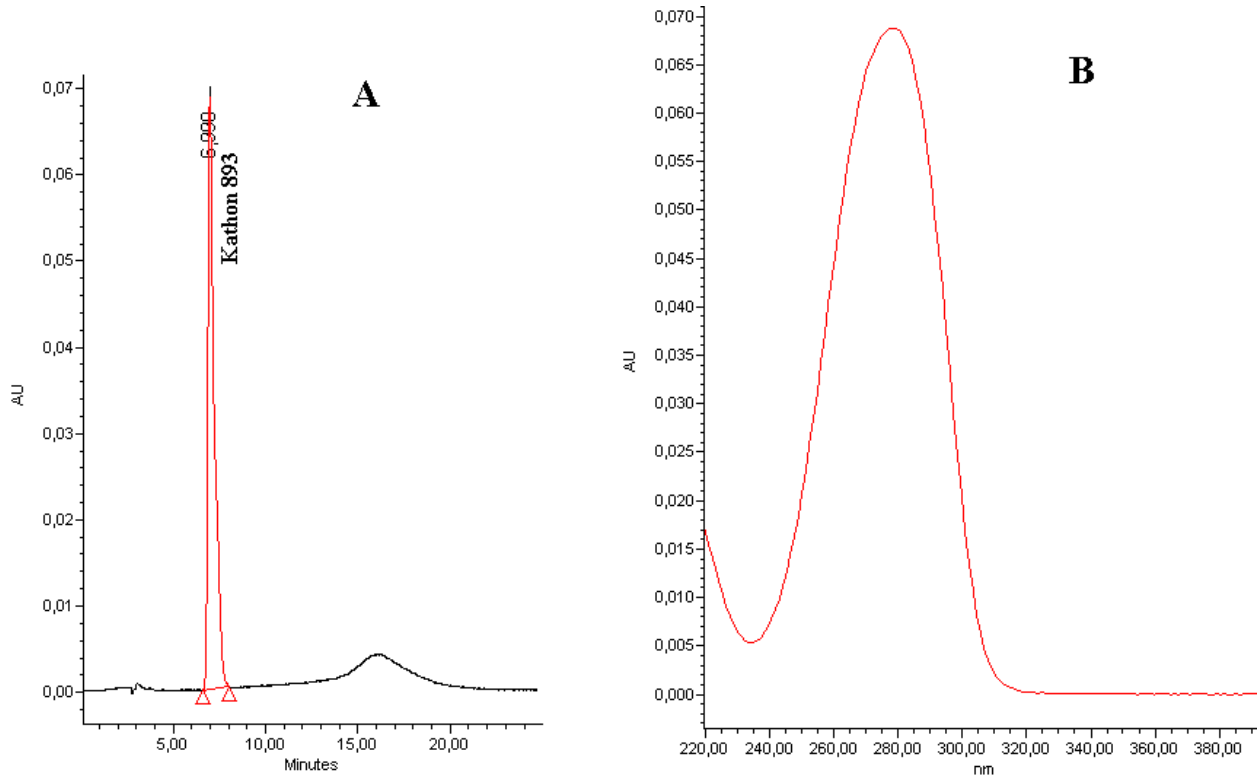


Figure 4: HPLC chromatogram (A) and UV spectrum of hexachlorophen 0,01%. (The large peak at 5.8 min is the solvent peak, and the peak at 14.6 min is a ghost peak)

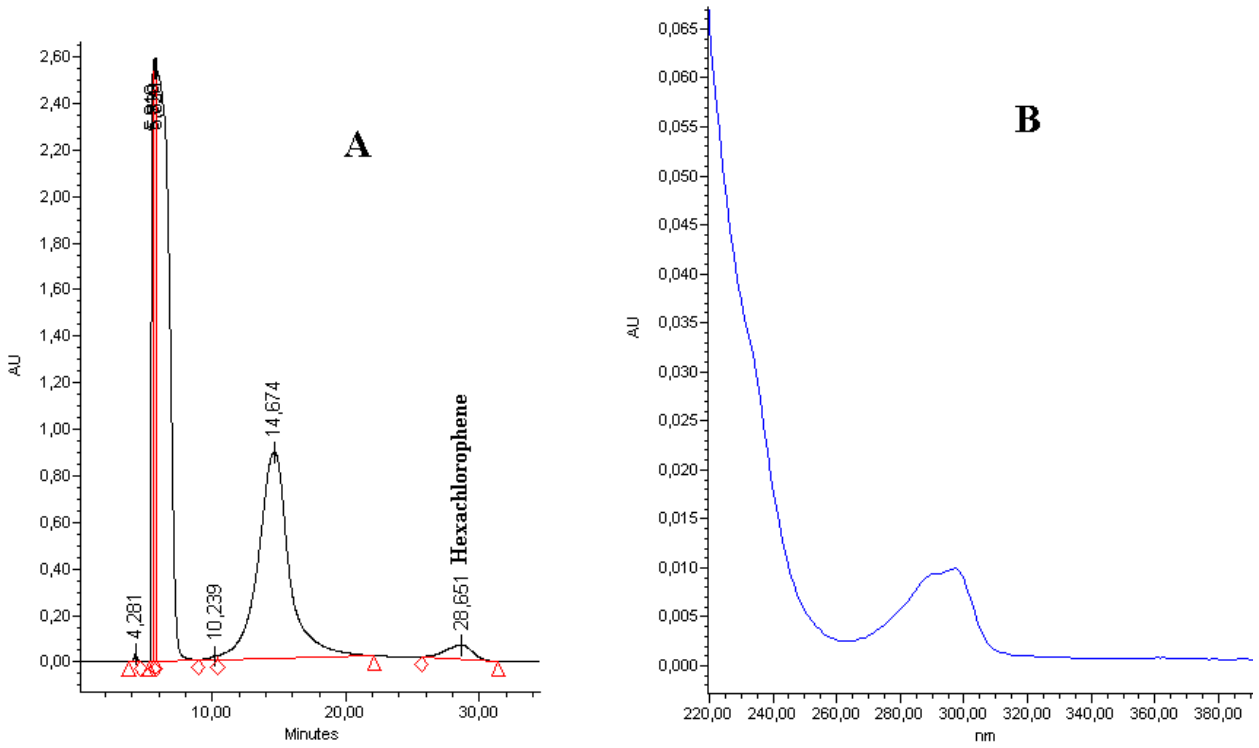
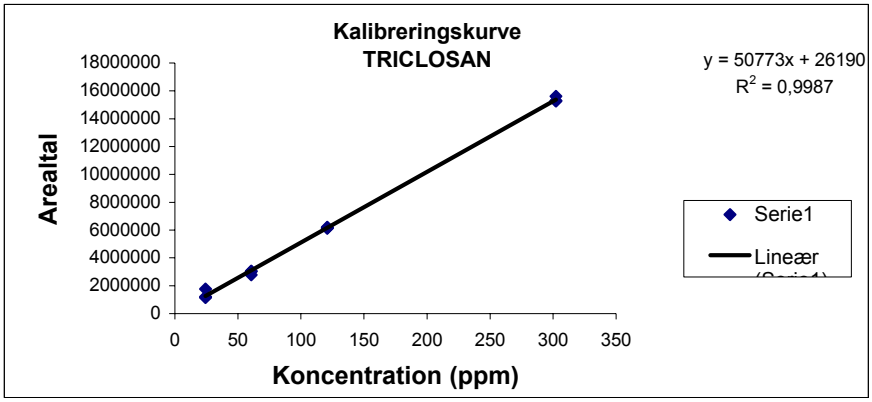
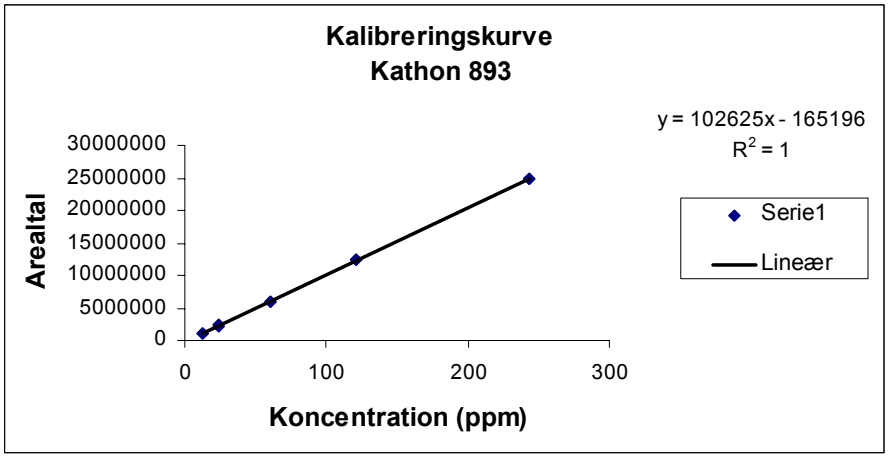
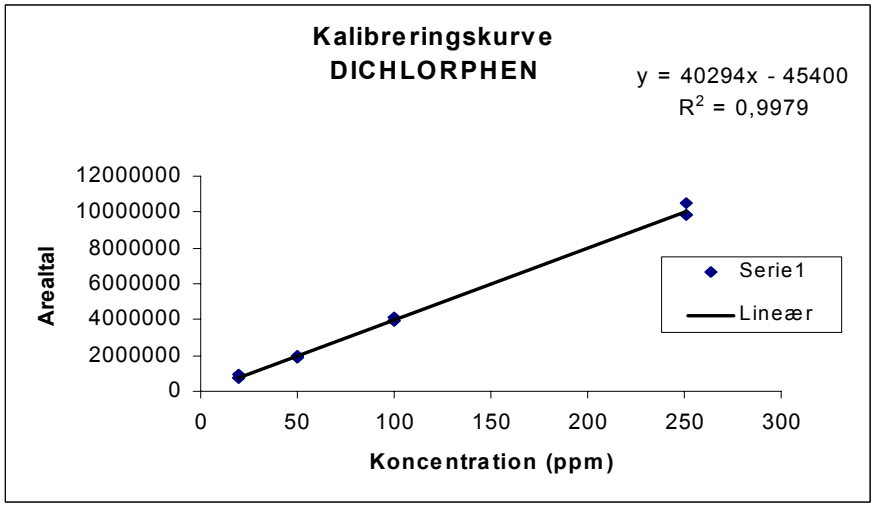


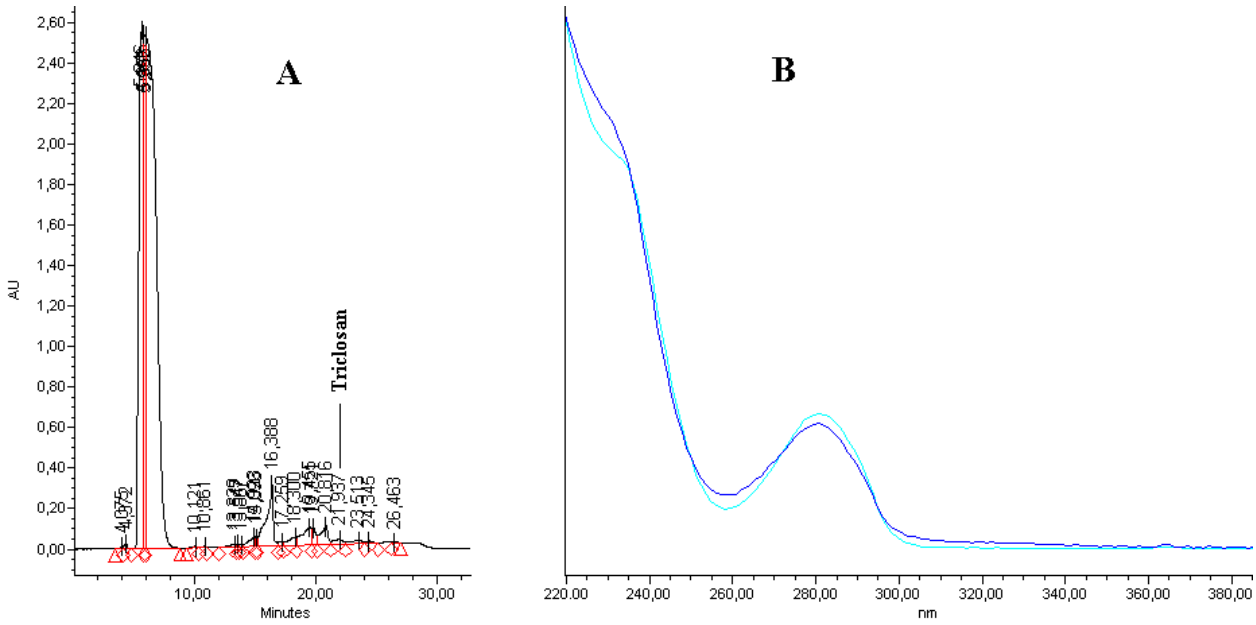
Figure 5: Calibration curves of some selected antibacterial substances.



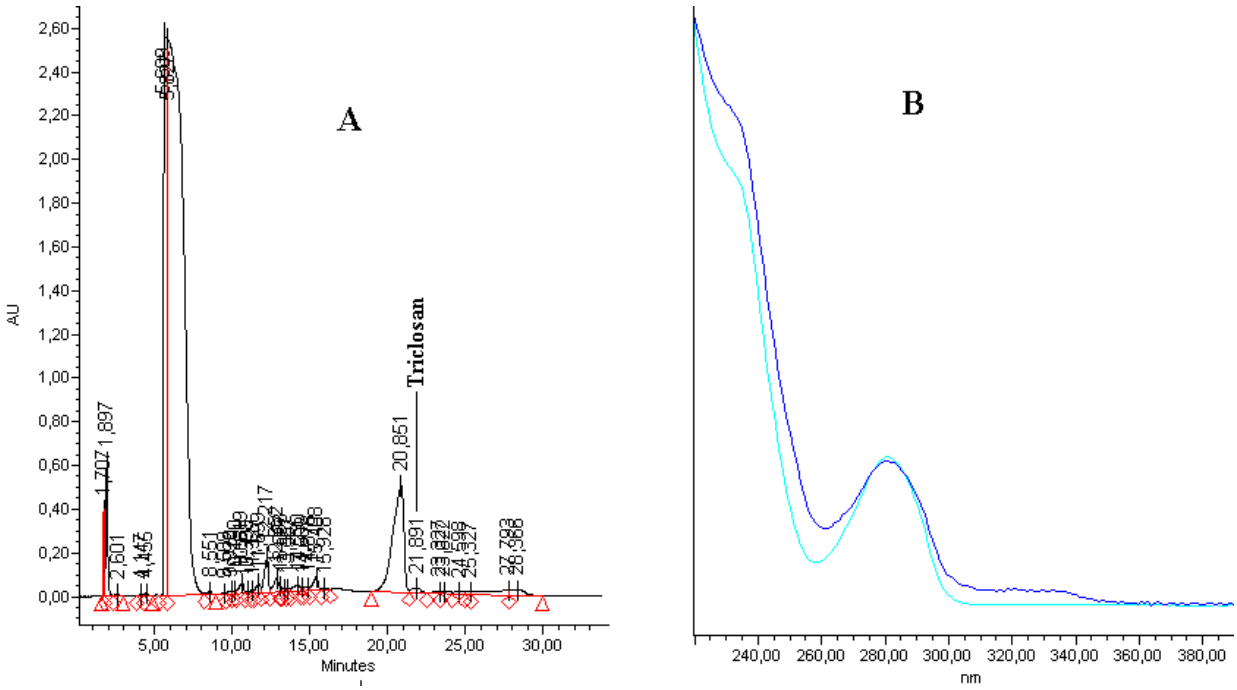




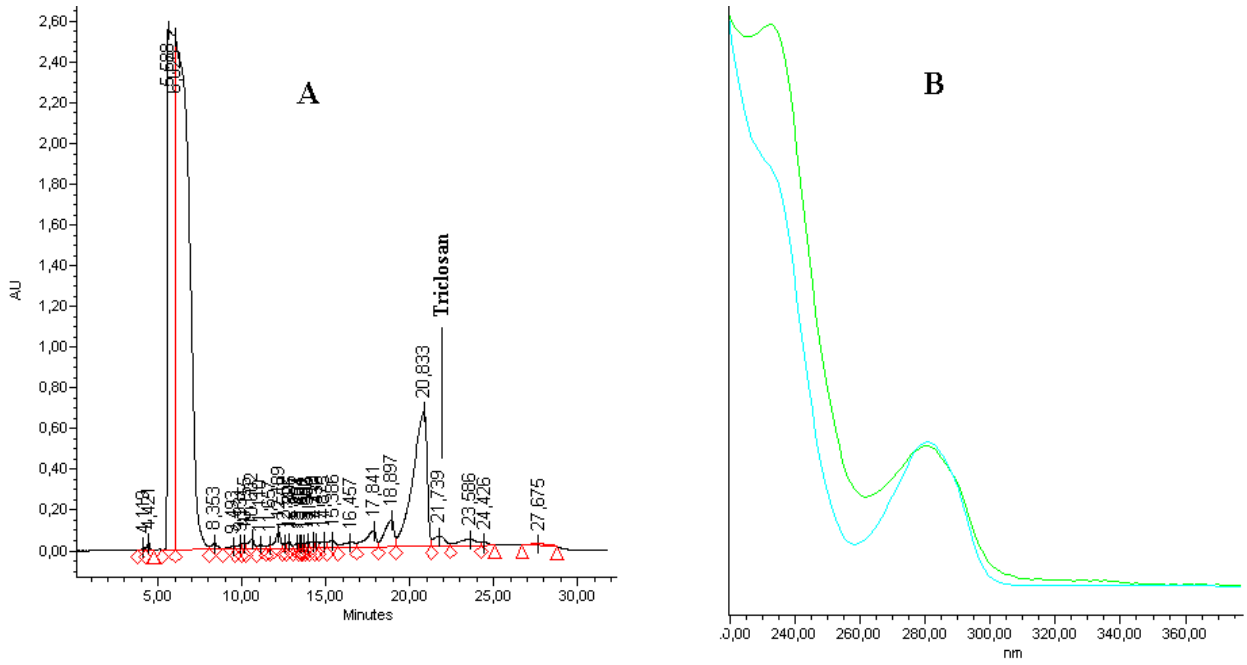
Figur 6: Identification of triclosan in HPLC chromatogram (A) of the sample 2-0937 and spectrum match (B)



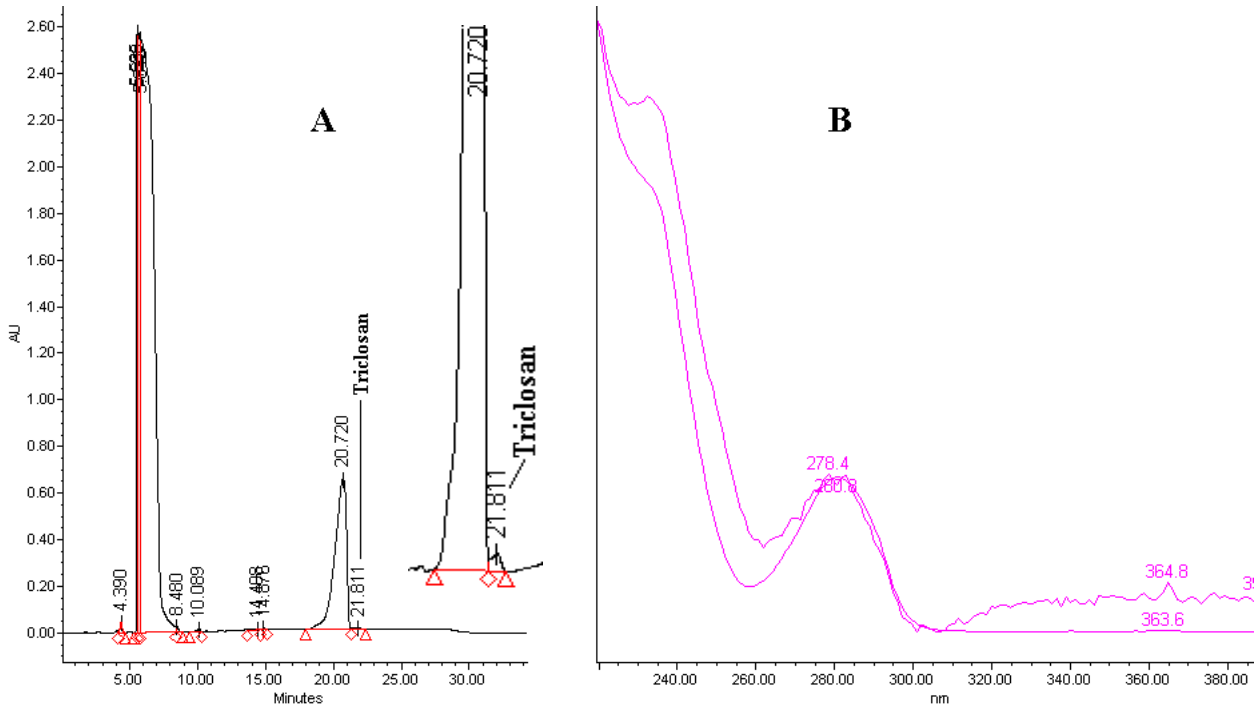
Figur 7: Identification of triclosan in HPLC chromatogram (A) of the sample 2-0938 og spectrum match (B)



Figur 8: Identification of triclosan in HPLC chromatogram (A) of the sample 2-0939 and spectrum match (B)



Figur 9: Identification of triclosan in HPLC chromatogram (A) of the sample 2-0942 and spectrum match (B)



Figur 10: Identification of triclosan in HPLC chromatogram (A) of the sample 2-0947 and spectrum match (B)