National Institute
for Public Health
and the Environment

Letter report 320104010/2010
S.W.P. Wijnhoven | M.W. Kooi | J.D. te Biesebeek

Consumer exposure to chemicals in the indoor environment

A specific focus on chemicals from textile products

rivm

RIVM letter report 320104010/2010

Consumer exposure to chemicals in indoor environment

A specific focus on chemicals from textile products

S.W.P. Wijnhoven
M.W. Kooi
J.D. te Biesebeek

Contact:
S.W.P. Wijnhoven
RIVM, Centre for Substances and Integrated Risk Assessment
susan.wijnhoven@rivm.nl

This investigation has been performed by order and for the account of Food and Consumer Products Safety Authority, within the framework of V/320104 Consumer Exposure

rivm

Abstract

Consumer exposure to chemicals in indoor environment
A specific focus on chemicals from textile products

Textile products in indoor environment contain a variety of chemicals. Well-known examples are flame retardants, phthalates, formaldehyde and dimethylfumarate. Consumers are potentially exposed to these chemicals since a lot of textile products are present in indoor environment (clothing, curtains, floor covering, and upholstery of furniture) and consumers are in contact with these products for up to 24 hours a day.

The Food and Consumer Product Safety Authority (VWA) commissioned RIVM to make an inventory on the presence of potential hazardous chemicals in indoor environment with a specific focus on textile products. The aim of this study is to investigate whether there are new substances present in textiles indoors that need urgent action with respect to surveillance and enforcement. Therefore, an inventory of all possible hazardous chemicals in textile products used indoors has been made in this report. Furthermore, recent emission studies have been mapped as well as potential health effects and specific regulation of substances in textiles.

From this inventory it can be concluded that no urgent action is needed. Textiles can contain a couple of potential hazardous chemicals but for nearly all of them there is already specific regulation on national or European level effective. There are hardly any emission or exposure studies available which makes it very difficult to do a proper risk assessment on these chemicals. However, from the existing data, the contribution of the chemicals emitting from textiles to the concentration in indoor air and total exposure is expected to be low. In the future specific attention should be given to chemicals without regulation as well as to new developments such as nanotechnology.

Key words:
consumer exposure, chemicals, textiles, indoor environment

Contents

List of abbreviations

BHT	butylated hydroxytoluene
CMR	carcinogenic, mutagenic, toxic to reproduction
DecaBDE	decabromodiphenyl ether
DeBDethane	decabromodiphenyl ethane
DEHP	bis(2-ethylhexyl)phthalate
DINP	bis(3,5,5-trimethylhexyl) benzene-1,2-dicarboxylate
DMF	dimethylfumarate
DPCF	durable press chemical finishes
FTOH	fluorotelomer alcohols
HBCD	hexabromocyclodecane
NP	nonyl-phenol
NPE	nonphenol ethoxylates
PAH	polycyclic aromatic hydrocarbons
PBDE	polybrominated diphenylether
PCB	polychlorinated biphenyls
PFAS	perfluoroalkylated compounds
PFBS	perfluorobutane sulphonate
PFC	per(poly) fluorinated compounds
PFNA	perfluoronoic acid
PFO	anion of PFOA
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulphonates
POC	polybrominated and organophosphoric compounds
PTF(E)	polytetrafluoroethylene
PVC	polyvinyl chloride
TBEP	tributoxy ethyl phosphate
TCEP	tris(chloropropyl)phosphate
TCPP	tris(2-chloro-isopropyl)phosphate
TMCP	tris monochloropropyl phosphate
TPP	triphenyl phosphate
VOC	volatile organic compounds

rivm

Summary

The aim of the current report is to gain more insight into the chemicals used in consumer products in indoor environment. The Dutch Food and Consumer Products Safety Authority (VWA) commissioned RIVM to investigate consumer products and especially textile products used indoors in further detail for determination of future policy and activities with respect to surveillance and enforcement.

First a general inventory has been made on chemicals in consumer products that are emitted into indoor air. Existing reports of well-known institutes were used for this first impression. These reports show that there is a large variety of products used in the indoor environment that contain chemicals to be released to indoor air. From this, the group of textile products has been chosen in the current study to investigate in more detail. Textile products in indoor environment are clothes, shoes, mattresses, cushions, bed linen and bed spreads, furniture upholstery and curtains, floor covering, carpets and mats, table cloths, bath towels, napkins and pilches (diapers).These products are used in almost every indoor location and on large surfaces. For some textile products like clothing, there is extensive contact of the consumer with the product. Textile fabrics are made of natural and/ or man-made fibres and different kind of fabrics are used in different textile products. Textile fabrics contain a variety of potential hazardous substances in their native state. They can also be added during the process of converting the fabrics into textile products.
Substances present in textile products can be categorized in different (functional) groups such as detergents and auxiliaries, water-, oil-, stain- and wrinkle-resistant coatings, flame-retardants, plastic coatings, anti-bacterial, anti-mould agents and pesticides, dyes and colours, VOC and nanomaterials. There are only few studies that describe the potential emission of chemicals from textiles and the potential exposure of consumers to different chemicals. From these it can be concluded that for most organic compounds the detected concentrations are so low that after exposure no health risk is expected. No potential to cause any health effects was found for PFO, pesticides, VOC, organotin compounds after inhalation of these substances. Only formaldehyde may give some problems for allergic people and some heavy metals like arsenic, chromium, copper and tin can cause health problems when a worst case scenario is taken into account. Flame-retardants are emitted to indoor air, however for these and all other investigated compounds, not sufficient data are available for a proper exposure and risk assessment.
Contact allergy is the most prominent described health effect. This is not unexpected since the main exposure route of consumers to chemicals in textiles is the dermal route. Furthermore, contact allergy is easy to directly relate to exposure with the textile product while other more systemic effects (CMR effects) are difficult to relate to exposure to substances from textiles. A number of substances are regulated on national or European level for their use in textiles. Despite this, still notifications are made in RAPEX, the European rapid alert system for dangerous consumer products, meaning that the substance is encountered in a product in concentrations that exceed the legal limit values.
For the identification of potential problem substances for the future, it is more useful to investigate the substances with a potential exposure that not have been regulated yet. Especially the group of flame retardants (TCPP, TCEP, TPP, TBEP) needs some extra attention since they are known to be emitted into indoor air, but exposure data are not sufficient for a proper risk assessment. Also new developments such as nanotechnology and the use of nanomaterials in textiles are of interest, especially when free particles can be emitted into air or come in contact with skin/ sweat.
The main conclusion of the current study on chemicals from textiles is that for now there is no need for urgent action with respect to surveillance and enforcement. However, more emission data are needed for proper risk assessments of chemicals in textile products.

Samenvatting

Het doel van het huidige rapport is meer inzicht krijgen in chemicaliën die in consumenten producten zitten die binnenshuis worden gebruikt. De Nederlandse Voedsel en Waren Autoriteit heeft opdracht gegeven aan het RIVM om consumenten producten, en speciaal textiel producten, die binnenshuis worden gebruikt in verder detail te onderzoeken. Met de resultaten kunnen het toekomstbeleid en activiteiten worden bepaald met betrekking tot toezicht en handhaving.

Allereerst is een algemene inventarisatie gemaakt van chemicaliën in consumenten producten die in de binnenlucht worden afgegeven. Bestaande rapporten van een aantal bekende instituten zijn gebruikt om een eerste indruk te krijgen. Deze rapporten laten zien dat er een grote variëteit aan producten bestaat die stoffen in de binnenlucht afgeven. In de huidige studie is de groep van textiel producten uitgekozen om in verder detail te onderzoeken. Tot de groep van textiel producten binnenshuis horen kleding, schoenen, matrassen, kussens, bed linnen en spreien, stoffering van meubels en kussens, vloerbedekking, matten, tafelkleden, badhanddoeken, servetten en luier(broekje)s. Deze producten worden in bijna alle binnen ruimtes gebruikt en het betreft vaak grote oppervlaktes. Voor sommige producten zoals kleding is er een intensief contact van de consument met het product. Textiel stoffen zijn gemaakt van natuurlijk of synthetische vezels en verschillende stoffen worden voor verschillende producten gebruikt. Verder bevatten textiel stoffen van zichzelf al een heleboel potentieel gevaarlijke chemicaliën. Deze kunnen ook worden toegevoegd in het productie proces van de textiel producten. Chemische stoffen in textiel producten kunnen in verschillende (functionele) groepen worden ingedeeld zoals detergentia en hulpstoffen, water-, olie-, vlekken- en kreuk-resistente coatings, vlamvertragers, plastic coatings, anti-bacteriele en anti-schimmel stoffen en pesticiden, keurstoffen, vluchtige organische stoffen en nanomaterialen. Er zijn maar een paar studies beschikbaar die de emissie van stoffen uit textiel beschrijven en de mogelijke blootstelling van de consument aan deze stoffen. Uit deze studies kan geconcludeerd worden dat voor de meeste organische stoffen de gemeten concentraties zo laag zijn dat dit waarschijnlijk niet tot blootstelling en een gezondheidsrisico zal leiden. Ook na inhalatie van PFO, pesticiden, VOC en organotin verbindingen is de mogelijkheid tot het veroorzaken van gezondheidseffecten er nauwelijks. Alleen formaldehyde kan problemen geven in allergische mensen en sommige zware metalen zoals arseen, chroom, koper en tin kunnen gezondheidseffecten veroorzaken wanneer er uit wordt gegaan van een worst-case scenario. Van vlamvertragers is bekend dat deze in de binnenlucht wordt afgegeven maar hiervoor geldt, net als voor de meeste onderzochte stoffen, dat er niet genoeg data beschikbaar zijn voor een goede blootstellingsschatting en risicobeoordeling.
Van de beschreven gezondheidseffecten is contact allergie het meest prominent. Dit is niet onverwacht omdat de blootstelling van consumenten aan stoffen uit textiel voornamelijk via de huid plaatsvindt. Daarnaast is contact allergie eenvoudig direct te relateren aan de blootstelling aan textiel producten. Dit is voor andere (meer systemische effecten zoals CMR effecten) veel moeilijker. Voor een aantal stoffen is er nationale of Europese wetgeving voor het gebruik in textiel. Ondanks dat worden er nog steeds meldingen gemaakt in RAPEX, het Europese meldingssysteem voor gevaarlijke consumentenproducten. Dit betekent dat de stof is waargenomen in een product in een concentratie die de wettelijke limiet overschrijdt. Voor het identificeren van potentiële probleemstoffen in de toekomst is het nuttig om de aandacht te richten op de stoffen waar nog geen regelgeving voor is. Vooral de groep van vlamvertragers kan extra aandacht gebruiken omdat ze in de binnenlucht worden afgegeven, maar data zijn niet voldoende om het mogelijke gezondsheidsrisico te schatten. Ook nieuwe ontwikkelingen zoals nanotechnologie en het gebruik van nanomaterialen in textiel zijn interessant, vooral als er vrije deeltjes in de lucht terechtkomen of in contact komen met huid en zweet.

De belangrijkste conclusie van de huidige studie is dat er geen urgentie is om actie te ondernemen met betrekking tot toezicht en handhaving van stoffen in textiel. Om in de toekomst een goede risicobeoordeling van stoffen in textiel producten uit te kunnen voeren zijn er meer emissiedata nodig.

1 Introduction

Consumers are potentially exposed to many chemicals through contact with non-food consumer products. A variety of chemicals is incorporated or processed in consumer products and are released or emitted from the products during use. Exposure to these chemicals via indoor air or dermal contact can cause adverse health effects. A lot of (household) consumer products are used indoor in domestic environment. Dutch people spend 85% of their life indoor, of which 70% at home (see RIVM website). Since the greatest part of our life is resided indoor, the indoor climate is very important for public health. Within its responsibility to monitor the safety of consumer products, the Dutch Food and Consumer Products Safety Authority (VWA) has initiated a project to gain more insight into the chemicals used in consumer products in indoor environment to determine future policy and activities with respect to surveillance and enforcement.
Because of the large number of consumer products and associated chemicals, the project was focussed on one product type. Textile products such as carpets, curtains, clothing, and others were chosen for the present inventory because of the large number of textile products that are used in every indoor environment. Furthermore, consumers might have direct contact with some of these products.

The project encompasses the following questions:

- Which chemicals are used in indoor textile products, and what are the mechanisms of emission or release of these chemicals?
- What is the potential exposure to these chemicals in textiles?
- What is the contribution of exposure to chemicals from textile products to indoor environment when compared to other exposure sources?
- Which chemicals in textiles might cause a risk for the consumer?

The report starts with a general inventory of chemicals in the indoor environment (chapter 2). This inventory is based on recent reports of organizations that are studying emissions of chemicals to indoor air which originate from consumer products. The remainder of the report is focused on chemicals in textiles used indoors. Chapter 3 describes shortly the various textile products used indoors and which fabrics and fibres they are made of. In chapter 4 the most common chemicals in textiles are presented and divided in different groups of substances. The report is limited to chemicals that are used in the production process of textiles, chemicals added in containers during transport are excluded. The possible exposure of consumers to different groups of substances is described in chapter 5, potential health effects are drawn up in chapter 6. Chapter 7 contains conclusions and recommendations.

2 Chemicals in the indoor environment

2.1 Approach

For a general overview on chemicals in consumer products that are emitted in indoor air, recent reports were used of a couple of known organizations/ institutes that are working on emissions of chemicals to indoor environment originating from consumer products or processed construction materials. The organizations with relevant information on this subject are the National Institute of Public Health and the Environment of the Netherlands (RIVM), the Danish Environmental Protection Agency (DEPA) and the Institute for Health and Consumer Protection (IHCP, one of the seven scientific institutes of the Joint Research Centre (JRC) of the European Commission). Most of these reports concerning exposure to chemicals in indoor environment were published in the past 5 years (2004-2009). The most relevant reports are summarized in the current chapter.

2.2 Summary of the existing information

2.2.1 Health-based guideline values for the indoor environment

The reports "Health-based guideline values for the indoor environment" (2004) and its update (2007) of Dusseldorp *et al*[1,2] provide health-based guideline values for a wide range of chemical agents which may be found in dwellings, and also for some physical agents such as noise and radiation. The authors concluded that there is a need for such guideline values, as for many agents there are no values for assessing the indoor environment of dwellings. The guidelines are intended for residential dwellings but could also be applied to public indoor environments, such as schools and offices. Although the guidelines are not laid down by law, they provide the basis for future indoor environment policy. Given the diversity of agents and their wide range, Dusseldorp *et al* made a selection of agents found in the indoor environment. This selection included substances often associated with contaminated indoor environments and this list was drawn up by the supervisory committee at the start of the project. Only substances were chosen that lead to exposure via air. Furthermore, the exposure to chemicals via household dust as important exposure route has been excluded.

Sources of chemicals in indoor environment according to Dusseldorp (2004, 2007) are summarized in Table 1. Relevant groups of substances are ozone, aromatic compounds, formaldehyde, aliphatic compounds, chlorinated aliphatic compounds, chlorinated benzenes and pesticides. Not all substances have consumer products as the major source.

Table 1 Substances in indoor air according to the report "Health-based guideline values for the indoor environment" of Dusseldorp *et al*, 2004, 2007

Substance	Example product source
polycyclic aromatic hydrocarbons (PAH)	traffic
pesticides	disinfectants
chlorinated benzenes	disinfectants
aromatic compounds	printing ink

chlorinated aliphatic compounds	ink
chlorinated benzenes	insecticides
chlorinated aliphatic compounds	varnish
ozone	laser printers
aromatic compounds	glue
chlorinated aliphatic compounds	glue
pesticides	ant trap
aliphatic compounds	oil fractions
pesticides	vermin powder
pesticides	vermin spray
formaldehyde	chipboard
ozone	UV lights
aromatic compounds	paint
chlorinated aliphatic compounds	paint
chlorinated benzenes	paint

2.2.2 Substances in the indoor air and house dust of dwellings

In the report "Substances in the indoor air and house dust of dwellings" of Hall et al, 2009[3], concentrations of volatile organic compounds (VOCs), nitrogen dioxide, carbon monoxide and carbon dioxide were measured in the indoor air of sixty dwellings in Groningen, the Netherlands, both in summer and winter. In winter also measurements on house dust and components within have been carried out.
The health-based guidelines for these compounds were not exceeded in the majority of the living rooms. However, the guideline for the concentration of total VOCs (200 µg/m^3) was exceeded in five living rooms in the winter, primarily caused by the higher concentrations of limonene in these living rooms. Limonene is a common constituent of air fresheners and cleaning products. The concentrations of a number of substances in house dust were also measured during this study. The concentrations of polycyclic aromatic hydrocarbons (PAHs) and a number of metals were below the guideline levels. However, lead in house dust of a couple of dwellings could form a potential health risk for children. Although this study was carried out only in one single city (Groningen), the results are generally in agreement with those of other recent studies in Dutch dwellings.
Table 2 summarizes the substances that are measured in indoor air and house dust. Metals found were aluminium, chromium, arsenic, cadmium en lead. Also PAH and flame retardants (BDE-47 en BDE-209) were found in house dust. Product sources or product groups were not always mentioned in the report, therefore outdoor sources cannot be excluded.

Table 2 Substances in indoor air according to the report: "Substances in the indoor air and house dust of dwellings" of Hall *et al*, 2009[3]

Substances in house dust	**Source**
Al	not mentioned
Cr	not mentioned
As	not mentioned
Cd	wood-burning stove
Pb	lead containing paint
Pb	fossil fuels
Pb	construction materials (old)

Pb	hobby's
PAH	wood-burning stove
PBDE-47	not mentioned
PBDE-209	not mentioned
Substances in indoor air	**Source**
total VOC's	not mentioned
d-limonene	cleaning products
d-limonene	air fresheners

2.2.3 Total health assessment of chemicals in indoor climate

The aim of the project of Jensen and Knudsen, described in the report "Total health assessment of chemicals in indoor climate from various consumer products" (DEPA, 2006[4]), was to make an inventory of chemicals that emit in indoor air during normal use of consumer products. Both existing reports of the Danish EPA concerning this subject as well as selected relevant studies from literature were reviewed. This report was focused on less volatile brominated flame retardants (PBDE) often used in electronics, textiles and furniture foam, phthalate plasticizers (phthalates) occurring in vinyl floors, vinyl wall paper and toys and the water-oil dirt repellent perfluoroalkylated compounds (PFAS) added to carpets, textiles and outdoor clothes. Potential indoor concentrations of 8 selected volatile chemicals were estimated in three model rooms after which the potential health risks resulting from this exposure were evaluated. Also advice on reduction of risks was given.
The data in this report showed that large variations of concentrations of chemicals exist within product groups. Furthermore, although the report is focused on the contribution of substances in consumer products to indoor air, the concentrations are highly influenced by other sources of the substances like smoking and construction materials. Estimation of substances in three model rooms showed that the highest potential concentrations are expected in children's rooms, since these rooms are smaller than other rooms and they contain many products that release chemicals. Another conclusion was that new products emit more substances than old(er) products. The use of scented consumer products and spray products indoors are considered extreme pollution sources for the indoor air.
Important criteria for the generation of a priority list are type of room, ventilation, frequency of use and amount of product, the route of pollution (gas, aerosol, dust), persistence and exposure route. The following priority list of substances is made based on the persistence, bioaccumulation, and toxicity of the substance: formaldehyde, acetaldehyde, phenol, benzene, toluene, xylene, styrene, limonene, phthalates, brominated flame retardants and perfluoroalkylated compounds (PFAS). Product groups and substances are summarized in Table 3.

Table 3 Substances in indoor climate according to the report "Total health assessment of chemicals in indoor climate from various consumer products" of Jensen and Knudson, 2004[4]

Occurrence/release in DEPA reports	Substance
agents to metal	formaldehyde
air freshener	limonene
bath curtain	phthalates
beads	phthalates, styrene, toluene, xylene
carpet tiles	phthalates
chargers	acetaldehyde, formaldehyde, phenol, xylene
chloroprene products	phenol
christmas spray	xylene

cleaning agents	limonene
computer	acetaldehyde, formaldehyde, phenol, styrene, xylene
decorative lamp	acetaldehyde, formaldehyde, styrene, tolune, xylene
el panel	formaldehyde
el radiator	acetaldehyde, formaldehyde
floor carpets	formaldehyde
glues	acetaldehyde, formaldehyde, phthalates
hair dryer	acetaldehyde, formaldehyde, limonene, phthalates, styrene, xylene
household oven	acetaldehyde, benzene, formaldehyde, limonene, phenol, phthalates, styrene, xylene
impregnation agents	perfluoroalkylated compounds
incense	acetaldehyde, benzene, formaldehyde, toluene, xylene
mobile phone	acetaldehyde, formaldehyde, toluene, xylene
monitor	acetaldehyde, benzene, formaldehyde, phenol, styrene, toluene, xylene
moulding wax	benzene, phthalates
playing console	formaldehyde, phenol, styrene, xylene
pressing iron	acetaldehyde, brominated flame retardants, formaldehyde, phenol, tolunene
printed matters	acetaldehyde, formaldehyde, limonene, toluene, xylene
printer	formaldehyde, limonene
products of exotic wood	formaldehyde
products of exotic wood	toluene
recharged batteries	acetaldehyde, formaldehyde, limonene, styrene, toluene, xylene
sealing agent	phthalates
shoe care products	perfluoroalkylated compounds
stain remover	limonene, phthalates
children's tents	acetaldehyde, formaldehyde, styrene, toluene, xylene
textile fabrics	formaldehyde, phthalates
tv apparatus	acetaldehyde, formaldehyde, limonene, phenol, phthalate, styrene, toluene, xylene
vinyl floors	phthalates
vinyl wall paper	phthalates

2.2.4 The INDEX project

Scope of the INDEX project (Critical Appraisal of the Setting and Implementation of Indoor exposure Limits in the EU, EU 2005[5]) was to identify priorities and to assess the needs for a Community strategy and action plan in the area of indoor air pollution by three subsequent steps:
- setting up a list of compounds to be regulated in indoor environments with priority on the basis of health impact criteria
- providing suggestions and recommendations on potential exposure limits for these compounds, and

- providing information on links with existing knowledge, ongoing studies, legislation etc. at world scale. For this, scientific publications, databases and personal communications were consulted.
Based on exposure assessment and toxicology, 14 substances (of 41) were divided in three different categories. These 14 substances are individual chemicals originating from sources in indoor environment that dominate the exposure. Furthermore, indoor sources have to be used by a significant part of the population and the substances must have known health effects. Substances that already have been regulated are not taken into account.
"High priority pollutants" are formaldehyde, NO2, CO, benzene en naphthalene; "low-priority pollutants" are acetaldehyde, xylene, toluene en styrene. The category "pollutants requiring further research with regard to human exposure or dose-response" consists of ammonia, limonene and α-pinene.
Recommendations were formulated for all 14 individual substances. Furthermore for all substances it was recommended that garages are separated from living and working rooms and sufficient ventilation is required when working with these substances.
All substances and product sources are described in Table 4.

Table 4 Substances in indoor climate according to the report of the INDEX project: "Critical appraisal of the setting and implementation of indoor exposure limits in the EU" [5]

Source	Substance	Priority
burning paraffin blocks	NO_2	high
coatings	formaldehyde	high
deodorant	α-pinene	further research required
disinfectants	formaldehyde	high
gas hot plate	NO_2	high
gas oven	NO_2	high
scented product	acetaldehyde	low
scented product	D-limonene	further research required
insecticide (spray)	naphthalene	high
cooking and central heating boiler	CO	high
leather products	xylene and toluene	low
glue	acetaldehyde	low
glue	formaldehyde	high
furniture	formaldehyde	high
perfume	xylene and toluene	low
pesticides	xylene and toluene	low
chipboard	formaldehyde	high
chipboard	benzene	high
plastics	ammonia	further research required
plastics	styrene	low
plastics	xylene and toluene	low
rubber	styrene	low
rubber	xylene and toluene	low
cleaning product	α-pinene	further research required
cleaning product	ammonia	further research required
cleaning product	D-limonene	further research required
cleaning product	formaldehyde	high
white spirit	D-limonene	further research required
textiles	formaldehyde	high

thinner	xylene and toluene	low
paint	α-pinene	further research required
paint	formaldehyde	high
paint	xylene and toluene	low

2.3 Conclusion from the product inventory

The information in the existing reports shows that there is a large variety of products used in the indoor environment that contain chemicals to be released to indoor air. The overview above has been presented to the Dutch Food and Consumer Products Safety Authority (VWA), after which the focus of the remaining of the project and this document has been discussed. It has been agreed that the group of textile products like floor carpets and furniture is a very relevant product group to further investigate. Textile products are used in every indoor environment and may be applied on large surfaces (floor, curtains, and furniture). From the overview presented above, it can be concluded that textiles may contain a variety of chemical substances that are used in the production process such as high priority pollutants like for example formaldehyde and phthalates. Consumers may be in direct contact with these products and thus the chemicals they contain. However, the contribution of chemicals released from textile products for pollution of indoor air is relatively unknown. Other products related to indoor air like for instance scented articles, construction materials and house dust have already been covered in other studies. Furthermore, construction materials and house dust are often related to outdoor sources.
Therefore, substances in textiles are further investigated in this document; they will be sketched in broad outlines and presented in the following chapters.

3 Textile products and fabrics

3.1 Textile products in indoor climate discussed in this report

Textile products can often be found to be used indoors in various forms. The products used by consumers include: clothes, shoes, mattresses, cushions, bed linen and bed spreads, furniture upholstery and curtains, floor covering, carpets and mats, table cloths, bath towels, napkins and pilches (diapers). A consumer is in contact with several textile products for up to 24 hours a day, e.g. clothing and home decoration like furniture upholstery and curtains.
Textiles products like tents, umbrellas, parasols are excluded from this inventory since these products are mainly used in outdoor situations and therefore unlikely to pollute the indoor environment. Although car interior is considered to be indoor climate, we excluded textiles used in cars from our study since our focus is on textiles in households. Textiles used in toys are also excluded because they are already regulated via the Toys Directive (Directive 2009/48/EC).

3.2 The use of textile fabrics in textile products

3.2.1 Textile fabrics

Textile fabrics are manufactured from natural and/or man-made fibres. Natural fibres are available from animals and plants, like cotton and sheep's wool. Man-made fibres are from natural or synthetic origin. Viscose and acetate are examples of man-made fibres of natural origin. Polyester, polyamide, polyacrylonitrile and poly propylene are the most important synthetic fibres. Also blends of different types of fibres are frequently used in textile products.
A detailed list of textile fabrics has been published earlier in directive 96/74/EC, 1996, see also appendix 1 of this report.

3.2.2 Type of textile fabrics used in textile products

To unravel the exposure of consumers to chemicals in textile fabrics and fibres, it is important to know what kind of textile fabrics are incorporated in the various consumer products made of textile. A short overview on the type of textile fabrics used in textile products is presented in Table 5.

Table 5 Type of textile fabrics used in textile products (adapted from Laursen, 2003[6])

Fabrics for	Description
Clothing	Very large group. Primarily cotton, wool, viscose (and modal), polyester and nylon. To a certain extent also acrylics. Furthermore also silk, acetate and polypropylene (silk, acetate and polypropylene (among other things in linning). For linning primarily polyester, but viscose, nylon and acetate are also relevant. Shrink resist treatments are widely used in connection with natural fibres and regenerated fibres (e.g. viscose).
Curtains	Primarily cotton and polyester and blends. To a lesser extent acrylics, viscose, wool and polychloride (PVC-special fibre).
Table clothes	Primarily 100% cotton. To a lesser extent blends with polyester, acrylics and flax. Fabrics that have been treated with chemicals in order to make the product seem smooth and easy to maintain are very common. Shrink resist treatments are also widely used.
Upholstery (furniture) and cushions	In case wool, cotton and blends with polyester are used. Making up is more common in connection with cushions. In case coverings are primarily made of cotton and blends with polyester.
Dinner napkins	Primarily cotton and blends with polyester.
Bed linen and bed spreads	Primarily cotton and to a lesser extent blends with polyester.
Bath towels	Primarily 100% cotton
Bath/shower curtain	Primarily cotton and blends with polyester. Also polychloride (PVC-special fibre)
Floor covering	Polyamide, polypropylene are most often used. To a lesser extent natural fabrics like sisal, linen, wool, jute, goat's wool.

3.2.3 Foam in cushions and mattress

Apart from the upholstery also for stuffing of cushions and mattresses different materials can be used. Both materials with a natural origin like kapok, feathers or rubber (natural latex) as well as synthetic materials are processed in stuffing, like polyester fibres or foam. Commercial foam rubbers are generally either polyurethane foam or natural foam rubber latex. Latex foam rubber, used in mattresses, is well-known for its endurance.

4 Chemicals in textile products

4.1 Introduction

All fibres, natural and synthetic, contain a variety of substances present in their native state or added during the process of converting the fabrics. Depending on the type of fibre and the (pre)treatments it has received, the fabrics contain an amount of additives and contaminants. A number of chemical substances are added to perform specific functions in the fabrics. They can make the manufacturing process easier and endow the final products with a specific function or appearance.
The manufacturing of textiles, from fibre to finished product, takes place in several stages, and chemical substances are involved in multiple processes. Many of these chemicals are rinsed out with detergents and water during the manufacturing process. Some substances are broken down or are dealt with in wastewater treatment, while others reach watercourses. However, in the finished product residual levels of chemicals may still remain (KEMI, 2009[7]).

The different groups of substances in textile products according to their pattern of use are shown. Only those substances that are likely to be released during the use-phase of the end product are described (Draft report, Saarinen 2010[8]). Furthermore, chemicals that are added during transport of consumer products in for instance containers are excluded from this inventory.
A detailed overview of all substances likely to be present in textiles, together with the subgroup, the products in which the substances are found and potential exposure is given in appendix 2 of this report. Also current control measures, if any, for the different substances are described.

4.2 Different groups of substances in textile products

4.2.1 Detergents and auxiliaries

Nonphenol ethoxylates
Nonphenol ethoxylates (NPEs) are mixtures used as detergents, emulsifiers, wetting agents and defoaming agents. The use of NPEs in the textile industry is limited by the restrictions given in EU directive (2003/53/EC). In other countries outside the EU, NPEs are still commonly used in the textile industry. Therefore, remaining NPE can be found in imported textile end products, like towels, home-textiles and clothes. (Hansson, 2008[9])

4.2.2 Water-, oil-, stain-, and wrinkle resistant coatings

Highly fluorinated substances
Highly fluorinated substances are used in textile industry to make fabrics used for clothes or other textiles products resistant to oil, water and dirt because of their water, stain, and oil-resistant properties. Examples of this group are different per(poly) fluorinated compounds (PFCs) like perfluorooctane sulphonates (PFOS) and fluorotelomer alcohols (FTOH). PFOS are no longer used in the textile

industry in Europe and USA. Polytetrafluoroethylene (PTFE) is used as membrane in rainwear clothing (UBA, 2009[10]). Perfluorobutane sulphonate (PFBS) is used to impregnate textile fabrics. Perfluoronoic acid (PFNA) can also be found in textile products. Studies have shown that PFCs can be released from consumer products and inhaled(Massey et al. 2008[11], Gewurtz, 2009[12]).

Formaldehyde or formaldehyde resins
Various forms of formaldehyde like urea-formaldehyde and melamine/formaldehyde resins are used to make fabrics stain- and wrinkle-resistant. The resins are used in cotton, cotton/polyester blends, rayon and shrink-proof wool fabrics. The fabrics with textile formaldehyde resins are also used for upholstery etc. (De Groot 2009, 2010[13,14]).

4.2.3 Flame retardants

Flame retardants are used to make fabrics, furniture textiles and mattresses less flammable. There are two methods for manufacturing flame-retardant textiles: 1) impregnation or spraying the textile product and 2) building the flame-retardant substance into the textile yarn.
Flame retardants can be grouped in several categories. The most frequently used organic flame retardants groups are polybrominated and organophosphoric compounds (POC).

Polybrominated compounds
Polybrominated diphenylether (PBDE) and poly chlorinated biphenyls (PCB), hexabromocyclodecane (HBCD) are substances banned in the textile industry by EU, but still manufactured in other parts of the world (Karijawa 2009[15]).

Organophosphoric compounds
Tris(2-chloro-isopropyl)phosphate (TCPP) is one of the most commonly emitted organophosphate flame retardants in polyurethane foam (Kemmlein, 2003[16], Hartman, 2004[17]).

4.2.4 Plastic coatings

Plastic coatings, made of polyvinyl chloride (PVC), are used to make fabrics watertight in clothing like raincoats, shoes and shower curtains (KEMI, 2009[7]). PVC plastics can also be used in textiles containing polymer parts, such as t-shirts with prints to bring about patterns.
To make PVC softer and more flexible, plasticizers like phthalates (e.g. DEHP and DINP) are added (Wensing, 2005[18]). The PVC coatings also contain heavy metals, like cadmium, lead and organotin compounds. Organotin compounds are used as stabilizer in the PVC plastic but can also be used as fungicide to protect the fabrics against extreme conditions.

4.2.5 Antibacterial, anti-mould agents and pesticides

Anti-bacterial agents are used in sportswear, shoes, sponges and dishcloths to keep the fabrics longer fresh and avoid mal-odour. The anti-bacterial chemicals could build in the textile fibres or are used as a coating of the fibres or fabrics. Other anti-bacterial products are bed linen, filling and cover for pillows and carpets. Different substances are added to textiles for their antibacterial effect: silver based, hydantoin compounds, quarternary ammonium or phosphonium polymers. Most often, these agents leach from the fabric surface (reviewed by Martin, 2007[19]).
The main application of anti-mould is for preservation of textiles for outdoor applications (tents) and the storage of textiles. For normal consumer use the textile fabrics are not treated with anti-mould agents.

Dimethylfumarate
Dimethylfumarate (DMF) is often used in textiles and leather especially shoes but also sofas as an anti-mould agent. It is also added to the shoe packages in sachets. Although there is a temporary ban on the use of DMF in consumer products, there are more than 60 alerts on the RAPEX website in 2010 (until September) (http://ec.europa.eu/consumers/dyna/rapex/rapex_archives_en.cfm, see appendix 3).

Triclosan
Triclosan is one of the chemicals used for an anti-bacterial treatment. (Kalyon, 2001[20], Rastogi, 2003[21], KEMI 2009[7]). An increasing number of clothing articles are treated with biocides. Triclosan is one of the finishing agents for the production of such textiles (Orhan et al. 2009[22]).The fabrics finished with triclosan are treated with cross-linking agents to provide durable antibacterial properties. On the basis of the available information, 17 products from the Danish retail market were analysed for the content of some selected antibacterial compounds: triclosan, dichlorophen, Kathon 893, hexachlorophen, triclocarban and Kathon CG. Five of the products were found to contain 0.0007% - 0.0195% triclosan (Rastogi et al. 2003[21]).

Poly(dimethylaminomethyl) styrene
Nylon fabrics are coated with poly(dimethylaminomethyl) styrene to achieve anti-bacterial properties. (Martin, 2007[19])

Organic tin compounds
Organic tin compounds like dibutyltin, tributyltins, dioctyltins and trioctyltins are detected in several cotton consumer products, like pilches, napkins and clothing like underwear (Janssen 2000[23]). They are also detected in mattresses pads and top mattresses (Pors, 2003[24]). Triorganotins are very effective as bactericides and fungicides in textiles.

Permethrin
Permethrin is a common synthetic chemical, widely used as an insecticide, acaricide and insect repellent. It belongs to the family of synthetic chemicals called pyrethroids. Home textiles, wool carpets and wall-to-wall textile floor coverings are usually treated with pyrethroids against moths and keratine-digesting beetle larvae (Berger 2002[25]).

The first impression is that residues of pesticides that are used in the production of cotton are hardly found in textiles used in indoor environment. However, a more thorough research of literature on this subject is needed to confirm this.

4.2.6 Dyes and colours

Depending of the properties of the fabrics, different dyes and dyeing methods are used to obtain the desired colour and colour-fastness. Metals like barium, mercury, cadmium, lead and tin are reported to be used in pigments in textile dyes (Laursen, 2003[6]) to make sure that the dyeing process will work. Azo pigments like Disperse Blue 106, 124, and 85 as well as Disperse Orange and Disperse Red pigments are used in colouring agents for textiles (see also section 5.3).

4.2.7 VOC

Mattresses and cushions are filled with different types of foam. Volatile Organic Compounds (VOC) can be emitted from these products (Hillier, 2003[26]). An overview of different VOC is presented in appendix 4 of this document.

4.2.8 Nanomaterials

The key aims of applying nanotechnologies within the textiles sector are both to upgrade present functions and performance of textile materials and to develop innovative products. The most prominent nanoparticles that are used in textiles are ZnO for UV protection in furnishing materials, nano-silver as antibacterial and mal-odour agent in for instance socks, anti-static coating for protective work wear and high performance sportswear and carbon nanotubes (CNT) in filling materials, body armour, fibre-polymer composites, high performance sportswear and wearable electronics (Mantovani and Zappelli, 2009[27]). The expectation is that more applications are entering the market in the coming years, since a lot of potential applications are at this moment in the R&D stage.

5 Textile products and potential exposure

In this section, an overview is given on recent studies that describe the potential exposure to different chemicals from textile fabrics. In section 5.1 three surveys are described with a variety of substances. In section 5.2 an overview of public literature is given for the different groups of substances as already mentioned in chapter 4.

5.1 Surveys of the Danish and Swedish EPA

5.1.1 Survey of chemical compounds in textile fabrics

In the report "Survey of chemical compounds in textile fabrics" of Laursen et al. (DEPA, 2003[6]), the selection and testing of 20 textile fabrics on the presence of a number of different chemical compounds has been described. The aim of the study was to make an inventory of chemicals that are emitted from textile fabrics during normal consumer use and to evaluate the possible health effects of the detected chemical compounds.
Organic compounds that were found in a part of the fabrics were nicotine, naphthalene, DEHP and formaldehyde. Furthermore, nonyl phenole ethoxylates and 2 aromatic amines (4-chloroanline and o-toluidine) were found. Also heavy metals were found: arsenic, barium, cobalt, chromium, copper, nickel, lead, antimony and tin. The potential health effects of the detected chemical compounds have been evaluated with respect to oral exposure, inhalation and dermal exposure.
The measured concentration of detected organic compounds is so low that no health risk is expected. Only formaldehyde may give some problems for allergic persons. These problems will be reduced after the first laundry of the fabric since washing reduces the amount of free formaldehyde.
Also no health risk is expected from the measured amounts of the heavy metals barium, lead and nickel. Arsenic, chromium, copper and tin may cause a health problem using a worst case scenario on oral intake (a child chews or sucks the textile in the mouth). A part of the samples of cobalt were higher than the detection limit. From these samples a health risk is expected after oral intake. Furthermore, the possibility of developing an allergy or a sensitisation is present. Some samples contained copper in such relative high concentrations, that a health risk cannot be excluded after oral intake and inhalation. Substantial dermal uptake by skin is not expected at the measured concentrations.

5.1.2 Survey of chemical substances in baby products

Tønning et al. (DEPA, 2008[28]) describes in the report "Survey, emission and health assessment of chemical substances in baby products" selection and testing of baby products. Different baby products of textile or plastic with an upholstery or padding were selected and analyzed for the presence of chemical substances. In the selected group were products like feeding-pillows, mattresses and foam washcloths. Baby clothing and bed linen were excluded as well as shaped plastic objects like tubes, pots and plates.
The products were analyzed for different chemical compounds like colourants, organic tin compounds, flame retardants and were screened for phthalates and organic compounds. Migration tests were carried out in saliva and sweat.
The conclusion from this study is that low concentrations of hazardous substances were found in the products. However, some of the products contain several substances that can cause effects after chronic

exposure. Because these substances are found in a large number of other products the possibility of multi-source exposure (aggregated exposure) is present.

5.1.3 Release of Nonylphenol and Nonylphenol Ethoxylates

In a general overview for nonyl-phenol (NP) and nonyl-phenol ethoxylates (NPE), it has been concluded by Hansen et al, 2005[29] that in the Nordic countries, textiles is one of the major sources of NP and NPE to the (indoor) environment. High concentrations of NPEs are found in Sweden in different textile products like towels, t-shirts, overall and underwear. The concentration of the NPEs found in the different textile products greatly varies. However, since there is incomplete information on emission factors, concentrations and usage it is impossible to draw conclusions of a possible consumer exposure and the associated health risk.

5.2 Analysis of different substances in public literature

5.2.1 Water-, oil-, stain-, and wrinkle resistant coatings

PFOA

To understand the magnitude of exposures to PFO that may occur through consumer use of certain articles, concentrations of PFO, the anion of perfluorooctanoic acid (PFOA) were determined in certain treated consumer articles like carpeting, apparel, upholstery and textiles (from extraction tests and product formulation information) (Washburn et al. 2005[30]). Textiles finished with PFO (upholstery, seat covers and carpets) can contribute to an increased concentration of PFO elements in indoor air and also in dust. An exposure assessment and hazard characterization was conducted. The results indicate that exposure to PFOA during consumer use of the articles in this study does not cause adverse effects.

5.2.2 Flame retardants

Tris (2-chloro-isipropyl)phosphate (TCPP)

The emissions of selected flame retardants were measured in a study of Kemmlein et al, 2003[16] in upholstery, mattresses and other selected consumer products, like electronics. Tris (2-chloro-isipropyl)phosphate (TCPP) was observed to be one of most commonly emitted organophosphate flame retardants in polyurethane foam applications. Conclusion of the study is that emission of several brominated and organophosphate flame retardants is measurable. This suggests that the use of flame-retardant-treated products may affect indoor quality and could be a possible route of exposure for humans. However, until now, the data have not been sufficient for an adequate risk assessment. Based on the results of this study, the investigated samples of flame retardants would be classified as harmless materials. More data on emissions behaviour and the physical properties of flame retardants are needed for a comprehensive evaluation of the possible risks.

Hexabromocyclododecanes (HBCDs)

Hexabromocyclododecanes (HBCDs), the principal additive brominated flame-retardant in polystyrene foams, and upholstery textiles, were classified by the Japanese government as a Type I Monitoring Chemical Substance in the Law (in contrast to Europe and US were HBCDs are not subject to regulatory restriction at present. Because indoor levels of HBCDs were found to be higher than outdoor levels, significant sources of HBCDs very possibly are present indoors. One of the most probable

sources is HBCDs added to textiles, because of the high specific surface areas of textile. Furthermore, HBCDs are the most frequently added brominated flame retardants for textiles in Japan, followed by decabromodiphenylether (DecaBDE) and Decabromodiphenyl ethane (DeBDethane). Therefore, Karijawa et al, 2009[15] decided to study the presence of HBCDs (and isomer profiles) in commercially available textiles in Japan. They concluded that diatereomer profiles of HBCDs in textiles were the same as those found in house dust earlier, indicating that fibres of the flame-retardant textile indeed might be an important component of indoor dust. Further studies on the emission of HBCDs from textiles to the indoor environment are needed to estimate their contribution to air and dust pollution. In this stage it is impossible to draw conclusions on the possible consumer exposure.

5.2.3 Antibacterial, anti-mould agents and pesticides

Pyrethroids

Pyrethroids are among the most frequently used pesticides. One of the indoor applications that can lead to possible consumer exposure to pyrethroids is the treatment of home textiles such as woollen floor coverings. Human exposure to the pyrethroid permethrin from treated woollen textile floor coverings and possible adverse effects have been studied by Berger et al, 2002[25]. For indoor monitoring, permethrin was determined both in house dust and on airborne dust (suspended particles). The permethrin on suspended particles result from carpet fibre abrasion and not from an evaporation and re-condensation process. The internal exposure of the participants was determined by monitoring permethrin metabolites in urine. From these urine data the inhaled uptake of permethrin was calculated. The indoor and biological monitoring data as well as the evaluated symptoms give no indication of adverse health effects due to carpet treatment by permethrin.

Poly(dimethylaminomethyl) styrene

Nylon fabrics are coated with poly(dimethylaminomethyl) styrene to achieve anti-bacterial properties. The coating stick firm on the fabric and do not leach off the fabric (Martin, 2007[19]). This reduces the possibility for possible health problems with its use.

Organotin compounds

In 2000, Janssen et al[23] conducted a risk assessment for different organotin compounds in consumer products with textile fabrics such as napkins, pilches and clothing. The maximum possible exposure has been determined for each of the organotin-positive items using a worst-case scenario. The outcome of the risk assessment was that, although some data limitations remain, the contaminated items most likely did not pose any health risk for the consumers using them.

After analysis of organotin compounds in 17 products in Denmark, a migration test has been carried out in the selection of products with a detected content. Since no organotin compounds have been detected in artificial sweat following the migration test, no exposure of the consumer could be determined at simulated use of the products under given conditions (Pors, 2003[24]).

5.2.4 VOC

In a study of Hillier et al, 2003[26] the emission of volatile substances from flexible polyurethane foam mattresses were investigated. One week after production the concentrations of the VOCs were measured in different types of foam mattresses by using large scale chamber tests. Especially in new mattresses high concentrations of VOC were found that reduced progressively in time (for most measured substances). Not all substances have an equal diffusion rate from the foam substrate. Therefore, in this test the sampling time continued up to 160 hours. The study demonstrated that a

human spending 8 hours asleep on a new uncovered, polyurethane mattress, would not be exposed to any significant risk caused by VOCs.
The perceived odour of new foam mattresses is described in another paper by Hillier et al, 2009[31]. The data show evidence for the potential contribution of volatile organic compounds emitted by polyurethane.

5.2.5 Nanomaterials

The main route of consumer exposure to nanoparticles in textiles is following any wear and tear/ abrasion during use. Applications in which there exists the highest exposure potential are protective workwear, dirt-repellent and anti-microbial materials and high performance sportswear. There is a medium exposure potential to consumers via air or dermally due to wear and tear/ abrasion. The nanomaterials include ZnO in antistatic coating, silver in antimicrobial materials, nanospheres e.g. C60 fullerenes in water-repellent, dirt-repellent and anti-adhesive textiles. There are, however, no suitable emission studies performed to give this a scientific basis (Ross and Aitken, 2009[32]).

6 Potential health effects of chemicals in textiles

6.1 Overview of potential health effects

People who are most exposed to chemicals in the textile sector are obviously those who work in the textile industry and handle large quantities of newly produced textiles daily. Direct handling of chemicals can lead to dermal exposure in this context but also inhalation is possible via textile dust or volatile substances in the air (KEMI, 2009[7]).

Since textiles in indoor environment are often in contact with the skin, the main exposure route for consumers from direct contact with the skin is the dermal route. Substances that are particularly serious from the point of view of health are carcinogenic substances and substances that are mutagenic or toxic to reproduction (CMR substances). Examples of such substances in textiles are aryl amines which are formed from azo-dyes, chromium compounds and phthalates (KEMI, 2009[7]). Most publications on health effects refer to allergy, but this is probably the case since other (systemic) effects are difficult to relate to exposure to substances from textile.

6.2 Allergic contact dermatitis

An allergic response (contact allergy) is one of the most prominent effects of direct contact to substances in textiles (reviewed in Wijnhoven et al, 2008[33]). Patients with contact allergy may present a varied clinical picture, including urticaria, diffuse pruritus, and erythemamultiforme-like eruption (Uter, 2001[34] and Hatch and Maibach, 2000[35]).
Between 1 and 2% of contact allergies in dermatological clinics in Germany are triggered by textiles (BfR, 2007[10]). Approximately 7000 preparations of textile auxiliaries and finishing agents are known. One big group of allergenic substances are textile dyes, however, contact allergy to textile dyes is not very common and depends on the dye used. A distinction can be made between disperse dyes and non disperse dyes. Available data indicate a lower prevalence to non-disperse dyes than disperse dyes. In textiles, 4000 different colorants and dyes are handled of which 50% are azo-dyes (BfR, 2007[10]). In some cases, carcinogenic and allergenic amines may be released from them after reductive cleavage when applied to the skin (Collier et al, 1993[36]; Platzek et al, 1999[37]). Highly sensitizing disperse dyes are the thi-azol-substituted monoazo dyes Disperse Blue 106, 124, and 85 which often are used in combination and can release PPD or p-aminoazobenzene after azo-cleavage. Around 2/3 of all textile related cases of allergy are attributed to disperse dyes (Hatch and Maibach, 1995[38]; Lazarov, 2004[39]). Other important allergens in clothing are potassium dichromate, formaldehyde-releasing resins (wash-and-wear finish) and rubber chemicals like thiurams, dithiocarbamates or benzothiazoles (in rubber bands) (Schnuch et al., 2004[40]) as well as residues of anti-mould agents (dimethylfumarate) (KEMI, 2009[7]).

Another sensitizer is a group of durable press chemical finishes (DPCF) which are used on fabrics for several purposes. It makes the fabric wrinkle resistance during wear and laundering. It is used in the bleaching and dyeing process. And it also makes the fabric non-shrinkable, water and moth-proof.

Two substances of the DPCF group, urea-formaldehyde and melamine/formaldehyde contain large amounts of free formaldehyde. This free formaldehyde can cause allergic contact dermatitis. (De Groot et al 2009, 2010[13,14])

Dimethylfumarate (DMF) stored in sachets inside the sofas has been described in a Britisch newspaper in 2008 [41] to cause a series of violent reactions such as skin burns and allergies in babies, adults and even household pets. When the sofas went into people's homes the solid sachets with DMF turned into gas that burned through clothes and on to skin.

Clothes are washed with laundry detergents and fabric conditioners. Fragrances are added to detergents and fabric conditioners to give the laundry a fresh smell. Consumers are exposed to the fragrances and the allergic components and this can lead to skin sensitization and allergic contact dermatitis. Corea et al, 2006[42] investigated the risk of developing fragrance allergy from wearing clothes machine washed with laundry products and concluded that that the risk is extremely low. From this study it was concluded that it seems highly unlikely that the fragrances in laundry products and fabric conditioners cause the induction of sensitization.

6.3 Regulation of chemicals in textiles

Because of their potential health effect, a number of substances are already regulated on national or European level for their use in textiles. An overview of substances already regulated in different frameworks is given in Table 6. Per framework, different substances are mentioned.

Table 6 Regulation of substances in textile

Control measure	Substance (group)	Individual substance
REACH annex XVII	Phthalates	DEHP
		DINP
	Perflouroalkyl contaminants	PFOS
	Polybrominated compounds	PBDE (penta- and octo-)
		HBCD (candidate for authorisation)
	Metals	Organotin
		Chromium (Cr^{VI})
		Nickel (as textile components)
		Lead
		Cadmium
	Azo dyes which may release banned amines	Disperse blue 106, 124
		Disperse orange
		Disperse red
REACH annex XVII, appendix 8	Aromatic amines	4-chloroaniline (dye)
		o-toluidine (dye)
		benzidine(dye)
		p-aminoazobenzene (dye)
REACH annex XVII, temporary ban		Dimethylfumarate (DMF)
EU directive (2003/53/EC)		Nonphenol ethoxylates
"Warenwetbesluit formaldehyde in textiel (2001)"	Formaldehydes	Urea formaldehyde
		Melamine formaldehyde

"Regeling verwijdering PCB's" (1998)	Polybrominated compounds	PCB
Cosmetics Directive 76/768/EEC, Annex VI		Triclosan (only for cosmetics)

Despite the regulation of hazardous substances in textiles, still notifications of substances in textiles are made on the European rapid alert system for dangerous consumer products (RAPEX), meaning that the producer has broken the law and the substance is encountered in concentrations that exceed the legal limit values and may be considered a serious risk. An overview of RAPEX alerts of the year 2010 (about 80 textile products until September) is described in appendix 3 (http://ec.europa.eu/consumers/dyna/rapex/rapex_archives_en.cfm).

7 Conclusions and recommendations

In this document, an overview is given on the presence of potential hazardous substances in textile products that are used in the indoor environment. The reason for choosing textile as product group in the indoor environment was based on earlier inventories of the potential release of substances from consumer products into the indoor environment. Textiles are used in almost every indoor location and on large surfaces and, at least for some textile products like clothing, there is extensive contact with the product. Textile fabrics contain a variety of potential hazardous substances in their native state or they are added during the process of converting the fabrics into textile products. Although the majority is of the chemicals is rinsed out of the product, residual levels of manufacturing chemicals may remain in the finished products. Furthermore, substances are added to textile products with a clear function, like resistance against water, oil, stain and wrinkles, as flame retardants or to protect against microbes.
For determination of potential health effects for the consumer in an indoor situation, it is important to know how much of the chemicals present in textiles are released or emitted from the product. Consumer exposure to substances used in textiles is mainly via the dermal route, with the risk of causing contact allergy. Data on emission of substances from textiles into indoor air are hardly available.

The conclusion from the few surveys that are performed and described in this report is that for organic compounds, the detected concentrations are so low that no health risk is expected. Only formaldehyde and some heavy metals like arsenic, chromium, copper and tin may cause health problems. Formaldehyde may give some problems for allergic people. For the metals health problems are expected when a worst case scenario is taken into account (oral intake by a child). The question remains how realistic such a scenario is.
Literature data on individual substances lead to the same conclusion. There are only few data on health effects after inhalation of PFO, pesticides, VOC, organotin compounds. No potential to cause any health effects was found for these substances. Even after monitoring of metabolites in body fluids like urine or artificial sweat (which is an indication of exposure) no indication of adverse health effects could be found.
For flame-retardants it is proven that they are emitted to indoor air, however for a robust risk assessment, data are not sufficient. Also for other emission studies performed, the conclusion is that there is incomplete information on emission factors, concentrations and usage for the drawing of conclusions on possible consumer exposure and associated health risk.

It can be concluded that for the most hazardous compounds present in textiles, national as well as European control measures are already present (Table 6). When the limits are exceeded or there is a potential risk this can lead to an alert in RAPEX, the EU rapid alert system for all dangerous consumer products. However, RAPEX notifications give a biased picture of the problem substances because only the substances that are already regulated (and that have much attention in the media) can be tracked down in this system. It is not useful for identification of new substances that cause potential problems in the future.
For the identification of potential problem substances for the future, it is more useful to investigate the substances with a potential exposure that not have been regulated yet. These substances that may give problems in the near future are depicted in table 7.

Table 7 Substances for use in textiles without specific regulation

Substance	Components	Potential exposure
nicotine		-
naphtalene		-
perfluoroalkyl contaminants	**PTFE**	+
	PFOA	
	PFOS	
organophosphoric compounds POC	**TCPP**	+
	TCEP	
	TPP	
	TBEP	
triclosan		?
poly(dimethylaminomethyl)styrene		-
pyrethroid	**permethrin**	+
arsenic		+
barium		+
cobalt		+
copper		+
antimony		-
tin		+
nanomaterials		?

Substances with a potential exposure are given in bold and are worthwhile to give some attention in the future. Especially the group of flame retardants (TCPP, TCEP, TPP, TBEP) needs some extra attention since they are known to be emitted into indoor air, but exposure data are not sufficient for a proper risk assessment. Also new developments such as nanotechnology and the use of nanomaterials in textiles are of interest, especially when free particles can be emitted into air or come in contact with skin/ sweat.

However, the relative contribution of emission of the different substances from textiles compared to other sources (in indoor air) to the total exposure seems to be low, at least for the following groups of substances.

1. Flame retardants

Brominated flame retardants (BFR) such as PBDEs are usually found in much higher concentrations indoors than outdoors, therefore consumer products must be an important source. BFR are applied to textiles but the main source of these PBDEs is probably electronic products that emit these substances into indoor air. Exposure to flame retardants is mainly via house dust. Furthermore, because of their persistency, brominated flame retardants are also present in a wide variety of foods. For a couple of different PBDE's, it has been shown that the uptake via house dust is substantially lower than via food[43].

2. Phthalates (DEHP, DINP) are used in plastic coatings and textile fabrics (DEHP). However, they are used in such a broad variety of products (adhesives and glues, building materials, personal-care products, detergents and surfactants, packaging, children's toys, modelling clay, waxes, paints, printing inks and coatings) that the contribution of phthalates from textiles to the phthalate concentration in indoor air and to the total exposure is very low. Also food is an important source of phthalate exposure in children[44] as well as in the general population[45]. In infants and toddlers about 60 % of the exposure

is covered by food, 30% by ingestion of soil/dust and 10% by inhalation of indoor air. In adults, > 90% of exposure to DIBP occurs via food intake. The remaining < 10 % is due to inhalation of indoor air [45].

With this analysis one should bear in mind that the focus of this report is on substances that are added to textiles in the production process, however, the chemicals for treatment of textile products could also be of interest. Examples of such chemicals are trichlosan (5-chloor-2-(2,4-dichloorphenoxy)-phenol), 2-N-octyl-isothiazoline-3-one (Kathon 893), trichlocarbon, hexachlorophen en Kathon CG. Also nanomaterials are used for the treatment of textile products, for instance in do it yourself coating sprays for leather in shoes, clothes and furniture.

The main conclusion of the current study on chemicals from textiles is that for now there is no need for urgent action with respect to surveillance and enforcement.
However, since a very limited number of reliable studies is available on emission of substances from textiles, it should be worthwhile for the future to develop and extend a database on this subject.
Furthermore, it is very difficult to define and measure the health effects of substances in textiles, except the acute effects such as allergic reactions.
Specific attention should be given to new developments and applications and to the substances without specific regulation, especially with respect to leaching and emission of substances out of the textile products.

rivm

8 References

1. Dusseldorp,A., van Bruggen,M., Douwes,J., Janssen,P.J.C.M. & Kelfkens,G. Gezondheidskundige advieswaarden binnenmilieu. RIVM report 609021029. 2004.
2. Dusseldorp,A. & van Bruggen,M. Gezondheidskundige advieswaarden binnenmilieu, een update. RIVM report 609021043. 2007.
3. Hall,E.F., Dusseldorp,A., Aries,M.B.C. & Knoll,B. Verbindingen in lucht en huisstof van woningen. RIVM report 609021057. 2009.
4. Jenssen,A.A. & Knudsen,H.N. Total Health assessment of chemicals in indoor climate from various consumer products. Danish Environmental Protection Agency, Survey of Chemical Substances in Consumer Products, No.75 . 2006.
5. European Commission. The INDEX project; Critical Appraisal of the Setting and Implementation of Indoor Exposure Limits in the EU, final report January 2005. 2005.
6. Laursen,S.E. *et al.* Survey of chemical compounds in textile fabrics. Danish Environmental Protection Agency, Survey of Chemical Substances in Consumer Products, No.23 . 2003.
7. KEMI. Chemicals in textiles. Swedish Chemicals Agency . 2009.
8. Saarinen,K. Releases from the use phase of textile and leather products. Finnish Environment Institute. Finnish Environment Institute. 2010.
9. Hansson,K., Skarman,T. & Brorström-Lundén,E. Release of Nonylphenol and Nonylphenol Ethoxylates from the use phase of end products. SMED commissioned by theSwedish Environmental Protection Agency. 2008.
10. BfR,B.f.R. Opinion on Allergies caised by consumer products and foods.Expert Opinion 001.2007. 2006.
11. Massey,R.I., Hutchins,J.C., Becker,M. & Tichner,J. Toxic Substances in Articles: The Need for Information. *TemaNord 2008* **596**, (2008).
12. Gewurtz,S.B. *et al.* Perfluoroalkyl contaminants in window film: indoor/outdoor, urban/rural, and winter/summer contamination and assessment of carpet as a possible source. *Environ. Sci. Technol.* **43**, 7317-7323 (2009).
13. de Groot,A.C. *et al.* Formaldehyde-releasers: relationship to formaldehyde contact allergy. Formaldehyde-releasers in clothes: durable press chemical finishes. Part 1. *Contact Dermatitis* **62**, 259-271 (2010).
14. de Groot,A.C. *et al.* Formaldehyde-releasers: relationship to formaldehyde contact allergy. Part 2. Formaldehyde-releasers in clothes: durable press chemical finishes. *Contact Dermatitis* **63**, 1-9 (2010).
15. Kajiwara,N., Sueoka,M., Ohiwa,T. & Takigami,H. Determination of flame-retardant hexabromocyclododecane diastereomers in textiles. *Chemosphere* **74**, 1485-1489 (2009).
16. Kemmlein,S., Hahn,O. & Jann,O. Emissions of organophosphate and brominated flame retardants from selected consumer products and building materials. *Armospheric Environment* **37**, 5485-5493 (2003).
17. Hartmann,P.C., Burgi,D. & Giger,W. Organophosphate flame retardants and plasticizers in indoor air. *Chemosphere* **57**, 781-787 (2004).
18. Wensing,M., Uhde,E. & Salthammer,T. Plastics additives in the indoor environment--flame retardants and plasticizers. *Sci. Total Environ.* **339**, 19-40 (2005).
19. Martin,T.P., Kooi,S.E., Chang,S.H., Sedransk,K.L. & Gleason,K.K. Initiated chemical vapor deposition of antimicrobial polymer coatings.. *Biomaterials* **28**, 909-915 (2007).
20. Kalyon,B.D. & Olgun,U. Antibacterial efficacy of triclosan-incorporated polymers. *Am. J. Infect. Control* **29**, 124-125 (2001).
21. Rastogi,S.C., Krongaard,T. & Jensen,G.H. Antibacterial compounds in clothing articles. Danish Environmental Protection Agency, Survey of Chemical Substances in Consumer Products, No.24 . 2003.
22. Orhan,M., Kut,D. & Gunesoglu,C. Fabrics Finished with Triclosan by the Use of 1,2,3,4-Butanetetracarboxylic Acid and Ctric Acid. *J Appl Polymer Sci* **111**, 1344-1352 (2010).

23. Janssen,P.J.C.M., van Veen,M.P. & Speijers,G.J.A. Health Risk Assessment for Organotin in Textiles. RIVM report 613350 002. 2000.
24. Pors,J. & Fuhlendorff,R. Mapping and liberation of organic tin compounds in mattress pads, Top matrasses, and baby/junior duvets. Danish Environmental Protection Agency, Survey of Chemical Substances in Consumer Products, No.25 . 2003.
25. Berger-Preiss,E. *et al.* Indoor pyrethroid exposure in homes with woollen textile floor coverings. *Int. J. Hyg. Environ. Health* **205**, 459-472 (2002).
26. Hillier,K., Schupp,T. & Carney,I. An Investigation into VOC Emissions from Polyurethane Flexible Foam Matresses. *Cellular Polymers* **22**, 237-259 (2003).
27. Mantovani,E. & Zappelini,P. Report on Nanotechnology and Textiles. 2009.
28. Tonning,K. *et al.* Survey, emission and health assessment of chemical substances in baby products. Danish Environmental Protection Agency, Survey of Chemical Substances in Consumer Products, No.90. 2008.
29. Hansen,O.C. Screening for health effects from chemical substances in textile colorants. Danish Environmental Protection Agency, Survey of Chemical Substances in Consumer Products, No.57 . 2005.
30. Washburn,S.T. *et al.* Exposure assessment and risk characterization for perfluorooctanoate in selected consumer articles. *Environ. Sci. Technol.* **39**, 3904-3910 (2005).
31. Hillier,K., King,D.A. & Henneuse,C. Study of odours Coming Out Polyurethane Flexible Foam Mattresses. *Cellular Polymers* **28**, 113-144 (2009).
32. Ross,BL. *et al.* Environmental, Health and Safety (EHS) Impacts. 2009.
33. Wijnhoven,S.W.P., Ezendam,J., Schuur,A.G., van Loveren,H. & van Engelen,J.G.M. Allergens in consumer products. RIVM Report 320025001. 2008.
34. Uter,W., Geier,J., Lessmann,H. & Hausen,B.M. Contact allergy to Disperse Blue 106 and Disperse Blue 124 in German and Austrian patients, 1995 to 1999. *Contact Dermatitis* **44**, 173-177 (2001).
35. Hatch,K.L. & Maibach,H.I. Textile dye allergic contact dermatitis prevalence. *Contact Dermatitis* **42**, 187-195 (2000).
36. Collier,S.W., Storm,J.E. & Bronaugh,R.L. Reduction of azo dyes during in vitro percutaneous absorption. *Toxicol. Appl. Pharmacol.* **118**, 73-79 (1993).
37. Platzek,T., Lang,C., Grohmann,G., Gi,U.S. & Baltes,W. Formation of a carcinogenic aromatic amine from an azo dye by human skin bacteria in vitro.. *Hum. Exp. Toxicol.* **18**, 552-559 (1999).
38. Hatch,K.L. & Maibach,H.I. Textile dye dermatitis. *J. Am. Acad. Dermatol.* **32**, 631-639 (1995).
39. Lazarov,A. Textile dermatitis in patients with contact sensitization in Israel: a 4-year prospective study. *J. Eur. Acad. Dermatol. Venereol.* **18**, 531-537 (2004).
40. Schnuch,A. *et al.* Untersuchungen zur verbreitung umweltbedingter Kontaktallergien mit Schwerpunkt im provaten bereich. Forschungsbericht 29961219, Umweltbundesamt, Berlin . 2004.
41. Simpson,A. Argos to be sued after toxic sofas blamed for causing skin burns and allergies. Telegraph . 5-28-2008. On line available: http://www.telegraph.co.uk/news/uknews/2042460/Argos-to-be-sued-after-toxic-sofas-blamed-for-causing-skin-burns-and-allergies.html
42. Corea,N.V. *et al.* Fragrance allergy: assessing the risk from washed fabrics. *Contact Dermatitis* **55**, 48-53 (2006).
43. Zeilmaker,M.J. *et al.* Polybrominated diphenyl ethers: occurrence in Dutch duplicate diets and comparison with exposure from European house dust. RIVM report 320100003. 2008.
44. Tonning,K., Strange,M. & Moller,L. Survey and health assessment of the exposure of 2-year olds to chemical substances in consumer products. Danish Environmental Protection Agency, Survey of Chemical Substances in Consumer Products, No.102. 2009.
45. Wormuth,M., Scheringer,M., Vollenweider,M. & Hungerbuhler,K. What are the sources of exposure to eight frequently used phthalic acid esters in Europeans? *Risk Anal.* **26**, 803-824 (2006).

Appendix 1: Textile fabrics according to directive 96/74/EC, 1996

	Name	Fibre description
1	wool (1)	Fibre from sheep's or lambs' fleeces (Ovis aries)
2	alpaca, llama, cammel, kashmir, mohair, angora, vicuna, yak, guanaco, beaver, otter, followed or not by the name 'wool' or 'hair' (1)	Hair of the following animals: alpaca, llama, cammel, kashmir goat, angora goat, angora rabbit, vicuna, yak, guanaco, beaver, otter
3	animal or horsehair, with or without an indication of the kind of animal (e.g. cattle hair, common goat hair, horsehair)	Hair of the various animals not mentioned under 1 or 2
4	silk	Fibre obtained exclusively from silk-secreting insects
5	cotton	Fibre obtained from the bolls of the cotton plant
6	kapok	Fibre obtained from the inside of the kapok fruit (Ceiba pentandra)
7	flax	Fibre obtained from the bast of the flax plant (Linum usitatissimum)
8	true hemp	Fibre obtained from the bast of hemp (Cannabis sativa)
9	jute	Fibre obtained from the bast of Corchorus olitorius and of Corchorus capsularis. For the purposes of this Directive, bast fibres obtained from the following species shall be treated in the same way as jute: Hibiscus cannabinus, Hibiscus sabdariffa, Abultilon avicennae, Urena lobata, Urena sinuata
10	abaca (Manila hemp)	Fibre obtained from the sheating leaf of Musa textilis
11	alfa	Fibre obtained from the leaves of Stipa tenacissima
12	coir (coconut)	Fibre obtained from the fruit of Cocos nucifera
13	broom	Fibre obtained from the bast of Cytisus scoparius and/or Spartium junceum
14	ramie	Fibre obtained from the bast of Bohemeria nivea and Bohemeria tenacissima
15	sisal	Fibre obtained from the leaves of Agave sisalana
16	Sunn	Fibre from the bast of Crotalaria juncea
17	Henequen	Fibre from the bast of Agave Fourcroydes
18	Maguey	Fibre from the bast of Agave Cantala
19	acetate	Cellulose acetate fibre wherein less than 92% but at least 74% of

		hydroxyl groups are acetylated
20	alginate	Fibre obtained from metallic salts of alginic acid
21	cupro (cuprammonium rayon)	Regenerated cellulose fibre obtained by the cuprammonium process
22	modal	A fibre of regenerated cellulose having a high breaking force and high wet modulus. The breaking force (BC) in the conditioned state and the force (BM) required to produce an elongation of 5% in the wet state are: BC (centinewton)>=1,3 sqr(T) + 2T BM (centinewton) >= 0,5 sqr(T) where T is the mean linear density in decitex
23	protein (1)	Fibre obtained from natural protein substances regenerated and stabilized through the action of chemical agents
24	triacetate	Cellulose acetate fibre wherein at least 92% of the hydroxyl groups are acetylated
25	viscose	Regenerated cellulose fibre obtained by the viscose process for filament and discontinuos fibre
26	acrylic (1)	Fibre formed of linear macromolecules comprising at least 85% (by mass) in the chain of the acrylonitrilic pattern
27	chlorofibre	Fibre formed of linear macromolecules having in their chain more than 50% by mass of chlorinated vinyl or chlorinated vinylidene monomeric units
28	fluorofibre	Fibre formed of linear macromolecules made from fluorocarbon aliphatic monomers
29	modacrylic (2)	Fibre formed of linear macromolecules having in their chain more than 50% and less than 85% (by mass) of the acrylonitrilic pattern
30	polyamide or nylon (2)	Fibre formed of linear macromolecules having in their chain the recurring amide functional group
31	polyester	Fibre formed of linear macromolecules having in their chain at least 85% (by mass) of an ester of a diol and terephthalic acid
32	polyethylene (2)	Fibre formed of un-substituted aliphatic saturated hydrocarbon linear macromolecules
33	polypropylene (2)	Fibre formed of an aliphatic saturated hydrocarbon linear macromolecule where one carbon atom in two carriers a methyl side chain in an isotactic disposition and without further substituition
34	polycarbamide (2)	Fibre formed of linear macromolecules having in their chain the recurring ureylene (NH-CO-NH) functional group
35	polyurethane (2)	Fibre formed of linear macromolecules composed of chains with the recurring urethane functional group
36	vinylal (m)	Fibre formed of linear macromolecules whose chain is constituted by poly(vinyl alcohol) with differing levels of acetilization

37	trivinyl (2)	Fibre formed of acrylonitrile terpolymer, a chlorinated vynil monomer and a third vinyl monomer, none of which represents as much as 50% of the total mass
38	elastodiene (2)	Elastofibre composed of natural or synthetic polyisoprene, or composed of one or more dienes polymerized with or without one or more vinyl monomers, and which, when stretched to three times its original length and released, recovers rapidly and substantially to its initial length
39	elastane	Elastofibre composed of at least 85% (by mass) of a segmented polyurethane, and which, when stretched to three times its original length and released, recovers rapidly and substantially to its initial length
40	glass fibre	Fibre made of glass
41	name corresponding to the material of which the fibres are composed, e.g. metal (metallic, metallized), asbestos, paper, followed or not by the word 'yarn' or 'fibre'	Fibres obtained from miscellaneous or new materials not listed above

(1) The name 'wool' in item 1 of this list may also be used to indicate a mixture of fibres from sheep's or lambs' fleeces and the hairs listed in the third column of item 2. This provision is applicable to the textile products listed in Articles 4 and 5 and to those referred to in Article 6, provided that the latter are partly composed of the fibres listed in items 1 and 2. (2) The 'word' fibre is understood.

Appendix 2: Substances present in textiles

Substance	Subgroup	Components	Present in	Possible exposure	Possible adverse health effects	Reference	Control measure	Comments
formaldehyde	wrinkle resistant coating	urea formaldehyde melamine formaldehyde	upholstery fabrics clothes textile fabrics	+	contact allergy	[13,14]	Yes	"Warenwetbesluit formaldehyde in textiel" (2001)
			textile fabrics	+	contact allergy	[6]		
			textile (baby products)	+	-	[28]		
phtalathes	plasticizer	DEHP	plastic coatings (baby products) textile fabrics	+	-	[6, 28]	Yes	REACH annex XVII
		DINP		+	in one product possible risk by skin contact		Yes	REACH annex XVII
nicotine			textile fabrics	-	-	[6]	No	
naphthalene			textile fabrics	-	-	[6]	No	
aromatic amines		4-chloroaniline o-toluidine	textile fabrics	-	-	[6]	Yes (as dye) Yes (as dye)	REACH annex XVII (appendix 8)
nonphenol ethoxylates	detergent and auxiliaries		textile fabrics	+	incomplete information	[9]	Yes	EU directive (2003/53/EC)
perfluoroalkyl contaminants	water,-oil-,-stain resistant coating	PFOS PTFE	fabrics clothes	+	possible	[11]	Yes No	REACH annex XVII
		PFOA PFOS	carpets	+	no information	[12]	No	

		PFO	carpets, upholstery textiles		adverse effects not expected	[30]	-	Unknown (no CAS number found)
polybrominated compounds	flame retardants	PBDE PCB	textile	+	possible	[15]	Yes (penta en octo PBDE) Yes	REACH annex XVII REACH annex XVII "Regeling verwijdering PCB's" (1998)
		HBCD	textile (baby products)	-	-	[28]	Yes	Candidate for authorisation
Organophos phoric compounds POC	flame retardants	TCPP	upholstery mattresses foam	+	data not sufficient for adequate risk assessment	[16]	No	
		TCEP TPP TBEP	upholstery	+	-	[17]	No No No	
triclosan	pesticide anti-bacterial		upholstery clothing	no information	no information	[20]	Yes, for cosmetic products	Cosmetic Directive 76/768/EEC, Annex VI
			clothing	+	-	[21]		
			textile fabrics	+	no information	[7]		
poly (dimethylaminomethyl)styrene	pesticide, anti-bacterial		nylon fabrics	-	-	[19]	Yes	
	pesticide anti-bacterial		textile fabrics	+	-	[23]	Yes	REACH annex XVII
			mattress pads, top	+	-	[24]		

			mattresses, baby/junior duvets					
pyrethroid	insecticide	permethrin	carpets floor covering	+	-	[25]	No	
dimethylfumarate	anti-mould agent	DMF	textile fabrics leather furniture	+	contact allergy, skin burns	ref	Yes	REACH annex XVII, temporary ban
disperse azo dyes	pigment	disperse blue 106, 124, 85 disperse orange disperse red	textile fabrics	+	contact allergy	[34,35,38]	Yes, disperse blue 106, 124 and for some disperse orange en red dyes	REACH annex XVII
arsenic	metals		textile fabrics	+	adverse effects expected after oral intake by a child	[6]	No	
barium	metals		textile fabrics	+	-	[6]	No	
cobalt	metals		textile fabrics	+	adverse effects expected after oral intake allergic reaction possible	[6]	No	
chromium	metals		textile fabrics	+	adverse effects expected after oral intake	[6]	Yes, for Cr^{VI}	REACH annex XVII
copper	metals		textile fabrics	+	health risk by oral intake and inhalation	[6]	No	

nickel	metals		textile fabrics	+	-	[6]	Yes, For components of textile products	REACH annex XVII
lead	metals		textile fabrics	-	-	[6]	Yes	REACH annex XVII
antimony	metals		textile fabrics	-	-	[6]	No	
tin	metals		textile fabrics	+	adverse effects expected after oral intake	[6]	No	

* Azoic and disperse dyes do fall under the ban in REACH annex XVII as they can split off carcinogenic amines. The complete list can be found at http://www.ethiopianchamber.com/LinkClick.aspx?fileticket=dHcMxM3O2RQ%3D&tabid=36&mid=475 or www.cbi.eu

Appendix 3: RAPEX alerts of textile products in 2010

Product description	Substance	number of products
shoes	DMF	21
shoes	DMF in sachets	33
shoes	DMF in sachets and in shoe	4
clothes, jeans	DMF	3
boots	azo-dyes	1
fleece blanket	azo-dyes	1
scarves	azo-dyes	4
cushion cover	azo-dyes	1
clothes, jeans	azo-dyes	1
clothes, sweatshirt	azo-dyes	1
baby-sling	azo-dyes	1
socks	azo-dyes	1
pyjamas	azo-dyes	1
children's pirate costume (toy product)	Toluylendiamine	1
scarves	Benzidine	3
clothes, dress	Benzidine	1
children's fireman costume (toy product)	DEHP	1
baby changing mat	DEHP	1
baby carrier	DEPH, DINP	1

Appendix 4: VOC emissions from foam mattresses

	Standard polyether	Combustion Modified High Resilence foam	High Resilence foam	Combustion Modified Polyether	HR/FR foam
BHT				x	
Siloxanes	x	x	x	x	x
TMCP		x	x	x	
Methylene chloride			x		x
Propane oxybischloro					x
Dichloroprpane					x
Chloropropanol				x	
Dichlorobenzene			x		
Chloro octane					x
2-ethylhexanoic acid		x	x	x	
Triethylene diamine	x			x	
Dimethyl dioxanes					x
Phathalates	x				
Alkanes C6-C15	x	x	x	x	x
Toluene	x		x	x	x
Xylene			x	x	
C3 benzenes				x	
Styrene			x		x
Propanol, propenyloxy				x	
Propanal					x
Hexanal			x		x
Hexanal, propylene glycol acetal					x

BHT butylated hydroxy toluene; TMCP tris monochloropropyl phosphate

RIVM

National Institute
for Public Health
and the Environment

P.O. Box 1
3720BA Bilthoven
the Netherlands
www.rivm.nl