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Survey and risk assessment of chemical substances in rugs for children

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Survey and risk assessment of chemical substances in rugs for children

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Preface

This project ”Survey and Risk Assessment of Chemical Substances in Rugs for Children” was carried out from March 2015 - April 2016.

The project was carried out by Danish Technological Institute (DTI) together with DHI Denmark, who is responsible for the hazard assessment, exposure assessment and risk assessment of the selected rugs.

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Summary and Conclusion

Children are exposed to chemical compounds through their childhood e.g. by skin contact with different products (e.g. toys and cosmetics) and inhalation of airborne chemicals in the indoor air. In the children's rooms, there is special exposure to chemicals from furniture, rugs, toys and other things as the room typically acts as both bedroom and play room – the children thus stay there for many hours a day. Therefore, a special focus should be brought on the materials and products used in children's rooms. In this report, we will examine the impact from rugs on the indoor environment of children's rooms, as rugs are made of several materials that may contain problematic chemicals both in the textile top side (nap) and in the backing.

Purpose of the project
The project focuses on 3 groups of chemicals; 1) volatile organic compounds (VOC), 2) phthalates and 3) per- and polyfluoroalkyl substances (PFAS). The purpose is to survey, which VOCs are emitted from the rugs, including which rugs emit odours, and if there is a health risk. Emission of PFAS and phthalates to the indoor air and content in dust should also be measured. An assessment is required, as to whether the rugs pose a risk to the children, when they are in indoor air. Furthermore, an assessment whether the findings, if any, of the above compounds (VOC, phthalates and PFAS) can obstruct recycling of the rugs. The project focuses on imported products from non-EU countries.

Chemicals in rugs
Previously, examinations of carpets and their content of chemical compounds and potential impact on the indoor air have been carried out. The chemical compounds originate from the materials and are added with different purposes during the production. Carpets are considered to have a major impact on the indoor air due to the large surface. In addition, carpets are usually not washed prior to use, which means that surplus chemicals are still present in the in-use phase. Rugs are typically mass-produced and mainly imported from non-EU countries. There is no special regulation of chemicals in rugs, therefore the general rules must be followed in the EU regulation REACH. REACH applies to chemical substances, chemical mixtures and chemicals in articles (products). Distributors of articles in EU (including rugs) are a.o. obliged to inform content above 0.1 weight percent of problematic chemicals (Substances of Very High Concern (SVHC)). More substances appertaining to chemical classes VOC, phthalates and PFAS are on the Candidate List (SVHC) and also on the Danish "List of Undesirable Substances" (LOUS). It is relevant to examine, whether rugs produced in non-EU countries contain substances included in these lists/regulations.

Survey
In the initial survey, we both found examinations of rugs for emissions of VOC and for content of phthalates and PFAS. On basis of the compiled data and initial considerations about health aspects, we assessed and gave priority to the substances. This order of priority was carried out in cooperation with The Danish Environmental Protection Agency. The conclusion of the order of priority was that the chemical analysis should focus on *phthalates*, *fluorinated compounds* and on the emission of VOC within the sub-classes *aldehydes, carboxylic acids and hydrocarbons* (*C7-C12, aliphatic and aromatic hydrocarbons*) from the rugs (hereby 52 out of the 90 identified VOCs are identified).

No overall examination of children's rugs exist for the above mentioned selected chemical substances/substance classes. Therefore, the initial survey focused on identifying, which children's rugs are sold in Denmark (market survey), which materials the rugs are made of and a review of the results from previous examinations regarding chemical content. The previous examinations showed that rugs emit many different kinds of volatile compounds to the indoor air. Even though no data were found in the literature on emission of phthalates and volatile PFAS from rugs, phthalates and PFAS have previously been found in rugs and therefore, it was expected that they also could be in children's rugs.

Market survey

The market survey showed that a large part of the children's rugs sold in Denmark are produced in non-EU countries, but that they are distributed typically via a retailer in an EU country. It is thus the retailer, who holds the information about country of origin and has the responsibility for procurement of information about content of SVHC compounds on the Candidate List including certain phthalates and PFAS. It was possible to procure information about country of origin for most of the children's rugs. Though some of the rugs fulfilled the EU's requirements or were issued with a quality label (Oeko-Tex®, GUT), where the limit values for the substances in question are fulfilled, we did not receive definite information such as analysis certificates on content or emission of the substances. The identified rugs were classified according to expected age groups of children; toddlers (0-2 years), young children (approx. 3-7 years) and older children (approx. 8-14 years). Most rugs are in the class young children (71%) and most are made of polyamide with a latex, rubber or non-skid backing (49%). Rugs made of acrylic (19%) and polypropylene (11%) are also frequently occurring.

Test material

On basis of the survey, 21 children's rugs were selected for examination for odour, VOC, phthalates and PFAS. The criteria for selection of the rugs were that they design-wise should be appealing to toddlers and children, that they had no quality labels and that they were produced in non-EU countries. Rugs were selected so that the broadest range of distributors, materials and composition of materials were represented. Rugs were purchased with and without "rubber" backing. Rugs intended for older children of 8-14 years were not purchased.

Sensory evaluation

A qualitative sensory evaluation of the rugs was carried out. The sensory evaluation showed that the odour was acceptable for 9 out of 21 rugs. The odour was described as: Rubber, chemical, rug, sour, sweet/nauseating, rotten/mouldy and fishlike. There were many odour relevant VOCs in the emission after one day, including aldehydes, carboxylic acids and hydrocarbons. A substance, which is often connected with a sweet chemical odour of new rugs, is 4-phenylcyclohexene (4-PCH), which was subsequently found in the emission from most of the rugs.

Analyses of VOC

The chemical analyses of the rugs showed that all rugs emitted VOC at different levels, but only very low levels of C1-C4 aldehydes; formaldehyde, acetaldehyde, propanal and acrolein. VOCs, which emitted at the highest concentration, were acetic acid, aliphatic and aromatic hydrocarbons. Several VOCs (naphtalene, phenol, styrene, toluene, dimethylformamide, dichloromethane, benzene) with CMR hazard classication were identified in the initial emissions after 1 day. Naphtalene emitted from 8 of the rugs, and was the CMR substance that emitted in highest concentrations. The emission of VOCs decreased markedly between 1 and 28 days. There were 2 rugs, which still emitted semi volatile VOC (SVOC) after 28 days, and this was mainly hydrocarbons.
All the rugs fulfilled the limit values of the labelling criteria for aldehydes, aromatic hydrocarbons including 4-PCH after 1 day (Oeko-Tex®) and 28 days (GUT, Blauer Engel). The Labelling schemes does not include limit values for carboxylic acids. Two rugs, an Oeko-Tex labelled synthetic wool/jute rug and a polypropylene rug emitted high concentrations of volatile substances, and the

sum of VOCs and SVOCs (TVOC and TSVOC, respectively) exceeded the limit values for both Oeko-Tex (16 hours: TVOC 500 µg/m^3) and GUT/Blauer Engel (28 days: TVOC 100 µg/m^3 and TSVOC 30 µg/ m^3 respectively).

Analyses of phthalates, emission and content
Traces of diethyl phthalate (DEP) were detected in the emissions from 19 rugs after 1 day. The non-volatile phthalates diethylhexyl phthalate (DEHP), dibutyl phthalate (DBP) and diisobutyl phthalate (DIBP) could not be identified as SVOC in the emissions after 28 days. Subsequently, all rugs were analysed for content of the phthalates DEHP, DBP, DIBP, benzylbutyl phthalate (BBP), diisononyloctyl phthalate (DNOP). Only one wool rug contained traces of DBP.

Analyses of fluorinated compounds, emission and content
All 21 rugs were screened for total-fluorine in the textile surface, out of which 5 rugs with the textile materials polyamide and polypropylene contained fluorine. These 5 rugs were analysed closer for content of specific PFAS. The total content of fluorine was not correlated to the content found of monomers PFAS. One rug had a higher content of PFAS than the other 4 rugs, even though the rug had the lowest total-fluorine content in the surface. Perfluorooctanoic acid (PFOA) was found in all 5 rugs. Detection in several rugs of the fluorinated compounds PFOA, perfluorooctanesulfonic acid (PFOS), iso-PFOS and 4H-polyfluorooctanesulfonic acid/6:2 fluorotelomer sulfonate (6:2 FTSA) indicates that C8 chemistry is still used for impregnation of rugs. None of the 5 rugs contained volatile fluorinated compounds including fluorotelomers (FT-OH).

Analyses of dust
It was originally planned to carry out dust measurements for worst-case exposure scenarios for the rugs that emitted phthalates and PFAS to the highest concentrations. As no phthalates, (except DEP, which is not considered to be hazardous to health), or PFAS were found in the emission, the content analyses were instead given priority. Thus, no dust analyses were carried out in the project.

Health risk assessment
Risk assessment was carried out with selected exposure scenarios for all compound classes. The health risk assessment of analysis data concludes that, generally, there is no cause for concern when it comes to using the rugs in the children’s room. The aldehydes acrolein and acetaldehyde were found in one rug, which can cause respiratory irritation and discomfort when staying in the room the first day.
Most of the odours from the rugs (12 out of 21) are perceived as unacceptable according to assessment from an odour panel. There is no clear correlation between odour and the emission of health hazardous compounds. VOCs with CMR classification emitted from 5 out 9 rugs with acceptable odour. Odour is a parameter, which is especially important to the perception of comfort (the perceived air quality) in the indoor air, and which can cause other types of inconvenience, such as headache and fatigue.

Resource assessment
No compounds were found in amounts which could be assessed to obstruct recycling of rugs. The resource assessment concluded that the rugs advantageously could be recycled as whole rugs or they could be used for energy production as combustible waste. Recycling is assessed to be resource-intensive as it is hard to separate the materials in usable fractions.

Conclusion of the survey
This survey covered a wide range of children´s rugs consisting of different materials on the Danish market. Emissions of VOCs and unacceptable odour were found. Problematic substances on both the LOUS and SVHC lists were identified in the childrens rugs; the phthalate DBP, the PFAS PFOA and the VOC dimethylformamide (DMF). Also the following VOCs on the LOUS list were identified: Formaldehyde, hexane, phenol, styrene and toluene.

Even though the identified VOCs are not found to be hazardous to health at the measured concentrations, they can still cause bad odour and a decreased indoor air quality in the children's room. In very low concentration, acrolein can cause respiratory irritation, and was found in the emission from one rug. As acrolein is very volatile, and the areas of children´s rugs are small, it is probable that acrolein will not be found in the air after some time, however, this could not be confirmed by the performed measurements in this project. A low content of PFAS was demonstrated in 5 rugs and as well as the presence of phthalate in one rug, but the substances are considered not to cause any health hazard for children.

Sammenfatning og konklusion

Børn udsættes for kemiske stoffer gennem deres opvækst fx ved hudkontakt med forskellige produkter (fx legetøj og kosmetik) og indånding af luftbårne kemikalier i indeklimaet. I børneværelset er der er en særlig udsættelse for kemikalier fra møbler, tæpper, legetøj og andre genstande, da rummet typisk fungerer som både soveværelse og opholdsrum og børn derved opholder sig der en stor del af dagen. Derfor kræves der særlig fokus på de materialer og produkter, der anvendes i børneværelset. I nærværende rapport undersøges indeklimapåvirkningen fra løse gulvtæpper til børneværelser. Disse er sammensat af flere materialer, der kan indeholde problematiske kemikalier både i den tekstile overside (luv) og bagsiden.

Projektets formål
Projektet fokuserer på 3 grupper af kemikalier, nemlig 1) flygtige organiske stoffer (VOC) 2) ftalater og 3) per- og polyfluoralkylerede stoffer (PFAS). Formålet er at få kortlagt, hvilke VOC der afgives fra tæpperne, herunder hvilke der afgiver lugte, og om der er en sundhedsmæssig risiko forbundet derved. Afgivelse af PFAS og ftalater til luft og indhold i støv ønskes også målt. Der ønskes en vurdering af, om tæpperne udgør en risiko for børnene, når de findes i indeklimaet. Desuden ønskes en vurdering af, om eventuelle fund af nogle af de ovennævnte stoffer (VOC, ftalater og PFAS) kan hindre genanvendelse. Projektet har fokus på importerede produkter fra ikke EU-lande.

Kemikalier i tæpper
Der er tidligere gennemført undersøgelser af gulvtæpper og deres indhold af kemiske stoffer og eventuel påvirkning af indeklimaet. De kemiske stoffer stammer fra materialerne og tilsættes med forskelligt formål under produktionen. Gulvtæpper anses for at have stor indflydelse på indeklimaet på grund af den store overflade. Desuden vaskes gulvtæpper som regel ikke før brug, hvilket betyder, at eventuelle overskudskemikalier stadig er til stede i brugsfasen.
Børnetæpper er typisk et masseproduceret produkt, som hovedsageligt importeres fra lande uden for EU. Der er ingen særregulering af kemikalier i tæpper, det er derfor de generelle regler i EU's forordning REACH, der er gældende. REACH gælder for kemiske stoffer, kemiske blandinger og kemikalier i artikler (varer). Forhandlere af artikler i EU (inklusive børnetæpper) har bl.a. pligt til at oplyse et eventuelt indhold over 0,1 vægtprocent af særligt problematiske kemikalier (Substances of very high concern: SVHC). Flere stoffer, der tilhører kemikaliegrupperne VOC, ftalater og PFAS er på kandidatlisten (SVHC), og også på den danske "Liste over uønskede stoffer" (LOUS). Det er relevant at undersøge, om børnetæpper produceret uden for EU indeholder stoffer som er på en af disse lister.

Kortlægning
I den indledende kortlægning blev der fundet både undersøgelser af tæpper for emissioner af VOC og indhold af ftalater og PFAS. På basis af indsamlede data og indledende overvejelser omkring de sundhedsmæssige aspekter blev der foretaget en vurdering og prioritering af stofferne. Denne prioritering blev foretaget i samarbejde med Miljøstyrelsen. Konklusionen på prioriteringen blev, at den kemiske analyse skulle fokusere på *ftalater* og *fluorerede* forbindelser samt på afgasningen af VOC inden for undergrupperne *aldehyder*, *carboxylsyrer* og *kulbrinter (C7-C12, alifatiske og aromatiske kulbrinter)* fra tæpperne, (hermed dækkes 52 ud af de 90 identificerede VOC stoffer).
Der findes ingen samlet undersøgelse af børnetæpper for de ovennævnte udvalgte kemiske stoffer/stofgrupper, så den indledende kortlægning havde fokus på at afdække, hvilke børnetæpper der sælges i Danmark (markedsundersøgelse), hvilke materialer tæpperne er fremstillet af, samt en

gennemgang af resultater fra tidligere undersøgelser vedrørende kemikalieindhold. De tidligere undersøgelser viste, at tæpper afgasser mange forskellige typer af flygtige stoffer til indeklimaet. Selv om der ikke er fundet data i litteraturen på afgasning af ftalater og flygtige PFAS fra tæpper, er der fundet indhold af ftalater og PFAS i tæpper, og derfor kan det forventes, at de også findes i børnetæpper.

Markedsundersøgelse
Markedsundersøgelsen viste, at en stor del af børnetæpperne, der sælges i Danmark er produceret i lande uden for EU, men de forhandles typisk via en grossist fra et EU land. Det er altså grossisten, der sidder med oplysningerne om produktionsland og har ansvaret for at fremskaffe oplysningerne om indhold af SVHC stoffer på kandidatlisten, herunder visse ftalater og PFAS. Det var muligt at fremskaffe oplysninger om produktionsland for de fleste af børnetæpperne, men ud over at visse af tæpperne overholdt EU´s krav eller havde en kvalitetsmærkning (Oeko-Tex®, GUT), hvor grænseværdier for de pågældende stoffer overholdes, blev der ikke modtaget konkrete oplysninger i form af analysecertifikater med indhold eller afgasning af stofferne. De identificerede tæpper blev kategoriseret efter forventet aldersgruppe af børn: Småbørn (0-2 år), børn (ca. 3-7 år) og større børn (ca. 8-14 år). De fleste tæpper falder i kategorien børn (71% af alle), og langt de fleste er lavet af polyamid med bagside af latex, gummi eller skridsikker bagside (49% af alle). Tæpper af akryl (19%) samt polypropylen (11%) er også hyppigt forekommende.

Prøvemateriale
På baggrund af kortlægningen blev 21 børnetæpper udvalgt til undersøgelse for lugt, VOC, ftalater og PFAS. Kriterierne for udvælgelse af tæpperne var, at de designmæssigt appellerede til babyer og små børn, at de ikke havde en kvalitetsmærkning, og at de var produceret uden for EU. Der blev udvalgt tæpper, så flest mulige forhandlere, materialer og materialesammensætninger var repræsenteret. Der blev indkøbt tæpper med og uden ”gummi” bagside. Tæpper beregnet til større børn på 8-14 år blev ikke indkøbt.

Sensorisk bedømmelse
Der blev foretaget en kvalitativ sensorisk undersøgelse af tæpperne. Den sensoriske bedømmelse viste, at lugten var acceptabel for 9 ud af de 21 tæpper. Lugten blev beskrevet som: Gummi, kemisk, tæppe, sur, sød/kvalm, råd/mug og fiskeagtig. Der fandtes mange lugtrelevante VOC i afgasningerne efter 1 døgn, herunder aldehyder, carboxylsyrer og kulbrinter. Et stof, der ofte forbindes med en sødlig kemisk lugt af nye tæpper, er 4-phenylcyclohexene (4-PCH), som senere fandtes i afgasningen fra de fleste af tæpperne.

Analyser af VOC
De kemiske analyser af tæpperne viste, at alle tæpper afgassede VOC i forskellige niveauer, men kun meget lave niveauer af C1-C4 aldehyderne formaldehyd, acetaldehyd, propanal og acrolein. VOC, der afgassede i højeste koncentration, var eddikesyre, alifatiske og aromatiske kulbrinter.
Flere VOC (naphtalen, phenol, styren, toluen, dimethylformamid, dichlormethan, benzen) med CMR fareklassifikation blev identificeret i de initiale afgasninger efter 1 døgn. Naphtalen afgassede fra 8 af tæpperne og var det CMR stof, der afgassede i de højeste koncentrationer.
Afgasningen af VOC aftog kraftigt mellem 1 og 28 døgn. Der var 2 tæpper, som stadig afgassede tungt-flygtige VOC (SVOC) efter 28 døgn, og det var hovedsageligt kulbrinter.
Alle tæpper overholdt mærkningsordningernes grænseværdier for aldehyder og aromatiske kulbrinter inklusive 4-PCH efter 1 døgn (Oeko-Tex®) og 28 døgn (GUT, Blauer Engel). Der er ingen grænseværdier for carboxylsyrer i mærkningsordningerne. To tæpper, et Oeko-Tex mærket kunstuld/jute tæppe og et polypropylen tæppe, afgassede høje koncentrationer af flygtige stoffer, og summen af VOC og SVOC (TVOC og TSVOC) overskred grænseværdierne for både Oeko-Tex (16 timer: TVOC 500 $\mu g/m^3$) og GUT/Blauer Engel (28 dage: TVOC 100 $\mu g/m^3$ hhv. TSVOC 30 $\mu g/m^3$).

Analyser af ftalater, afgasning og indhold
Spor af diethylftalat (DEP) kunne detekteres i afgasningerne fra 19 tæpper efter 1 døgn. De tungtflygtige ftalater diethylhexylftalat (DEHP), dibutylftalat (DBP) og diisobutylftalat (DIBP) kunne ikke identificeres som SVOC i afgasningerne efter 28 døgn. Efterfølgende blev alle tæpper analyseret for indhold af ftalaterne DEHP, DBP, DIBP, benzylbutylftalat (BBP), diisononyloctylftalat (DNOP). Der var kun et enkelt uldtæppe, der indeholdt spor af DBP.

Analyser af fluorerede stoffer, afgasning og indhold
Alle 21 tæpper blev analyseret for indhold af total-fluor i den tekstile overside, hvoraf 5 tæpper med tekstile materialer polyamid og polypropylen indeholdt fluor. Disse 5 tæpper blev analyseret nærmere for indhold af specifikke PFAS. Det totale indhold af fluor var ikke korreleret til det fundne indhold af PFAS. Et tæppe havde et større indhold af PFAS end de andre 4 tæpper, selv om tæppet havde det laveste total-fluor indhold i oversiden. Perfluoroctansyre (PFOA) blev fundet i alle 5 tæpper. Detektion af de fluorerede stoffer i flere af tæpperne PFOA, perfluoroctansulfonsyre (PFOS), iso-PFOS og 4H-polyfluoroctansulfonsyre/6:2 fluortelomersulfonat (6:2 FTSA) tyder på, at der stadig anvendes C8-kemi til imprægnering af tæpper. Ingen af de 5 tæpper indeholdt flygtige fluorstoffer, herunder fluortelomerer (FT-OH).

Analyser af støv
Det var oprindeligt planen, at der skulle udføres støvmålinger til worst-case eksponeringsscenarier for de tæpper, som afgassede ftalater og PFAS i de højeste koncentrationer. Da der ikke fandtes ftalater (udover DEP, som ikke betragtes som sundhedsskadelig) eller PFAS i afgasningerne, blev indholdsanalyserne i stedet prioriteret. Der blev således ikke udført støvanalyser i projektet.

Sundhedsmæssig risikovurdering
Der blev udført en farevurdering med udvalgte eksponeringsscenarier for alle stofgrupperne.
Den sundhedsmæssige risikovurdering af analysedata konkluderer, at der generelt ikke er anledning til bekymring ved at anvende børnetæpperne i børneværelset. Aldehyderne acrolein og acetaldehyd fundet i ét af tæpperne kan dog give anledning til luftvejsirritation og ubehag ved ophold i børneværelset det første døgn.
De fleste af tæppernes lugt (12 af 21) opfattes som værende uacceptabel ifølge bedømmelse fra et lugtpanel. Der ses dog ikke en direkte sammenhæng mellem lugt og afgasningen af sundhedsskadelige stoffer. Der afgassede VOC med CMR klassifikation fra hele 5 ud af 9 tæpper med acceptabel lugt. Lugt er en parameter, der især har betydning for komfortoplevelsen (den oplevede luftkvalitet) i indeklimaet, og som kan give anledning til andre typer af gener, end dem der skyldes sundhedsskadelige stoffer herunder diffuse symptomer som ubehag, hovedpine og uoplagthed.

Ressourcevurdering
Det blev ikke fundet stoffer i mængder, som vurderes at kunne hindre genanvendelsen af børnetæpperne. Ressourcevurderingen konkluderede, at tæpperne med fordel kan genbruges som hele tæpper, eller de kan bruges til energiproduktion som brændbart affald. Materialegenvinding vurderes at være for ressourcekrævende, da det er svært at adskille materialerne i brugbare fraktioner.

Konklusion på undersøgelsen
Nærværende undersøgelse dækker et bredt udsnit af børnetæpper bestående af forskellige materialer på det danske marked. Undersøgelsen påviser afgasning af VOC og uacceptabel lugt. Problematiske stoffer identificeret i børnetæpper, som er på både LOUS og SVHC listerne, er ftalaten DBP, PFAS'en PFOA og VOC'en dimethylformamid (DMF). Endvidere er der påvist VOC som er på LOUS-listen: Formaldehyd, hexan, phenol, styren og toluen. Selv om de identificerede VOC ikke er fundet sundhedsskadelige i de målte koncentrationer, kan det ikke udelukkes, at de kan give anledning til dårlig lugt og være årsag til en forringet luftkvalitet i indeklimaet på

børneværelset. Acrolein kan selv i lave koncentrationer give anledning til luftvejsirritation og er fundet i afgasningen fra et enkelt tæppe. Da acrolein er meget flygtigt, og børnetæpper har små arealer, er det sandsynligt, at acrolein forsvinder fra luften efter noget tid, men det kunne ikke bekræftes ved de foretagne målinger i dette projekt. Der påvises meget lavt indhold af PFAS i 5 tæpper og ftalat i 1 tæppe, men stofferne vurderes til ikke at udgøre en sundhedsmæssig risiko for børn.

1. Introduction and background

Background

Based on the wish to ensure children and young ones against harmful and unnecessary chemistry, 20 million DKK in the period 2013-16 were allocated for "Børnekemipakken" (The Children's Chemistry Package). The funds should be used to increase the information and make the control of consumer products more stringent, which are intended for children including unborn children and young ones under 14 years[1]. Textile products were selected as one of the areas of focus under the Children Chemistry Package, as they are everywhere in children's immediate environment both as clothes, furnishings fabrics, or as parts of products especially for children.

Rugs for children's rooms have been chosen as area of focus in this project, and the purpose of the project is to get an overview of the risk of children's exposure to chemical substances from these products. The indoor air has for a long time been an area of focus in relation to exposure of hazardous substances. Due to the large surface of rugs, the possible content of problematic chemicals may lead to emission of these substances to the indoor air. Furthermore, rugs will not usually be washed prior to use, which means that surplus chemicals, if any, from the production will still be present in the in-use phase. Young children can due to their behaviour be especially exposed, as they often suck on things and crawl on the floor and thereby get in close contact with rugs and dust. Chemical substances and other allergens can origin from many different sources inside and outside the home (Kanchongkittiphon *et al*, 2014) e.g. from domestic animals, dust and rugs.

A number of examinations have been carried out on rugs to find the emission of volatile organic compounds, VOC. The rugs are made of many different materials, and a number of different VOCs in rugs have been identified depending on material type. The Environmental Protection Agency wishes to examine the emission of VOCs from children's rugs and selected Semi-Volatile Compounds, SVOC, such as phthalates and per- and poly fluorinated substances, PFAS. Children's rugs have often a polymer backing for a better anti-skid protection, which may contain glues and softeners such as phthalates. Phthalates could be emitted to the indoor air and adhere to dust. The exposure will therefore partly take place by inhalation and partly by oral intake of dust in connection with hand-mouth exposure. PFAS can be used for treatment of rugs to obtain a dirt and water repellent surface. Rugs are considered the main sources of the emission of PFAS measured in the indoor air (Lassen *et al*, 2015). PFAS will likewise be absorbed by inhalation and by intake of dust as well as by hand-mouth exposure.

Purpose

The purpose of the project is to map, which chemicals within the categories, VOC, phthalates and PFAS are emitted from rugs to the indoor air, and whether a health risk is connected thereby. The purpose of the project is also by means of sensory evaluation to assess, whether there is a connection between odours and content of chemical substances including VOC. The emission of VOC, phthalates and PFAS to the air will be measured. If rugs are found with a high emission of phthalates and content of PFAS, dust analyses will be carried out for exposure to dust. It will be assessed, whether the rugs compose a risk to children, if the substances are found in the indoor air. Furthermore, an assessment of the finding, if any, of some of the above substances (VOC,

[1] http://mst.dk/virksomhed-myndighed/kemikalier/kontrol-og-tilsyn/kontrolkampagner/boernekemi-2014-kontroldelen/

phthalates and PFAS) can hinder recycling. The project focuses on imported products from non-EU countries.

2. Survey

2.1 Purpose

The objective of the survey is to describe and identify chemically problematic substances in rugs for children. Three chemical groups were targeted: Volatile organic compounds (VOC), phthalates and fluorinated substances (PFAS).

The objective of the market study is to identify the children's rugs available on the Danish market. Collating information about target group (age), materials, content of VOC, phthalates and PFAS, as well as origin (country of production). The market study will result in the selection of a number of representative samples of children's rugs for analysis regarding the three substance groups in order to compile health and risk assessments in addition to a resource assessment.

2.2 Definitions and delimitation

Definition of a rug or carpet;"Textile floor covering with a textile surface of friction made of yarn or fibres onto which a substrate has been attached" (McIntyre and Daniels, 1995). The substrate is the part of the rug that makes up the basic material or the fundamental woven fabric on to which the yarns/fibres are attached. In addition, a backing has often been mounted mainly for reasons of comfort or function, e.g., anti-skidding backing. Activity mats for babies (e.g., made of soft textile with an arch for toys or foam puzzles) are not covered by the definition of rugs in connection with this survey. Carpets cover the whole surface area of the floor (wall to wall), while rugs are smaller carpets lying loose on the floor. In the following the term "rug" is used, while "carpet" is used as a general term for textile floor covering of both small and large areas.

The rugs surveyed in this project are intended to be used in children's rooms. Therefore, they must be especially appealing to children. Rugs intended for play (e.g., with a car track theme), but also rugs that due to the design, colour and possibly price are assumed to be used in children's rooms. If the manufacturer states that the intention of the rug is to be played on by a child, and if the rug has a CE label, then the rug is considered to be a toy.

According to the REACH regulation, an article is a solid product, and therefore a rug is by definition regarded as an article (Regulation no. 1907/2006). According to REACH, a customer who purchases articles within the borders of the EU is entitled to know, if the article contains more than 0.1 weight % of a substance that is included in the Candidate List of Substances of very high concern (SVHC).

The survey will identify which substances might be emitted from carpets/rugs, based on previously performed analysis in the laboratory, literature searches, and relevant past surveys. A study of the children's rugs available on the Danish market will be performed.

The literature search was carried out from March to May 2015. In general, data regarding content and emission of VOCs from rugs prevail in the literature, whereas only a few references with analysis data were found for the other two substance groups, phthalates and fluorinated substances.

The literature search was mainly carried out in the database on scientific papers (ScienceDirect) and the following key words were used: VOC, SVOC, phthalates, perfluorinated and polyfluorinated substances, rugs (combined with latex, SBR (styrene butadiene rubber) and emission) and other relevant words in Danish and English.

In connection with the literature search, no difference was made in the emphasis placed on the three substance groups. Information collected in connection with surveys carried out for the Danish EPA on consumer products and on substances on the List of Undesirable Substances (LOUS) within the three substance groups has also been included in the literature search.

The Danish EPA's List of Undesirable Substances (LOUS) is an advisory list intended to guide companies on problematic substances regarding whether their use in the long term should be reduced or terminated. The newest version of the list was published in 2009, and it comprises 40 substances/substance groups that all have a number of undesirable effects (the Danish EPA, 2010). The list includes several single substances and substance groups included within the three selected substance groups of this project and the relevant LOUS surveys.

The three substance groups: VOC, phthalates and PFAS are described in the following.

2.3 Volatile organic compounds (VOCs)

There are several different definitions of the group of substances termed VOC.
According to WHO's original classification, volatile organic compounds are substances with a boiling point in the range between 50-100 °C and 240-260 °C (WHO, 1989). The European Parliament and the Directive of the Council of Europe on the limitation of emissions of volatile organic compounds define VOC as substances with a boiling point lower or similar to 250°C measured at a normal pressure of 101.3 kPa (Directive 2004/42/EC). The definition stated by the European Parliament is used in the present survey. ISO 16000-9 and prEN 16516 specify a climate chamber method for measuring the emission of dangerous substances to indoor air from construction pro-ducts. ISO 16000-6 and prEN 16516 define the limits of the VOC range according to the retention time in gas chromatography (GC). On a weakly polar column VOC elutes between n-hexane and n-hexadecane (including both endpoints), which is equivalent to the boiling point range of between about 68 ° C and 287 ° C. SVOC are defined as semi-volatile organic compounds eluting between n- hexadecane (C16) and n- docosane (C22). TVOC is the total sum of VOC eluting between hexane and hexadecane. TSVOC is the total sum of VOC, eluting between n-hexadecane and n-docosane.

The group of substances covers very different chemicals with many different functions. The emitted VOC may originate from the raw materials or unintentional impurities in these. VOC may also be added during the manufacturing proces or be reaction products formed during aging of the materials. Rugs can consist of different materials such as polyester, polyamide, polypropylene, acrylic, wool, cotton, rubber and adhesive and a wide range of VOCs may be emitted from them. Previous studies have typically focused on substances that are harmful to the enviroment or human health as well as malodourous substances.

2.3.1 Literature survey of VOCs

In relation to volatile compounds, a number of such substances was investigated under LOUS, including the substances formaldehyde, n-hexane, styrene, toluene and N,N-dimethyl formamide.

The LOUS survey of formaldehyde states exposure via indoor air where carpets could be a possible source (Andersen *et al.*, 2014) and refers to a study carried out in 2008-2010, where the emission of formaldehyde from carpets (among other things) was investigated and the emission of formaldehyde was seen in two out of two carpets (Kolarik *et al.*, 2010). Formaldehyde is also delared to be an intermediate product used in the textile industry. Industrial chemicals such as butanediol are made of formaldehyde. Butanediol is used to make intermediate products for the production of textile fibres. Formaldehyde-based resin is also used in the textile industry, for instance in printing inks, dyes and textile products for finishing. The compound helps bind dyes and pigments to the textiles, prevents the colour from running, reduces wrinkling of the clothes, eases care and maintenance and prevents rot-degradation (Andersen *et al.*, 2014).

Formaldehyde is identified in the carpets in two different surveys: *Total health assessment of chemicals in indoor environment from various consumer products* (Jensen and Knudsen, 2006) and *Kemiske stoffer i gulvtæpper (Chemical substances in carpets)* (Pors and Fuhlendorff, 2002) at levels between 0.6 to 13 mg/kg carpet.

In *Chemical substances in car safety seats and other textile products for children* a survey was conducted and the chemical analysis of selected chemical substances, including formaldehyde was performed. Formaldehyde was not detected above the detection limit of 2-5 mg/kg in any of the 37 examined textiles (Kjølholdt et al., 2015).

The LOUS survey of n-hexane suggests that a possible commercial exposure to n-hexane is likely for furniture and textile workers as well as for carpet fitters (Mikkelsen *et al.*, 2014B) indicating that n-hexane exists in those types of products. However, further details or sources of further information have not been included. The substance is also recognized as a possible solvent in rubber in order to adapt the viscosity during production of e.g. tyres and in glues (Mikkelsen *et al.*, 2014B).

The LOUS survey of styrene suggests that carpets could be a possible source of exposure to styrene, especially from styrene-butadien rubber-based products used for backings (SBR/Latex) (Kjølholdt *et al.*, 2014A). The investigation refers to an older source claiming that SBR rubber can contain residual styrene in the polymer (data from 1995 and older).

The LOUS survey of toluene concludes that when consumers install carpets, the exposure to toluene is high enough to give rise to concern (Kjølholdt *et al.*, 2014B).

The LOUS survey of N,N-dimethyl formamide (DMF) does not specifically mention carpets, but the textile industry is cited as a possible commercial source of exposure to DMF, and exposure via textiles (e.g., tents) for consumers in general (Larsen *et al.*, 2014). However, for textiles and flooring, Larsen *et al.* state that DMF is not permitted, if the product is to be eco labelled as the substance is classified as reprotoxic (Larsen *et al.*, 2014).

According to literature, more than 250 volatile substances are emitted from carpets and many of them are VOCs (Guo *et al.*, 2004). In chambers, Guo *et al.* (2004) analysed the emission from 11 new carpets with different types of pile (pure and mixtures of wool, nylon, propylene and olefin, respectively) with polypropylene backings. The result is given in total VOC (TVOC), and no specific substances were identified in the analysis of the 11 carpets. Guo *et al.* point at an expected content of the single substances 4-phenylcyclohexene (CRI, 1997) and 2,2,6,6-tetramethyl-4-methylideneheptane from a carpet with a SBR-backing (Sollinger *et al.*, 1993).

Wilke *et al.* (2004) describe emission analyses of VOCs and SVOCs partly from single components for flooring (glue and different types of flooring such as PVC, linoleum, rubber, polyolefin or carpet) and partly complete systems (installed floors including products used to fix the product to the surface). 14 carpets were investigated as well as a combination of carpet and glue. In six of the carpets, unidentified volatile substances were found in concentrations of 1-270 $\mu g/m^3$ (cyclodecane equivalents) and 25 substances were found in concentrations from 1 to 3300 $\mu g/m^3$ at an area specific ventilation rate of $q = 1.25\ m^3/m^2h$. Acetic acid emits at high levels from the three carpets (105-3300 $\mu g/m^3$) and 4-PCH emitted from 10 of the carpets (1-18 $\mu g/m^3$). Mounting a carpet using an adhesive results in an increase in the total concentrations of VOC (TVOC) and SVOC (TSVOC) compared to values for the carpet alone. The emission was followed for up to 130 days for selected glues utilized for mounting on the reverse side of the carpets. In the case of gluing a number of new substances are created over a longer period of time, and they cannot be detected during the first 28 days – e.g., acetone, pentanal, hexanal, 3-heptanone, heptanal, 2-ethylhexanal, octanal, 2-octanon, nonanal, 2-octenal, decanal, 2-nonenal, 3-isopropylbenzaldehyde and carboxylic acids from formic acid to heptane acid (up to 25 μg/m^3 in the course of 130 days). Many of these compounds were also identified in other sources (the underlined substances) and especially the aldehydes can result in obnoxious smells. By summing up the emission rates of TVOC and the sum of the SVOCs in the course of time, respectively, Wilke *et al.* demonstrated that the emission rate of SVOC is constant and exceeds the rate of TVOC after 26 days. Therefore, the conclusion is that the SVOC in the course of time will dominate the emission and be decisive for the indoor environment and exposure.

Katsoyiannis *et al.* (2008) describe the emission analysis of VOCs from four carpets made of different materials (pile of pure nylon, wool or polypropylene as well as a mixture of these) with different types of backing (synthetic non-SBR and SBR). Analyses were carried out for individual and named VOCs, total VOC and different carbonyls. The analyses include the following VOCs: benzene, ethyl benzene, xylenes, styrene, 4-phenylcyclohexene (4-PCH) and 2,2-butoxyethoxyethanol (2,2-BEE). 4-PCH is described as being the cause of the smell of new carpets and is often found together with styrene and 4-vinylcyclohexene (butadiene dimer). The main source is regarded to be SBR latex, which is used for the backing of carpets. 4-PCH is most likely emitted over a long period, and on the basis of data, it is estimated that even after 14 days there will probably be a high emission rate. In addition the analyses include: formaldehyde, acetaldehyde, acetone and propanal. An expected source of emitted formaldehyde, is formaldehyde in the glue that has not reacted. The glue binds the backing of the carpet to the textile fibres. According to Katsoyiannis *et al.*, pronounced differences in the emission of total VOC seem to be connected to the backing material where the highest emission was seen in SBR backings. That is supported by other sources including Little *et al.*, 1993. Three out of four carpets emit TVOC above the acceptance levels according to various labeling schemes (Katsoyiannis *et al.*, 2008).

In a study of eight new carpets bought in the UK, Greenpeace found a content of formaldehyde in six of the carpets in a concentration interval of 1.1-7.6 mg/kg (Greenpeace, 2001). The carpets were made of the materials 80% wool/20% nylon (4 carpets), where one had a backing made of jute[2], polyester (PES), polypropylene (PP) and EVA latex[3]. Other carpets were made of the materials 80% wool /10% PP /10% PES with PP backing (1 carpet) or of 100% PP (2 carpets).

2.3.2 Emission tests of VOCs from carpets at the Danish Technological Institute

At the Danish Technological Institute, the emission of VOCs was investigated during the years 2011 through 2014 on 34 carpets in a climate chamber according to ISO 16000-9. Sampling for VOC analyses were performed at different times after the carpets were placed in the climate chamber (1, 2, 3, 10 or 28 days). Six of the carpets were also analysed for emission of carbonyls, including formaldehyde (ISO 16000-3). The carpets consisted of a mixture of wall-to-wall carpets and rugs and they were not specifically rugs for children, except for one rug that had a car lane as playing motive. The materials differed, and 13 of the rugs had a combined polya-mide (nylon) upper side and rubber (latex) backing, which was the most common combination. The following backings were found: 21 latex, 8 Action Bac (woven polypropylene), 1 synthetic rubber and 1 textile. The following upper sides were: 20 nylon, 12 polyolefin (polypropylene (PP) or polyethylene (PE)) and 1 wool. One carpet was made of unknown materials and one carpet had an unknown upper side. Information regarding content of possible glue or rubber, or surface treatment was not available. 27 of the carpets had been produced in the USA, whereas no information was available on the country of origin for the rest of the carpets.

[2] Material of plantefibres based on bast frayings of different *Corchorus* species belonging to the *Malvaceae* family. The fibres can be spun to strong threads.

[3] Ethylene-vinyl acetate (EVA) – a soft and flexible co-polymer of ethylene and vinyl acetate.

Information about the carpets and the analytical findings is shown in the appendix of all compounds found in carpets, identified by the mapping (Appendix 1). After 24 hours in climate chamber the highest amounts and concentrations of VOCs were measured. An outline of the found relevant substances and groups from 26 of the carpets appears in Table 1. They have been arranged according to the material of the textile upper side of the carpet. During emission testing the carpets were placed lying flat on the bottom of the climate chamber and the backing material was not directly exposed. However, due to the open structure of the textile upper layer emission of volatile substances from the backing is expected.

There was no clear indication of the connection between the materials and emissions of VOCs, but some conclusions could be drawn. 4-PCH was emitting from all material combinations in 20 out of 34 carpets, including carpets with textile backing, which indicates styrene-butadiene rubber (SBR) and/or glues content in these carpets. Caprolactam was found in the emission from some of the carpets with a polyamide upper side, which is the monomeric precursor for synthesis of PA-6, indicating the content of PA-6 in 3 carpets.

Very volatile organic compounds (VVOC) was measured in 6 carpets (polyamide upper side). These data are not shown in Table 1, but are found in appendix 1.3. The emission of VVOCs after 3 days was: 2-10 µg/m²h formaldehyde (n=6), 3-5 µg/m²h acetaldehyde (n=6) and 1 µg/m²h propanal (n=1). In one carpet intended to be installed as a wall-to-wall carpet in an office, an emission rate of 155 µg/m²h formic acid was measured after 3 days.

No volatile phthalates or PFAS were identified in the emissions as either VOC or SVOC, since these substances had not been prioritized in the emission tests that were carried out.

TABLE 1
VOLATILE COMPOUNDS QUANTIFIED IN THE EMISSIONS FROM 26 CARPETS AS AREA SPECIFIC EMISSION RATE AFTER 24 HOURS IN CLIMATE CHAMBER (ISO 16000-9, 6) AND DIVIDED IN THE CARPET UPPER SIDE MATERIALS

Volatile compounds	Type	CAS No.	Polyamide (n=14) µg/m²h	Polyolefins (n=11) µg/m²h	Wool[1] (n=1) µg/m²h
Caprolactam	VOC	1163-19-5	1-9 (n=4)	-	-
4-PCH	VOC	4994-16-5	1-13 (n=7)	3-13 (n=8)	5
Acetic acid	VOC	64-19-7	21-194 (n=7)	13-85 (n=8)	12
N,N-dibutylformamide	VOC	761-65-9	4 (n=1)	-	-
Aldehydes (C4-c12)	VOC	-	0-13	0-8	3
Aliphatic hydrocarbons	VOC SVOC	-	0-1382	0-512	942
Aromatic hydrocarbons	VOC	-	0-70	0-14	5
Total emissions	VOC, SVOC	-	2-1569	8-1064	1247

[1]Wool-upper side with synthetic backing
n=number of carpets

2.3.3 Conclusion of the VOC survey

The identified VOCs have been sub-grouped according to their chemical structure such as; aldehydes, aliphatic hydrocarbons, aromatic hydrocarbons, carboxylic acids, chlorinated substances, esters, ethers, glycols, ketones, siloxanes, terpenes and others. The outline of VOCs grouped according to type appears in Table 2.

TABLE 2
VOC SUB-GROUPS IDENTIFIED IN THE SURVEY

VOC subgroup	No.	Material/reference and other information*
Aldehydes	17	Many different materials (upper side and backing). Substances found in few rugs (TI), and some were confirmed by other references and in more than 2 of 6 rugs
Aliphatic hydrocarbons	13	Many different materials (upper side and backing). Substances found in few rugs (TI); 1 was confirmed by other reference, and several were found in more than 2 rugs (of 4)
Alcohols	7	Many different materials (upper side and backing). Substances found in few rugs (TI); 2 confirmed by other reference and 1 found in more than 2 samples (of 3)
Other	7	Many different materials (upper side and backing). Substances found one rug (TI) (not included)
Aromatic hydrocarbons	14	Many different materials (upper side and backing); 8 substances found by either two references or in more than 2 rugs in one reference
Carboxylic acids	8	Many different materials (upper side and backing); 4 substances found by either two references or in more than 2 rugs in one reference
Chlorinated compounds	1	Found in 4 rugs (TI) of nylon/olefin and latex/actionbac
Esters	3	All substances found in 2 rugs (nylon/used rug and latex/PP/textile) (not included)
Ethers	3	One substance found in multiple references, while other only found in 1-2 rugs (TI)
Glycols	6	One substance found in multiple references and rugs of different materials, while other only found in 1-2 rugs by a single reference.
Ketones	5	One substance found in multiple references and rugs of different materials, while other only found in 1-2 rugs by a single reference.
Siloxanes	3	One substance found in more than 2 rugs of different materials (TI), while 2 other only found in 1-2 rugs (TI).
Terpenes	3	One substance found in more than 2 rugs of different materials (TI), while 2 other only found in 1-2 rugs (TI).
SUM	**90**	

*(TI) indicates the data originates from the laboratory at the Danish Technological Instute.

For each sub-group in appendix 1.3, data and information about the frequency of the individual substances found in rugs are shown with reference to the sources where the substance was identified. There is no clear connection between the material and the types of identified subtances. However, it should be mentioned that some of the analyses carried out at Danish Technological Institute were on used rugs. In those cases, the analysed substances might not only originate from the rug, but could be substances that the rug has absorbed over time, for instance from paint or other materials present in the indoor environment, e.g., some glycols and esters.

2.4 Phthalates

Phthalate is the general term for a group of different esters of phthalic acids that typically belong to the group of semi volatile organic compounds (SVOCs). According to the definition of WHO, SVOCs are organic compounds with a boiling point between 240-260 °C and 380-400 °C (WHO, 1998). Phthalates exists with long side chains of 9 carbons or more, they are not volatile. The chemical structure shown in Figure 1 consists of a benzene dicarboxylic acid, where the two carboxylic acids are placed in an *ortho*-position in the benzene ring. The length of the side chains (R and R' in the figure) are typically between 4 and 13 carbon atoms and can be linear, branched or in combinations, that may also can contain ring structures. The side chains can be identical or different (Mikkelsen *et al.*, 2014A). SVOC phthalates are for instance used as plasticizers and are released slowly from sources such as rugs and they tend to absorb to surfaces. That is why they can remain in the indoor environment for many years (Berkeley Center for Green Chemistry, 2011).

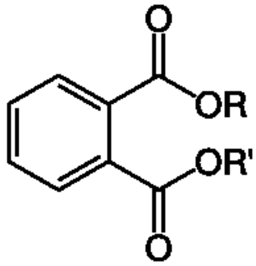


FIGURE 1. STRUCTURAL FORMULA OF PHTHALATES

2.4.1 Literature Survey of phthalates

The LOUS survey of phthalates took place on a selected group of phthalates, namely six phthalates, where the two side chains in the phthalate are identical (Mikkelsen *et al.*, 2014A). The six phthalates in the LOUS survey comprise: Diethyl phthalate (DEP), Diisopentyl phthalate (DIPP), Bis(2-propylheptyl)phthalate (DPHP), Bis(2-methoxyethyl)phthalate (DMEP), Diisononyl phthalate (DINP, or 1 ,2-Benzendicarboxylic acid, di-C8-10-chained alkyl esters, C9-rich), Diisodecyl phthalate (DIDP or 1 ,2- Benzendicarboxylic acid, di-C9-11-chained alkyl esters, C10-rich). From these investigated phthalates, Mikkelsen *et al.* (2014A) point at examples where DINP and DEP were identified in products with a certain relevance to rugs (activity rug, sex toys of latex rubber and textiles).

In the report *Phthalates in products with large surfaces* investigations were carried out for DIBP, DBP, BBP and DEHP in seven carpets with rubber backing and in one carpet tile with glue on the back. None of the analysed phthalates were found in the carpets with rubber backing, but 0.28 g/m^2 DIBP was found in the carpet tile that had glue on the back, which indicates that the source of phthalates could be glue (Tønning *et al.*, 2010).

In *Chemical substances in car safety seats and other textile products for children* a survey and a chemical analysis of the content of selected chemical substances, including phthalates and formaldehyde, were carried out. Only one sample was analysed quantitatively for phthalates. In that one sample (a coated textile from the reverse side of a seatbelt), a very high content of di-isodecyl-phthalates (DIDP) of app. 390,000 mg/kg was found (Kjølholdt *et al.*, 2015).

In 2001, Greenpeace investigated eight new carpets purchased in the UK for their content of a number of problematic substances distributed on the following substances and substance groups: organotin, phthalate, permethrin, triclosan, brominated flame retardants and formaldehyde. Within the phthalates, analyses were carried out for DINP, DEHP, Di-n-octyl phthalate (DnOP), DBP, DIDP, BBP. The eight carpets consisted of different types of material and mixtures: wool, nylon, polypropylene and polyester with or without a backing made of bitumen[4], jute, polyester, polypropylene or EVA latex. Substances found in concentrations exceeding the detection limit are listed in Appendix 1; none of the samples contained phthalates in amounts that exceeded the detection limit. The source indicates that no scientific literature was found that at that time (2001) demonstrated the presence of phthalates in carpets (Greenpeace, 2001).

In 2015, the Danish Building Research Institute (SBi) published a report on how construction products contribute to the content of phthalates in the indoor air; carpet tiles with a PVC backing are stated to be a building material (Øien *et al.*, 2015). Today, alternative backing materials are to a high degree used for carpet tiles made in the EU, but 10 – 15% of carpet tiles still have a PVC backing (the Danish EPA 2011). The investigation identified three types of phthalates (DINP, DBP, DEHP) in carpet tiles with PVC backing (Müller *et al.*, 2003). In the investigation, contact to the manufacturers indicated that PVC-free alternatives have been developed that use textiles or bitumen for backing material. Several manufacturers recycle materials for new products, and a result of increased recycling could be that phthalates are submitted to carpets through reused PVC material, e.g., from electronics or the car industry when they are used to make backing material. However, two mats were investigated by Raman spectroscopy and showed no content of PVC or phthalates (Øien *et al.*, 2015).

The German consumer magazine Öko-Test published in 2002 an examination of the odour load factor and content of problematic substances from 51 rugs. The phthalate DEHP was identified in one of the wool rugs and in all of the 6 examined woll rugs, high concentrations of the biocide permethrine were found. A polyamide rug contained o-phenylphenol (2-hydroxybiphenyl) and chlorcresol. In an examination of 15 children's rugs, Öko-Test found in 2015 content of the phthalate DEHP in two polyester rugs with rubber backing. Other problematic substances identified in a few children's rugs were (the material stated in parenthesis) were the pigments benzidine and anilin (woll/cotton), optical brightener (acrylic), latex proteins (nylon/latex).

2.4.2 Conclusion of the phthalates survey

Identified phthalates such as SVOCs appear in Table 3. Several references state that the phthalates probably originate from the backing material; especially glue is in question (Tønning *et al*, 2010; Kaberlah *et al*, 2011). No emission data was found regarding phthalates from rugs.

[4] Most often a black-brown thermoplastic substance that appears as a residual product when refining crude oil. It mainly consists of a mixture of high molecular hydrocarbons.

TABLE 3
PHTHALATES IDENTIFIED IN THE SURVEY

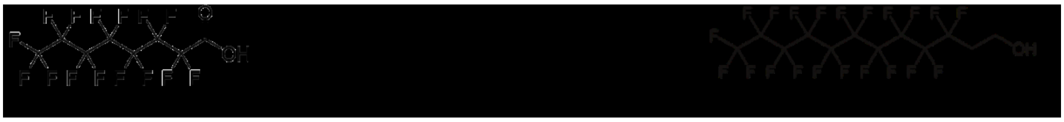
Substance	CAS	Boiling point (°C)	Further information about sources and content
Diisobutylphthalate (DIBP)	84-69-5	296	The substance was found in one rug out of 8 analysed ones. The rug differs from the other by being in tiles and with glue on the backing. Content in the rug: 0,27-0,30 g/m^2 (Tønning *et al.*, 2010)
Dibutylphthalate (DBP)	84-74-2	340	The reference states content of the phthalate in rugs (Müller *et al.*, 2003)
Bis(2-ethylhexyl) phthalate (DEHP)	117-81-7	384	Two wool rugs (Öko-Test, 2002) Children's rug of PES (Öko-Test, 2015). Wool rug, DEHP maybe originate from self adhesive backing (Kalberlah *et al.*, 2011). The substance is stated as probable in rugs (Müller *et al.*, 2003)
Diisononyl phthalate (DINP)	28553-12-0	-	The reference states content of the phthalate in rugs (Müller *et al.*, 2003)

2.5 Fluorinated substances

Per- and polyfluoroalkyl substances (PFAS) form a very large group of surface active agents and they are used for different applications. Due to their persistence and toxicity they are of special concern due to their effects on the environment and health, respectively. The substances differ in the functional groups and in the length of the carbon chains (Buck *et al.*, 2011).

Perfluoroalkylated substances are a sub group of PFAS. In perfluoroalkylated substances all carbon atoms are fully fluorinated. The substance group consists of a large group of compounds consisting of a hydrophobic alkylated chain of varying length (typically 4 to 16 carbon atoms) and a functional end group, typically carboxylic acid or sulfonic acid. The most commonly found types are based on C8-chemistry (8 carbon atoms). Perfluorooctane sulfonic acid (PFOS) is the most dominating type of perfluoroalkane sulfonic acids (PFSAs). PFOS has a linear perfluoroalkylate carbon chain with 8 atoms and a functional sulfonic acid group. Among the perfluoroalkyl carboxylic acids (PFCAs), perfluorooctanoic acid (PFOA) with an 8 carbon chain is the most dominating. The structures of PFOA and PFOS are shown in Figure 2. A distinction is made between short- and longchained perfluorinated substances, based on differences in toxicity and bioaccumulation between the two groups. According to OECD (undated) "Long-chained perfluorinated substances" are perfluorinated carboxylic acids with carbon chain lengths of eight carbon atoms (C8) and higher, including perfluorooctanoic acid (PFOA), perfluoroalkylated sulfonates with carbon chain lengths of six carbon atoms (C6) and higher, including PFOS.

Fluorotelomers are another sub group of PFAS, where the carbon chain is not fully fluorinated, but the molecule still contains a perfluorinated part and a functional group for instance alcohol, sulphonamide or acid. The fluorotelomers have two extra carbon atoms in the chain and they are not fluorinated. 10:2 fluorotelomer alcohol (10:2 FTOH) is an example of a fluorotelomer alcohol (FTOH) that has a perfluorinated part with 10 carbon atoms. The structure is shown in Figure 2. The perfluorinated part is very stable, but fluorotelomer alcohols can be degraded to perfluorinated substances in the environment (Lassen *et al.*, 2013; Jensen *et al.*, 2008).



Perfluorooctanoic acid (PFOA) Perfluorooctane sulfonic acid (PFOS) 10:2 Fluorotelomer alcohol (10:2 FT-OH)

FIGURE 2. STRUCTURES OF PERFLUOROOCTANOIC ACID (PFOA), PERFLUOROOCTANE SULFONIC ACID (PFOS) AND 10:2 FLUOROTELOMERALCOHOL (10:2 FTOH)

In general, the group of substances that either are fully or partly fluorinated will be designated as PFAS, but for some specific sub groups acronyms will be used, and they will be continuously explained in the text and in the list of abbreviations in this report.

The ability of the fluorinated sustances to repel water, oil and dirt makes them suitable for surface treatment of i.a. the textile upper side of rugs (Poulsen *et al.*, 2005). However, already in 2002, the use of PFOS in textiles was phased out by the company 3M. Subsequently, import or sale of PFOS or chemical products that contain PFOS in concentrations exceeding the limits determined under the EU chemical legislation through the regulation on persistent organic pollutants (POP regulation, Regulation No. 850/2004) has been prohibited. Worldwide, there has been a considerable decline in the use of PFOS, and therefore the use of PFOS in rugs must be expected to be limited today (Tsitonaki, 2014).

Some of the compounds in this substance group can have boiling points within the VOC range, but if the compounds contain fluorine they are in this project categorized as PFAS.

2.5.1 Literature survey of fluorinated substances (PFAS)

According to the LOUS strategy, the perfluorinated substances are divided into 3 categories: PFOS, PFOA and other perfluorinated substances, respectively (Lassen *et al.*, 2013). The survey states that fluorotelomers are used in carpets, and as previously mentioned they can be transformed to other perfluorinated substances (e.g., 8:2 fluorotelomers can be transformed to PFOA). An Australian source also points out that fluorinated substances based on C4-chemistry (perfluorobutane sulfonic acid, PFBS) are mainly used for carpets. According to Lassen *et al*, other fluorinated substances expected to be used in carpets are based on ex. C6-chemistry. The use in the textile production amounts to more than 50% of the total use of fluorotelomers, whereas the use for carpets and carpet impregnation agents is believed to be the second largest application of the substance within consumer products (Lassen *et al.*, 2013).

The survey *Polyfluoroalkyl substances (PFASs) in textiles for children* states the use of impregnation products i.a. for carpets as an important source of PFAS, where exposure mainly is expected to be to FTOH and other PFOS/PFOA precursors (i.a., FTCA – fluorotelomer carboxylic acids and FTSA – fluorotelomer sulfonic acids), and not PFOS/PFOA itself (Lassen *et al.*, 2015). In spite of considerable focus in the trade regarding the change from C8-based to C6-based fluorine chemistry, Lassen *et al.* found that C8 chemistry dominated for all substance groups and all samples in the investigation. The survey comprises textiles for children, and therefore the same impregnation agents are not necessarily used for carpets, but the basic chemistry that is used can be of relevance to this investigation. PFOA was the dominating perfluoroalkyl carboxylic acid, 8:2 FTOH the dominating fluorotelomer alcohol, 8:2 FTCA the dominating fluorotelomer acid, 8:2 FTAC the dominating fluorotelomer acrylate and 8:2 FTSA the dominating fluorotelomer sulfonic acid.

In the survey *Chemical substances in car safety seats and other textile products for children* (Kjølholt *et al.,* 2015) it is stated that the company 3M markets impregnation based on perfluorobutanoic acid (PFBA), whereas other large companies such as Bayer and Dupont market products based on PFAS for i.a. carpets (Jensen *et al.*, 2008). The specific fluorinated substances that form part of the products are most often a trade secret and are not stated. According to manufacturers and carpet retailers, carpets made of synthetic textiles (e.g., polyamide) are often impregnated when the purchaser buys them, whereas carpets made of wool rarely are. Woollen carpets are often much more expensive than synthetic carpets, and therefore it is considered realistic that the carpets probably have been surface treated to extend their durability. Two carpet retailers informed that nearly all carpets were impregnated at that time, and that fluorine impregnation was not widely used due to the financial costs of the treatment (Jensen *et al.*, 2008). That means that the decline in use was not motivated by environmental/health related consequences. No explanation was given to the conflicting information in the report.

According to the survey *Perfluoroalkylated substances: PFOA, PFOS and PFOSA. Evaluation of health hazards and proposal of a health based quality criterion for drinking water, soil and ground water* (Larsen and Giovalle 2015), the rug industry has formerly been responsible for up to 30% of the PFAS consumption in Denmark (data from 2001), whereas in 2011 the main part of the PFAS (87%) was used in the paint and laquer industry (Tsitonaki, 2014). Screenings of ground water with a rug manufacturer in Denmark was carried out with analysis of 9 PFAS compounds, out of which 8 was found in the ground water sample taken with the rug manufacturer: Perfluorooctane sulfonic acid (PFOS), perfluorooctanoic acid (PFOA), perfluoroheptanoic acid (PFHpA), perfluorononanoic acid (PFNA), perfluorobutane sulfonic acid (PFBS), perfluorohexane sulfonic acid (PFHxS), perfluorooctanesulfonamide (PFOSA) og perfluorohexanoic acid (PFHxA). The concentration of PFAS-compounds were analysed to approx. 1500 ng/l (out of which PFOS+PFOA constitute 1130 ng/l) (Tsitonaki, 2014). The result indicates that the compounds at a time have been used in the production of rugs, whether the compounds are used today does not appear from the report.

Herzke *et al.* (2012) surveyed chemical substances in perfluorinated and polyfluorinated substances in consumer products in Norway. In the survey, 30 random samples were taken for analysis and two of them were carpets. Analyses were made for the content of 24 different PFASs, of which nine were identified in at least one of the two carpets: 6:2 FTSA, PFHxS, PFOS, PFHxA, PFHpA, PFOA, 6:2 FTOH, 8:2 FTOH and 10:2 FTOH. The substances found in the highest concentrations in the carpets were: 6:2 FTOH, 8:2 FTOH and 10:2 FTOH, and 8:2FTOH was found in the highest concentration. They are considered to be volatile PFASs. In connection with one of the analysed carpets it is stated that the carpet is Teflon® treated, and the content in that carpet is ten times higher than in the carpet where no treatment is stated. The sum of FTOHs amounts to more than 90% of the total content of PFAS in the two analysed carpets (Herzke *et al.*, 2012). Haug *et al.* (2011) state a content of PFAS in dust collected from sofas and carpets in Norwegian homes. PFOA (117 ug/kg) is the dominating substance in dust from sofas, whereas PFBA and PFUnA mainly were detected in dust from carpets (Haug *et al.*, 2011).

Liu *et al.* (2014) investigated a number of consumer products for selected PFAS including PFOA and other PFCAs in the period from 2007-2011. Included were 9 treated carpets made of nylon, polypropylene and a maize-based polymer. All the carpets were made in the USA. Liu *et al.* (2014) found the following PFASs in the carpets: PFBA, perfluoropentanoic acid (PFPeA), <u>PFHxA</u>, <u>PFHpA</u>, <u>PFOA</u>, PFNA, perfluorodecanoic acid (PFDA), perfluoroundecanoic acid (PFUnDA), PFDoDA. Three of the substances that Lui *et al.* (2014) found were also identified by Herzke *et al.* (2012) (the underlined substances). Carpets made of maize-based polymers contain less of the analysed PFCAs than carpets made of nylon or polypropylene, respectively. In their investigation, Liu *et al.* observed that the content of PFCA in general declined within most product groups in the period from 2007-2011, although the content of PFCA in some samples remained high (among them one of the pre-treated carpets). They also observed that the use of PFBA, which is a short-chained PFAS (C4), increased in the course of the period for 19 out of the 35 products that were followed. That is believed to indicate that the manufacturers replace long-chained PFASa (e.g., PFOS) with the short-chained (Liu *et al.*, 2014).

Liu *et al*. followed up on their previous investigation of PFASs in consumer products in the USA (from 2007-2011) with a study that took place from 2011-2013 concerning the content of fluorotelomer alcohols (FTOHs) within the same product group. The analysed FTOHs were 6:2 FTOH, 8:2 FTOH, and 10:2 FTOH. 8:2 FTOH is the substance that appears most frequently (four out of five carpets), and in the highest concentrations (352-1500 ng/g) in the analysed carpets of nylon, polyester and polyolefin, respectively, whereas 6:2 FTOH and 10:2 FTOH, respectively, only were identified in one carpet made of nylon. That confirms the results of Herzke *et al*. (2012) of the analyses they carried out on carpets in Norway, where the three substances also were found. In addition, experimental data showed that one washing and drying cycle did not reduce the FTOH concentration in the tested consumer products (treated furnishing fabrics), whereas a reduction could be demonstrated during accelerated ageing (at increased temperatures) (Liu *et al*., 2015).

Guo *et al*. (2009) analysed the PFAS content in 116 consumer products, and they concluded that maintenance products for carpets and impregnated carpets are substantial sources of PFAS in the indoor environment.

In 2004, *Statens forureningstilsyn* (SFT) in Norway published a report on the use of PFAS in products in Norway. The possible sources are i.a. regarded to be textiles such as carpets. Due to the natural content of lanolin, regarded as dirt and water repellent, woollen carpets are rarely impregnated; but according to major carpet producers typically 5-10% of wool carpets are impregnated with Teflon®. Synthetic carpets are more often impregnated then woollen carpets. New impregnation products with fluoroalkylacrylic polymers are being developed to replace impregnation agents with PFOS, and in the future it will be hard to find PFOS-related substances in carpets. SFT remarked that a new technology is being developed, and it will make it possible to incorporate dirt and water repellent properties in synthetic fibres that are used for the production of carpets (polypropylene).

A German investigation of outdoor jackets by Knepper et al. (2014) identified FTOH in four of the analysed jackets. It was also found that 27 to 70% of the content of extractable 10:2 FTOH of the material was emitted to the air during a period of 5 days (all four jackets). The emission of 8:2 FTOH was a bit lower and had an emission of 7 to 18% of the content of the materials (all four jackets) whereas 6:2 FTOH had an emission of 54% of the content of the materials (in only one of the four jackets).

Specially developed methods are used to analyse fluorinated substances in air and other matrixes (Jahnke and Berger, 2009). When measuring volatile fluorinated substances in air, FTOH (6:2, 8:2, 10:2), it was found that the concentrations measured indoor were significantly higher than outdoor, and it was concluded that there were indoor sources that emitted FTOH (Knepper *et al*., 2014).

2.5.2 Conclusion of the literature survey of fluorinated substances (PFAS)

The identified PFASs appear in Table 4. The expected source of PFAS is the surface treatment of the rugs (dirt or water repelling treatment). In a study by Huber *et al*. (2011) sources of PFAS were investigated by collecting dust samples various places in a house, and it was concluded that the rug must be the main source of PFAS. All the rugs analysed for content of PFAS were often made of polyamide and polypropylene, which agrees with the expectations as several references state that synthetic rugs are impregnated more frequently than rugs made of pure wool and rugs of wool mixtures. No emission data was found for PFAS from rugs. Even though more substances have a boiling point in the VOC range, the acids exist in non-volatile forms such as free acids and as salts that are not volatile.

TABLE 4
IDENTIFIED FLUORINATED SUBSTANCES (PFAS) IN THE SURVEY

Substance	CAS*	Concentration (unit)	Boiling point (°C)***	Material
6:2 Fluorotelomer alcohol (6:2 FTOH)	647-42-7	17-220 µg/m² (Herzke *et al.*, 2012)	88-95**	
8:2 Fluorotelomer alcohol (8:2 FTOH)	678-39-7	22-368 µg/m² (Herzke *et al.*, 2012)	113**	
10:2 Fluorotelomer alcohol (10:2 FTOH)	865-86-1	13.7-169 µg/m² (Herzke *et al.*, 2012)	145**	
6:2 Fluorotelomer sulfonate (6:2 FTS)	29420-49-3	1.35 µg/m² (Herzke *et al.*, 2012)	-	Stated as sulfonate 6:2 FTS, the salt of acid 6:2 FTSA
Perfluorohexane sulfonic acid (PFHxS)	355-46-4	0.08 µg/m² (Herzke *et al.*, 2012)	239	
Perfluorobutanoic acid (PFBA)	375-22-4	4.1-131 ng/g (Liu *et al.*, 2014)	121	Nylon, mais-based polymer, polypropylene (Liu *et al.*, 2014)
Perfluoropentanoic acid (PFPeA)	2706-90-3**	11.5-22.6 ng/g (Liu *et al.*, 2014)	140**	Polypropylene (Liu *et al.*, 2014)
Perfluorohexanoic acid (PFHxA)	307-24-4	1.11 µg/m² (Herzke *et al.*, 2012) 3.7-40.1 ng/g (Liu *et al.*, 2014)	157**	Nylon, mais-based polymer, polypropylene (Liu *et al.*, 2014)
Perfluorheptanoic acid (PFHpA)	375-85-9	0.51 µg/m² (Herzke *et al.*, 2012) 14.1-146 ng/g (Liu *et al.*, 2014)	175**	Nylon, polypropylene (Liu *et al.*, 2014)
Perfluorooctanoic acid (PFOA)	335-67-1	1.67 µg/m² (Herzke *et al.*, 2012). <0.2-23, 28-50 ng/cm² (Jensen og Knudsen, 2006) 3.5-226 ng/g (Liu *et al.*, 2014)	189 (ECHA, 2013)	Nylon, polypropylene (Liu *et al.*, 2014)
Perfluoro-octanoate (PFO)	1763-23-1	5-900 µg/kg PFO, 0.2-2 mg PFO/kg, 232 mg fluorine/kg (Kalberlah *et al.*, 2011) 0.71-1.04 µg/m² (Herzke *et al.*, 2012)	260**	PFO is the salt of free acid PFOA. No information regarding material (Kalberlah *et al.*, 2011)
Perfluorononanoic acid (PFNA)	375-95-1	6.3-236 ng/g (Liu *et al.*, 2014)	218	Nylon, polypropylene (Liu *et al.*, 2014)
Perfluorodecanoic acid (PFDA)	335-76-2	5.2-179 ng/g (Liu *et al.*, 2014)	218**	Nylon, polypropylene (Liu *et al.*, 2014)

Perfluoro-undecanoic acid (PFUnDA)	4234-23-5	2.3-160 ng/g (Liu *et al.*, 2014)	160**	Nylon, polypropylene (Liu *et al.*, 2014)
Perfluorododecanoic acid (PFDoDA)	307-55-1	3.4-129 ng/g (Liu *et al.*, 2014)	249	Nylon, polypropylene (Liu *et al.*, 2014)

*CAS number from Lassen *et al.*, 2013 unless stated otherwise

**Data retrieved from www.chemicalbook.com (date 2015.05.27)

***Data retrieved from www.chemidplus.com unless stated otherwise (date 2015.05.27)

2.6 Identified substances of concern in rugs

Substances identified in rugs in this survey are listed in Appendix 1, in which sources and the information found about emission and content in rugs are listed.

Identified substances found in surveys for the Environmental Protection Agency

Totally the survey from the Environmental Protection Agency gives information about content and emission of substances within three selected substance groups for rugs. The examinations do, however, indicate that more phthalates are used in i.a. foam products, rugs with glue and textile pro-ducts e.g. the phthalates DEHP, DIBP, DBP and DIDP. A number of fluorinated substances were found in a ground water sample taken in connection with a survey published in 2014 with a Danish carpet manufacturer (PFOS, PFOA, PFHpA, PFNA, PFBS, PFHxS, PFOSA and PFHxA), which indicate use in this industry, but most probably a consumption, which took place years ago. Whereas *Lassen et al.* (2015) in textiles for children found perfluoroalkylcarboxyl acid (PFCA), 8:2 FTOH, 8:2 FTCA, 8:2 FTAC and 8:2 FTSA as the dominating substances. A former report had also indicated that PFBA is used for impregnation of rugs. Formaldehyde had also been identified in rugs in 2002 (0.6-13 mg/kg), whereas no formaldehyde was identified above the detection threshold of 2-5 mg/kg in one single children's textile out of 37 in the examination in 2015.

The LOUS survey gone through for the Environmental Protection Agency indicate content in rugs of more substances relevant for this survey. Within fluorinated substances, it is indicated that fluortelomers are much used in rugs (e.g. C6-fluortelomers) and PFBS-based substances, if any. No information is given about typical phthalate types in rugs, but DINP and DEP are identified in products with a possible relevance to rugs (activity carpets, latex rubber and textile). Among the volatile organic compounds (VOC), the LOUS reports confirm that rugs are considered as possible sources of exposure for the substances formaldehyde, n-hexane, styrene, toluene and partly dimethylformamide.

Identified substances found by surveys for Umwelt Bundes Amt (UBA)

The German environmental agency UBA published in 2011 a comprehensive report on carginogen, mutagen and harmful to reproduction substances (CMR substances) and other problematic substances in consumer products *(Kalberlah et al., 2011)*. UBA has prepared a master list of problematic substances found in consumer products in the categories "toys", "electrical appliances" and "rugs and wallpaper". The examination included information from e.g. BfR Bundesinstitut für Risikobewertung), DIBt (Deutsches Institut für Bautechnik), GUT (Gemeinschaft umweltfreundlicher Teppichboden), the Swedish environmental protection agency, test results from consumer organizations (Öko-Test), scientific articles and own data. In relation to own data, the UBA report describes 30 products within the category rugs and wallpaper such as e.g. structured wall paper, flexible PVC floors, flexible flooring made of rubber or rugs made of textile. Seven of the products examined were rugs made of textile. More the rugs examined contained problematic substances.

In 2011, the German environmental protection agency (UBA) published an extensive report about carcinogenic, mutagenic and reprotoxic substances (CMR substances) and other problematic substances in consumer products (Kalberlah *et al.*, 2011). UBA has prepared an advisory list of problematic substances found in consumer products in the categories ”toys”, “electric devices” and “carpets and wallpaper”. The investigation included information from, i.a., BfR (Bundesinstitut für Risikobewertung), DIBt (Deutsches Institut für Bautechnik), GUT (Gemeinschaft umweltfreundlicher Teppichboden), the Swedish EPA, test results from consumer organisations (Öko-Test), scientific articles and own data (the complete reference list can be seen on pages 457-60 in the UBA report). In relation to own data, the UBA report describes 30 products within the category of carpets and wallpaper, for instance surface structured wallpaper, elastic PVC floors, elastic flooring made of rubber or textile carpets/rugs. Seven of the investigated products were textile carpets. Several of the investigated carpets contained problematic substances.

UBA has on basis of the above sources of information from the period 1998-2010 and own data from the period 2009-2010 set up a list of problematic substances and substance groups (e.g. CMR substances) in floorings. For the category rugs made of textile, which is relevant to this survey, the list covers 14 different substances and substance groups. Among these, one phthalate was identified (DEHP), one VVOC (formaldehyde) and one fluorinated substance group (PFOS) cf. Table 5. The remaining 11 substances and substance groups include flame retardants, biocides, fungicides and pigments. Far the most sources, which UBA consulted, indicate that the analysed rugs were produced in Europe, whereas only one rug was made in India. Only limited information about the material examined exists, but the stated information indicate as expected that phthalate originates from flexible backing, the fluorinated substances originate from a dirt and water repellent treatment, and formaldehyde acts as biocide in wool rugs.

TABLE 5
SUBSTANCES OF CONCERN IDENTIFIED IN RUGS BY UBA, INFORMATION BASED ON TABLE IN APPENDIX 5B (Kalberlah *et al.*, 2011)

Substance	CAS no.	Content	Information of carpet (function)	Country	Year
Formaldehyde	50-00-0	14 µg/m3	Wool, synthetic backing (biocide)	EU? (uncertain)	before 2008
DEHP	117-81-7		Backing (glued)	Unknown	before 2007
Perfluorooctanoate (PFOS)	1763-23-1	1) 5-900 µg/kg PFOA 2) 0.2-2 mg PFOS/kg 3) 232 mg fluorine/kg	11) Carpet 2) Moth treated carpet or other treatment 3) Fluorocarbon treated carpet (dirt and water repellent)	1) Unknown 2) USA 3) Germany	1) before 2008 2) before 2004 3) 2010

Identified substances in carpets and rugs in this survey
The substances that were identified in rugs are stated in appendix 1, and the list comprises:
- 90 VOCs
- 15 fluorinated compounds
- 4 phthalates
- 32 substances that do not come within any of the three categories (not in appendix 1)

The last group of substances for instance comprises flame retardants, dyes and biocides, of which many are not volatile. They are regarded as irrelevant for the objective of this investigation and will not be investigated further.

In conclusion, it is possible to find all three compound groups VOC, phthalates, PFAS in rugs or materials contained in rugs and carpets. The previous surveys find emission of many different types of volatile compounds to the indoor environment, however no data were available from literature on emissions of phthalates and PFAS from rugs.

2.7 Labelling schemes for rugs

A number of labelling schemes exists for rugs, where GUT and Oeko-Tex® are the most frequent ones on the European market. The criteria of the Blauer Engel for textile floorings are stated in RAL-UZ 128 (2011). The Danish Indoor Climate Labelling does not have the same requirements for limitation of content of chemicals as GUT®, Oeko-Tex®, and Blauer Engel. Common to all these labelling schemes is that there are threshold values for the emission of VOC and the odour should be approved according to the test method and criteria of the labelling schemes.

2.7.1 Gemeinschaft umweltfreundlicher Teppichboden (GUT)

GUT is an organisation that consists of leading European carpet manufacturers and it has existed since 1990. The objective of GUT is to continuously improve all environmental and consumer related aspects throughout the life cycle of the textile flooring from production, to installation and usage and up to recycling. They have introduced a marking scheme that places demands on constituents, emissions and odour from the carpets in order to protect the consumer. A number of substances must not be used in GUT labelled carpets/rugs (e.g., DEHP, BBP, DBP, DIBP, formaldehyde and impregnating agents based on PFOS and PFOA (i.e. C8-chemistry)). Fixed emission limits for the finished carpets have been determined for other substances, e.g., for TVOC, SVOC and a wide range of single substances such as aldehydes, phthalates and VOCs (GUT, 2014). Selected emission limits determined by GUT appear in Table 6.

2.7.2 Oeko-Tex®

In Oeko-Tex®, legislative requirements, including the requirements in REACH, and a number of other requirements to the chemicals used in production have been met. Tests are carried out according to specific guidelines that shall ensure that products certified according to Oeko-Tex® Standard 100 meet the requirements (Oeko-Tex, 2015). The requirements are graded in four product classes, where class 1 has the strictest requirements as they concern products for babies/toddlers. As the distance between the products and the human body increases, the requirements gradually decline to class IV. The individual requirements according to Oeko-Tex® Standard 100 are evaluated at least twice annually and they are adapted according to legislation, REACH and the development of better and more accurate test methods.

Table 6 shows the emission limits of substances within the three compound groups that this report deals with according to the Oeko-Tex 100 standard for product class I. Corresponding limit values according to GUT have been included for comparison. Blauer Engel RAL-UZ 128 have the same limits for VOC and TSVOC as GUT, and other limits for 4-PCH (5 $\mu g/m^3$) and formaldehyde (27 $\mu g/m^3$).

TABLE 6
OEKO-TEX® STANDARD 100 (PRODUCT CLASS I) AND GUT EMISSION LIMITS FOR VOLATILE ORGANIC SUBSTANCES INCLUDING PHTHALATES FROM CARPETS AND RUGS

Volatile compounds	CAS No.	Oeko-Tex® 16 hours (µg/m³)	GUT 3 days (µg/m³)	GUT 28 days (µg/m³)
Aldehydes				
Formaldehyde (VVOC)	50-00-0	100	10	4
Acetaldehyde (VVOC)	75-07-0	-	10	4
Octanal (VOC)	124-13-0	-	11	5
Nonanal (VOC	124-19-6	-	20	8
Other single aldehydes (VVOC, VOC)	-	-	20	8
VOC				
Toluene	108-88-3	100	50	20
Styrene	100-42-5	5	5	2
Vinylcyclohexene	100-40-3	2	2	2
4-Phenylcyclohexene (4-PCH)	4994-16-5	30	-	-
Ethylbenzene	100-41-4	-	100	40
Naphthalene	91-20-3	-	7	3
Benzene	71-43-2	-	n.d.	n.d.
1,4-Dichlorobenzene	106-46-7	-	100	40
Vinylchloride	75-01-4	2	-	-
Vinylacetate	108-05-4	-	100	40
NMP	872-50-4	-	100	40
Butadiene (VVOC)	106-99-0	2		
Carcinogenic substances	-	-	n.d.	n.d.
Aromatic hydrocarbons	-	300	-	-
TVOC (C6-C16)	-	500	250	100
TSVOC (C16-C23)	-	-	30	30
Phthalates				
DBP, DEHP, DEP, BBP, DOP, DMP (single substances)	-	-	1	1

[1]Test by ISO 16000-9 chamber with loading factor of 0.4 m²/m³ and air change of 0.5 h^{-1}
n.d.: not detected

2.8 Survey of children's rugs on the market

It was examined which children's rugs were on the market by recording of relevant information, which was used for selection of rugs for chemical analyses.

A screening of distributors of children's rugs on the internet was carried out (desktop research) and subsequently twoshops were visited. In this survey, focus was on rugs produced in non-EU countries and the following information was recorded, if available:

- Country of origin
- Materials – upper layer of pile (nylon/polyamide, cotton, polyester, wool, etc.)
- Materials - backing (textile, rubber, plastic, PVC/vinyl, etc.)

- Size of rug
- Expected target group on basis of design and shape (toddlers, children or older children)
- Colour - bright/dark (picture), respectively
- Information on chemicals and labelling: e.g. substance, concentration, on the Candidate List

Results from the market survey
The internet search of children's rugs on Danish web-sites in the period March to May 2015 was carried out. 12 distributors were identified, who at their web-site market 196 children's rugs. Number of rugs identified with the individual retailer is stated in parenthesis after the retailer's name including:

- IKEA AB (17)
- Garant (11)
- Fætter BR (2)
- JYSK A/S (3)
- Bilka, Dansk Supermarked A/S (3)
- COOP A/S (1)
- Biva ApS (2)
- Idemøbler (1)
- Ups1 (1)
- MM-konsol ApS (94)
- Tæppebutikken (60)
- Rødovre centrums tæppeforhandler (1) – visit in the store

The identified rugs were categorized according to expected age group toddlers (0-2 years), young children (approx. 3-7 years) and older children (approx. 8-14 years) to give an overview. Here the rugs are considered to be market to the age group toddlers (0-2 years (<3 years)), if the retailer has stated that the rug can be used from 10 months and older. Rugs with very characteristic children's motives such as traffic lanes or animal motives are accepted used for the category young children (3-7 years). Rugs for older children (8-14 years) are plain-coloured, some has motives or logo of known football clubs. Some of the rugs are deemed to be used by all age groups. Toddlers are aged 1 up to 3 years, and rugs for young children can also be applied for this age group. Distribution of rugs on the indivial age groups appears from Table 7.

TABLE 7
IDENTIFIED RUGS (196) DIVIDED INTO PILE MATERIAL TYPE AND TARGET GROUP

Age group	Upperside material (pile)							
	Polyamide	Acrylic	Cotton	Polyester	Poly-propylene	Wool	Unknown	Total
Toddlers (0-2 years)	4	0	0	0	0	0	0	**4**
Young children (3-7 years)	83	34	3	3	10	1	5	**139**
Children (3-14 years)	6	4	0	0	12	6	0	**28**
Older children (8-14 years)	19	0	3	1	0	0	2	**25**
All	112	38	6	4	22	7	7	**196**

Most of the rugs come within the category of children (71% of all), and most of them are made of polyamide with a backing of latex, rubber or non-slip backing (49% of all). Acrylic and polypropylene rugs also frequently appear (19% and 11%, respectively). However, rugs made of a mixture of wool/ polyamide and acrylic/polyamide are also common, but have not been identified in the investigation of the market. Pure woollen rugs also seem to be a bit underrepresented compared to the general knowledge of the market.

The websites of the retailers have limited information about the content of chemical substances. Two rugs were labelled as phthalate-free (polyester rug with polyamide backing). One single carpet is stated to be;"anti static and dirt-repellent" (polyamide pile with foam backing), which can indicate a treatment with fluorinated substances.

More have described that the rug is made as cleaning friendly, but this does not necessarily be caused by a chemical treatment. Typically, fibres are used, which are dirt repelleant and easy to clean. This especially applies to chemical fibres (polyamide, acrylic etc.), where a round or trilobite fibre cross section combined with a smooth surface improves the properties of the rug in regard to soiling and cleaning.

Many rugs (74) were supposed to be easy to clean, e.g., with a damp cloth. Twentyfive rugs were stated to be easy to clean due to a special;"cleaning-friendly and wear-proof fibre" (Espirelle acryl – a special type of acrylic that is a heat-binding two-layer yarn that is spun at high revolutions), whereas the other rugs are made of different materials (polyamide, cotton, polyester, polypropylene). Five rugs contain luminous polyester fibres (2-3%), but they have an Oeko-Tex label, which means that they are subject to strict requirements regarding the content of problematic substances. 36 of the 196 rugs had an Oeko-Tex label.

A supplementary internet search for rugs for children was carried in July 2015 and 2 additional retailers were found:

- Eurotoys A/S (129 tæpper)
- RugVista A/S (82 tæpper)

The main part of the rugs from the former search could be retrieved and the new rugs represented the same materials, types of motives and target groups.

Information from retailers

The individual retailers were contacted (see example of inquiry Appendix 3) and in general they were co-operative. In some cases, the necessary information was not procured quickly enough. If there was no declaration describing the materials and/or surface treatment available for the rugs, contact was made to the retailer. The purpose of this inquiry was to obtain more information like e.g. content of substances and if possible, the concentration to be expected. The inquiry was followed-up one more time, if no answer was received.

In general, the retailers are aware that rugs for children are in question. The retailers state that the rugs are Oeko-Tex® Standard 100 certified and do not contain problematic substances or that they comply with the EU requirements to constituents. Many rugs from China, India and Egypt were Oeko-Tex® Standard 100 certified. Only a few retailers had limited knowledge of the products they sell and did not understand the questions regarding constituents. The typical response of the retailers are that their carpets fulfilled EU's requirements for chemicals or that they had a quality label (Oeko-Tex®, GUT), where the threshold values for the substances in question are fulfilled. However, no specific information in the shape of analysis certificates stating content or emission of the substances were received.

It was possible to procure information about country of origin for most of the children's rugs.

The immediate impression is that most rugs are produced in countries like China, India and Egypt and imported either via the Netherlands or more rarely from Sweden to Denmark. Very few rugs are made in Belgium and imported from there.

Shop visits
IKEA and Garant were visited in order to record information about rugs; information that is not available on the website of the retailers, for instance regarding packaging, odour or CE-marking. Only few rugs were displayed in the shops and only limited additional information was obtained when visiting the shops. CE-marking and marking with the circular label that indicates that the product is not recommended for children under 3 years of age were not observed on any of the rugs.

Via the survey on the internet it has become clear that the distributors to a very high degree use the internet as a marketing tool and thus invest a comprehensive work in ensuring that all their products are displayed on the internet. This was confirmed via communication with the persons responsible in the shops; that in the single shops they do not have all products of the market chain's range in the shop, but just refers to the website or that they can order a required product to the shop for the customer.

The market survey shows that a large part of the children's rugs sold in Denmark are produced in non-EU countries, but they are typically distributed via a retailer in an EU-country. It is thus the retailer who has the information about country of origin and is responsible for procuring information about content of SVHC substances on the Candidate List. It was impossible to procure this information for all the children's rugs.

3. Hazard assessment and development of exposure scenarios

The objective of the hazard assessment of the selected substances and substance groups is partly to review the critical effects of the substances and partly to assess which acceptance levels regarding exposure of children can be set for the substances for further risk assessment of rug emissions.

The hazard assessment is focused on the identified substances in rugs (see Appendix 1) and further intend to group the substances according to their health properties. Thus an additive approach wil be used if several substances are having the same toxicolocal properties, i.e. the total exposure to these substances will be considered and not only the exposure from the individual substances.

In the selection of subtances for toxicological assessment emphasis will also be put on substances included on the LOUS substance list (List of Undesirable Subtances by the Danish EPA) and substances on the REACH candidate list.

Also, it is to be considered whether the subtances possess effects, to which children are considered to be particularly sensitive, such as having impact on organ systems in children that are under development. This may be in relation to effects on development of the central nervous system, the immune system or hormone-dependent development processes.

In connection with the hazard assessessment knowledge is collected of limit values for indoor or outdoor air, respectively (eg WHO air guideline values), for tolerable levels eg DNEL values (Derived No Effect Levels) assessed by ECHA's Risk Assessment Committee (eg. for phthalates) or relevant substance assessments and values from other expert assessments such as SCOEL (European scientific Committee for establishing limit values in the work environment) or from the US EPA's IRIS database covering assessments of hundreds of substances.

A source particularly to be emphasised is a report from the European Commission's Joint Research Centre (JRC/EU Commission 2013): ”Harmonisation framework for health based evaluation of indoor emissions from construction products in the European Union using the EU-LCI concept”, as this report based on a common European approach has assessed a number of indoor-relevant substances and calculated so-called Lowest Concentration of Interest (LCI) values related to the emission of these substances. These assessments were performed using the guidelines in the REACH regulation for calculating DNEL-values. Thus, the calculated LCI-values may from a toxicological point of view be used as tolerable exposure levels or DNEL-values. The EU-LCI-list "Agreed LCI values" is updated regularly and can be downloaded from the Internet (EU LCI 2016).

3.1 Health basis for the selection of substances

The Danish EPA has as the starting point for this projct identified VOC, phthalates and PFOS as groups of substances to be covered. Considerations regarding the total content of the substances in the three groups is required, as the combination and additive/ synergistic effects of the substances in each of the groups have to be accounted for.

Also among the VOC substances these include substances or groups of substances having similar effects, and the risk from the total exposure should be assessed using an additive or combination assessment approach. From the overview tables regarding the VOC emissions from Annex 1 it can be seen, that especially *aldehydes, carboxylic acids and hydrocarbons* dominate the emission from rugs.

Also among the VOC substances these include substances or groups of substances having similar effects, and the risk from the total exposure should be assessed using an additive or combination assessment approach.

Among the 17 aldehydes, the most well-known is formaldehyde (a LOUS substance), which is already a focus substance due to its carcinogenic and respiratory irritant properties. The substance is also well known as a very frequently occurring substance in the indoor environment with a very low acceptance value (0.1 mg/m^3 according to WHO, 2010). Generally, aldehydes are substances with low acceptance levels because of the respiratory and eye irritant properties of the vapours (JRC/ EU Commission 2013). JRC/EU Commission (2013) thus recommend LCI-values for a number of relevant aldehydes, and identical values are used for several of the substances, as the substances are considered to be acting similarly in terms of their respiratory and eye irritant properties.

In assessing the overall exposure to respiratory and eye irritant substances, it is considered relevant to include the group of *organic acids*, and acetic acid and formic acid are the substances for which the highest emission levels are found. The direct irritant effect from the organic acids may be considered as additive in relation to the exposure and the similar effects from the aldehydes.

Especially respiratory irritation is considered to be a highly relevant effect to look at, as more and more children today have allergies and asthma, and so many children will be particularly sensitive to respiratory irritants.

The hydrocarbons (aliphatic and aromatic) represent the largest group of substances in the emissions from carpets. Hydrocarbons (in the range from 6 to 14 carbon atoms) and mixtures thereof are in connction with inhaltion known to distribute into fatty organs, including the brain, where an up-concentrating may take place (ECHA 2011). In addition to the fact that a number of individual substances in this category are considered chronic neurotoxic (e.g. hexane, toluene, xylenes, styrene), mixtures may also cause organic chronic brain damage (e.g. white spirit containing a mixture of C7 to C12 aliphatic, cyclic aliphatic and aromatic hydrocarbons) (Danish EPA 2016). The hydrocarbons toluene, styrene and white spirit are also focus substances appearing on the EPA LOUS list.

Due to the similar effects of the substances, the group can be assessed using a combined approach/ addition approach. The substances are also considered to be particularly relevant because children are considered to be espeically susceptible to neurotoxic substances, because their nervous systems are still under development right up until adolescence - adulthood (Danish EPA 2016). By focusing on this group, synergi is obtained with a parallel Danish EPA project on childrens exposure to neurotoxic substances from a wide range of other consumer and construction products (Danish EPA 2016).

Overall, the project will focus on phthalates and fluorinated compounds, as well as on the emission of the following VOCs*: aldehydes, carboxylic acids, and hydrocarbons (C7 -C12, aliphatic and aromatic hydrocarbons)* from the rugs (i.e. 52 out of 90 identified VOCs).

3.2 Hazard assessment

In the hazard assessment below and in the derivation of tolerable exposure levels, it will be specifically assessed whether the 1 to 3 year olds can be considered more sensitive to the critical effects of the chemical substance compared to adults.

In this context, the REACH Regulation guidance on the calculation of DNEL-values (ECHA 2012c) recommends incorporating an additional uncertainty factor in cases where the chemical substances can affect organ systems under development, for example the nervous system, the immune system or the hormone-related sexual maturation, in order to achieve adequate protection of children.

3.2.1 Hazard assessment of volatile organic compounds (VOC)

Hydrocarbons

In a parallel project, the the Danish EPA focused on the exposure of children to chronic neurotoxic substances with a starting point in the exposure to toluene (Danish EPA, 2016). Therefore, it will in this project be natural to take a starting point in the parallel project's assessment of hydrocarbons with regard to the chronic neurotoxic effects.

The report from the JRC/EU Commission (2013) has assessed a number of indoor environment relevant substances and calculated tolerable exposure levels using the REACH guidance for calculat-ing DNEL values. With regard to evaluation of mixtures of hydrocarbons, these were not included by the report from the JRC/EU Commission. Thus, the tolerable exposure level for white spirit was correspondingly calculated from specific data on white spirit as indicated in the report Danish EPA (2016).

It has to be mentiond that the JRC/EU Commission (2013) report calculated the LCI values for adults, and in connection with another project for the Danish EPA concerning the exposure of children, the values were reduced by a factor 4 in order to obtain a LCI value for children (Danish EPA 2016). This reduction of the values were made as children are assumed to be more at risk partly because their central nervous system is still under development and partly because they are exposed to a larger amount of the substance at a given concentration in the air, as they inhale a larger amount of air per kg body weight than adults do. Table 8 below shows the tolerable exposure levels for children regarding chronic neurotoxic hydrocarbons (Danish EPA, 2016)

TABLE 8
TOLERABLE EXPOSURE LEVELS (LCI LEVELS) FOR A NUMBER OF HYDROCARBONS BASED ON THEIR CHRONIC NEUROTOXIC EFFECTS (DANISH EPA, 2016) AND ODOUR THRESHOLDS

Substance	Tolerable exposure (mg/m^3)	Odour threshold * (mg/m^3)
n-hexane	0.20	-
n-heptane	-	0.67
Benzene**	0.60	2.7
Toluene	0.70	0.33
Xylenes	0.10	0.058-0.38
Ethylbenzene	0.20	0.17
Styrene	0.20	0.035
Methylstyrene	0.20	-
Propylbenzenes	0.25	0.0038-0.0084
Trimethylbenzenes	0.10	0.12-0.17

Diisopropylbenzene	0.20	-
Octylbenzene	0.30	-
White spirit C7-C12 hydrocarbons	1.40	0.5-5

* Odour thresholds from Nagata (2003) (White spirit: Danish EPA, 2008)

** Benzene is a potent carcinogenic substance. A recommended tolerable level in the indoor environment with regard to carcinogenic effect of 0.00017 mg/m3 has been calculated based on a lifetime risk of 1: 1000 000 for development of cancer (WHO, 2010).

For all hydrocarbons, the chronic neurotoxic effect is assessed to be the most critical effect (i.e. the effect that may occur at the lowest exposure level of the substances). However, this is not the case for the chronic carcinogenic substance benzene, where a tolerable level with regard to carcinogenic effcts would be lower. Thus, WHO (2010) considers an average exposure level of 0.00017 mg/m^3 to correspond to a lifetime risk of 1: 1.000.000 for the development of cancer.

Aldehydes

The report from the JRC/EU Commission (2013) established LCI levels for aldehydes based on the irritative properties of the vapours of the substances. Them mechanism of action was considered as identical for the aldehydes and the the LCI levels were determined by extrapolating data between the different types of aldehydes (read-across). The LCI-values derived for the values are given in Table 9 and will be further used in this project as tolerable exposure levels.

TABLE 9

TOLERABLE EXPOSURE LEVELS FOR ALDEHYDES (LCI VALUES FROM JRC/EU COMMISSION, 2013) AND ODOUR THRESHOLDS

Substance	Tolerable exposure (mg/m^3)	Odour threshold* (mg/m^3)
Formaldehyde	0.100	0.61
Acetaldehyde	1.20	0.002
n-Butanal	0.65	0.002
n-Pentanal	0.80	0.001
n-Hexanal	0.90	0.001
Nonanal	0.90	0.002
Ethylhexanal	0.90	-
n-Decanal	0.90	0.025
2-Nonenal	0.007[1]	-
2-Decenal	0.007[1]	-
Benzaldehyde	0.09	-

*Odour thresholds from Nagata (2003)

[1]Updated LCI (EU-LCI 2016)

Acrolein is an aldehyde, which may also be relevant with respect to emission from rugs, and was found in the analyses in this project (see Section 4, Table 15). Acrolein is different from the other aldehydes by the fact that the alkyl chain is unsaturated, i.e. containing a double bond in the molecular structure, making the substance additionally reactive. Thus, at very low exposure levels acute respiratory irritation in humans has been observed (by short-term exposure), and by prolonged exposure the impact may progress to tissue damage in the lungs, which has been observed in laboratory animals. Acrolein has not been assessed in the report by JRC/European Commission (2013), but the following relevant assessments suggesting tolerable exposure levels have been found:

US-EPA (2003):	0.02 µg/m³ for long-term exposure
WHO/CICAD (2002):	0.1-0.5 µg/m³ for long-term exposure
ATSDR (2007):	7 µg/m³ for exposure duration less than 14 days
	0.09 µg/m³ for exposure duration between 14 days and 1 year

The assessment conducted by the US EPA (2003) indicates the lowest tolerable level. Here it should be noted that the US EPA in calculating their limit values uses a relatively high uncertainty factor of 10 to extrapolate to chronic exposure from an animal study using subchronic (90 days) exposure. In connection with the guidelines of the REACH regulation, an uncertainty factor of 2 should be used here instead. On this background, a tolerable level of 0.1 µg/m³ (as also suggested by the WHO/CICAD) is assessed to be appropriate for acrolein in connection with long-term exposure. As for the short-term exposure, a tolerable exposure level of 7 µg/m³ is used, as proposed by ATSDR (2007).

The irritant effects of aldehydes on eyes and respiratory system are considered to be related to the concentration of the vapours in the air that come into contact with the mucous membrane surfaces, and not to the amount absorbed in the body after inhalation. On this background, it is assessed that there is no justification for the use of specific values for children as children cannot be considered more vulnarable than adults, and therefore a reduction of the tolerable levels in relation to children is not considered justified.

Carboxylic acids

Regarding emission of acids from rugs, the emission data indicate formic acid and acetic acid are the acids that evaporate to the greatest extent. These acids (as the aldehydes) also induce irritational effects. The report JRC/EU Commission (2013) states that no LCI levels have been published so far for organic acids, but lists French indoor environment levels (from AFFSET/ANSES) of 0.25 mg/m³ for acetic acid and 0.3 mg/m³ for propionic acid, butane acid, pentane acid, hexane acid, heptane acid and octane acid, respectively. An EU-LCI value was added at a later stage for 2-ethylhexanoic acid (0.15 mg/m³) (EU-LCI 2016).

Regarding formic acid, Danish researchers have suggested an indoor environment level of 0.3 mg/m³ in order to protect against irritation of the respiratory system, whereas a level of 1 mg/m³ was suggested for acetic acid, and levels of 3 mg/m³ and 1 mg/m³, respectively, were suggested for propionic acid and butanoic acid (Nielsen *et al.*, 1998).

No assessments were found of formic acid or acetic acid from WHO in connection with indoor environment levels in air, or from SCOEL (the European expert committee regarding determination of limit values in the working environment), or in the US-EPA IRIS database.

Based on this somewhat uncertain data set, it is assumed to be relevant for this project to use a tolerable indoor environment value of:

0,3 mg/m³

for each carboxylic acid, and their sums.

The irritating effects of carboxylic acids on the respiratory system are considered to be linked to the concentration of vapours in the air that comes into contact with the mucosal surfaces, and not the amount absorbed into the body after inhalation. On this background, it is assessed that there is no justification for the use of specific values for children, and therefore a reduction of the tolerable levels in relation to children is not considered justified.

3.2.2 Hazard assessment of phthalates

The toxicological effects and tolerable exposure levels of the most critical phthalates that are included in the authorisation regulation under REACH and classified as reprotoxic (Repr. 1B) have recently been described and assessed by the risk assessment committee of the European Chemicals Agency, RAC (ECHA, 2012A+B).

The following key information (Table 10) was given for the substances: diehylhexyl phthalate (DEHP), dibutyl phthalate (DBP), diisobutyl phthalate (DIBP) and benzylbutyl phthalate (BBP) with regard to their lowest-observed-adverse-effect levels (LOAEL) and no-observed-adverse-effect levels (NOAEL) from experimental animal studies.

TABLE 10
KEY DATA ON N(L)OAEL LEVELS AND DNEL LEVELS FOR THE PHTHALATES DEHP, DBP, DIBP AND BBP (ECHA 2012A)

	NOAEL mg/kg/d	LOAEL mg/kg /d	Uncertainty factor	DNEL mg /kg /d
Diethylhexyl phthalate, DEHP	4.4	14	100	0.05
Dibutyl phthalate, DBP	-	2	300	0.0067
Diisobutyl phthalate, DIBP	-	125	300	0.42
Benzylbutyl phthalate, BBP	50	100	100	0.5

For all substances, the lowest effect levels are related to effects on the testicles/endocrine disruptive effects, as the substances have an anti-androgynous biological effect. Furthermore, the table contains information from the expert committee regarding their conclusion on DNEL values (Derived no Effect Levels) for the four substances and the applied uncertainty factors when calculating DNEL levels.

As the basis for calculation of DNEL-values for phthalates are from animal studies, in which the animals were exposed in their most sensitive periods, i.e. during gestation and fetal development, ECHA (2012A + B) concluded that these also apply to children aged 1-3.

The substance diisononyl phthalate (DINP) was also assessed in connection with the assessment of the four mentioned phthalates, as that substance to a great extent is used as an alternative to the above-mentioned, strictly regulated phthalates. DINP is less toxic with regard to endocrine disruptive effects and on the basis of a NOAEL of 300 mg/kg/d for anti-androgynous effects, a DNEL level was calculated for an anti-androgynous effect of 3 mg/kg/d. With regard to non-hormone related effects, a DNEL for DINP was determined to 0.15 mg/kg/d in the light of a NOAEL for liver effects of 15 mg/kg/d. The DNEL level for anti-androgynous effects is therefore 20 times higher than the DNEL level of non-hormone-related effects, and also much higher than the DNEL of the above-mentioned phthalates. Thus, the impact of DINP with regard to endocrine disruptive effects may be considered as less important than from the other phthalates.

3.2.3 Hazard assessment of fluorinated compounds

Recently, the Danish EPA carried out a toxicological assessment of the most well-known dangerous perflourinated compounds PFOA and PFOS. Both substances are reprotoxic (classified Repr. 1B).

Overall, the data from experimental animals and humans show that the substances can lead to a number of adverse effects (Danish EPA, 2015):

- Liver damage
- Kidney damage
- Carcinogenicity
- Effect on development of embryo and teratogenic effects
- Endocrine disruptive effects
- Effect on the immune system
- Effect on lipid metabolism and increased cholesterol level

In various species of experimental animals a rather uniform toxicological pattern was seen and the effects in the liver was found to be the most critical effect occurring at at the lowest levels. Teratogenic effects and damages on the immune system appeared at somewhat higher exposure levels. In some (few) investigations with mice, effects on the immune system were seen at very low levels.

Human data indicate an association between the occurrence of PFAS compounds in the blood and health hazardous effects. However, the data must be regarded as very uncertain and cannot be used for actual quantitative assessments of the substances as several conflicting results exist. In addition, the exposure and conditions connected to the cause and effect relationship in population studies are much more complex with regard to elucidation and documentation than in the experimental animal studies where the effects only are associated to well-known and controlled PFOA/ PFOS exposure.

Based on the dose-response relationship on liver toxicity from experimental animals studies a tolerable daily intake (TDI) of 0.03 µg/kg/d was calculated for PFOS, and a TDI of 0.1 µg/kg/d was calculated for PFOA (Danish EPA, 2015).

The tolerable exposure level is as mentioned calculated based on harmful effects on the liver. Infants are generally not considered to be more sensitive than adults for adverse effects on the liver, and the calculated tolerable levels are therefore overall considered to protect against liver effects as well as developmental effects in children aged 1-3.

The TDI values were by the Danish EPA subsequently used to establish limit values for the substances in drinking water and soil.

The lowest limit values in drinking water and soil were calculated for PFOS. Therefore, the Danish EPA due to administrative reasons decided to use that value for a number of other perfluorinated compounds as well because of lack of data in these compounds. Therefore, the established limit values also covered the following C4-C10 PFAS:

- PFBS (perfluorobutane sulfonic acid)
- PFHxS (perfluorohexane sulfonic acid)
- PFOS (perfluorooctane sulfonic acid)

- PFOSA (perfluoroctane sulfonamide)
- 6:2 FTS (6:2 fluorotelomer sulfonic acid)
- PFBA (perfluorobutanoic acid)
- PFPeA (perfluoropentanoic acid)
- PFHxA (perfluorohexanoic acid)
- PFHpA (perfluoroheptanoic acid)
- PFOA (perfluorooctanoic acid)
- PFNA (perfluorononanoic acid)
- PFDA (perfluorodecanoic acid)

Therefore, in this project we likewise use a TDI level (DNEL level) of:

0.03 µg/kg/d

For the sum of these individual PFAS substances stated above and in Table 4, and the sum of these.

3.3 Evaluation of the fate of VOC in the indoor environment

The “fate” of volatile compounds emitted from the rugs can differ a lot in the indoor environment. The very volatile organic compounds (VVOC) and volatile compounds remain gaseous whereas the more semi-volatile organic compounds (SVOC) can condense on other surfaces in the room (including house dust) and subsequently be re-emitted depending on the concentration in the room air. Typically, the concentration of VOCs in the room air will eventually decline for instance when a new rug is taken into use, whereas the concentration of SVOCs in the room air can increase during a period of time.

Furthermore, the emission of the substances from the rugs and the resulting concentration in the room air will depend on the size of the room, the air change rate and the amount of material. These conditions will be included in the description, and the scenario of a children’s room will be assessed in relation to other rooms in the house and expected concentrations in for instance a standard room that is defined in ISO 16000-9 – Annex B.

Most of the phthalates, including DEHP, DIBP and DBP, are identified in the survey as SVOC, while some of the identified PFAS, including PFBA and fluorotelomers (FT-OH), fall into the VOC group. It applies only to the part of the substances that have an adequate vapour pressure, as larger molecules and salts cannot be described as volatile substances, and will therefore remain in the rugs.

It must be expected that emitted VVOCs and VOCs are solely found as vapour in the indoor environment. Emission of these substances is to a high degree independent of the concentration in the room air, but is conditioned by internal conditions in the material, e.g. vapour pressure and porosity (Xu and Zhang, 2003).

When a VOC source is introduced to the indoor environment, a state of equilibrium will rather quickly be established in the room air. It is mainly dependent on the source strength and the air change rate in the room. If the source is removed or if the air change rate is altered, then the concentration in the room air will quickly change. If ventilation is the only reducing factor, then it will be possible to find moderately adsorbing substances for hundreds or thousands of hours. It is possible to find strongly absorbing substances years after the primary source has been removed. However, a thorough wiping off/washing of the surfaces can remove a large part of the adsorbed substances – but it depends on the nature of the surfaces (e.g., textile or hard surfaces).

The fate of the semi-volatile organic substances in the indoor environment is more complex. The substances are emitted from the surface of the material as vapour and exist in vapour form in the room air. However, due to their semi-volatile nature, the substances tend to condense on the particles in the air, on house dust and other surfaces in the indoor environment, including the users of the building (Weschler and Nazaroff, 2010).

Weschler and Nazaroff (2008) calculated that the SVOCs can remain in the indoor environment for a long time after the primary source has been removed. If ventilation is the only reducing factor, then it will be possible to find moderately adsorbing substances for years.

Weschler and Nazaroff (2008) found that the vapour pressure of several phthalates correlate with the occurrence of the substance in gas form in relation to settled dust, which in general must be expected to apply to all SVOCs. Clausen *et al.* (2004) found that the emission rate of the phthalate DEHP increased when there was a dust layer on the investigated PVC floor. That indicates that the conditions that determine the emission of the semi-volatile substances are much more complex than for VOCs. In addition, the partial occurrence of SVOC in air borne and settled particles can be due to particles that contain SVOCs and that have been worn off the rug during use (play, walking, cleaning, etc.) (Schoeib *et al.*, 2005).

In addition, the concentration of the impurities and the chemical composition in the air depend on which kind of chemical reactions that occur upon contact with the material surfaces and in the air. This report does not take into account the potential significance of this.

3.4 Exposure scenarios

3.4.1 Exposure considerations when using rugs

On the basis of information on substances and materials in the surveyed rugs and their fate in the indoor environment, exposure scenarios are established for the use of rugs in a children´s room. It is evaluated which kind of exposure routes that are most relevant for the respective substances/ substance groups.

In this context, the following factors may be considered relevant for inclusion in the scenario build-up:

- Rug size
- Expected content of the substances
- Emission rate of the substances from the rug
- The size of the room
- Ventilation
- Duration of exposure
- Age and weight of the child
- Age-related parameters, eg. breathing volume, intake of dust, area of body surfaces, number of hours of activity/play on the rug, number of hours of sleep etc.

The sources for quantification/description of these parameters will be the REACH guidance document on consumer exposure, and the data from NCM (2012) and RIVM (2007), which describe many child-specific parameters relevant for building up exposure scenarios.

In the context of children's chemical exposure from rugs, inhalation of emitted VOC and inhalation of SVOC as a component of inhaled particles may occur. It is assumed that small children i.e. toddlers are most heavily exposed to vapours and dust from a rug, because they inhale a larger volume of air per kg body weight than older age groups. With regard to oral exposure, toddlers are also be more exposed because of their crawling and sucking behaviour. NCM (2012) indicates that children in this age group in average are sucking their fingers 13-20 times per hour (about 5% of the children suck their fingers more than 37-63 times).
On this background, this age group from 1-3 years is considered a special target group with high exposure for this project. This age group, which is generally considered the most heavily exposed is used as a starting point for the exposure assessment and risk assessment.

When exposure to the substances in the indoor environment has to be assessed it is important to set up a realistic scenario that could appear in a Danish house. In several of the Danish EPA's consumer reports (e.g. Jensen and Knudsen (2006)), a room of 7 m^2 with a volume of 17.4 m^3 was used for scenario calculations. The room is identical with the standard room that normally is used for emission tests (ISO 16000-9-Annex B and Dansk Standard, 1994), and corresponds to a toddlers's room in a single-family house. prEN 16516 defines a larger reference room with a floor area of 12 m^2 and a volume of 30 m^3 for use during emission testing of construction goods In connection with flooring, the material loading factor in the two reference rooms is identical (0.4 m^2/m^3). That means that the exposure scenario for rugs will be the same no matter if a reference room of 7 m^2 or of 12 m^2 is used. A temperature of 23 °C and a relative humidity of 50% RH are used for VOC emission tests according to the standards that are normally used.

In model calculations of the standard room, an air change of 0.5 times per hour (h^{-1}) is normally used. An air change of 0.5 times per hour corresponds to adding an amount of outdoor air every hour corresponding to half of the volume of the room. The same air change was used to calculate the scenarios in the Danish EPA's consumer reports. However, it should be noted that the air change can be much lower in a children's room. A larger investigation of 500 Danish households with children (Clausen *et al.*, 2012) demonstrated that the air change in 57% of the investigated children's rooms did not meet the requirements of the Danish Building Regulations for an air change of 0.5 h^{-1}. In about 30% of the children's rooms the air change was about 0.3 h^{-1} or lower.

The temperature has a great effect on the emission of organic compounds. Liang and Xu (2014) investigated the emission of phthalates from vinyl flooring and mattress covers and found that the concentration of phthalates in gas form in the room air increased by more than a factor 10 when the temperature increased from 25 °C to 35 °C. The temperature of the rug could be higher than the ordinary room temperature if there for instance is floor heating, if the sun is shining or if the child sits and plays on the rug. Although the heat from a child is local, a large amount of the emitted substances can be "caught" by the naturally upward moving air flow (thermal plume) that surrounds a person and in that way be transported to the inhalation area.

3.4.2 Calculation of concentrations of substances in children's rooms

In this project, emission measurements will be carried out from rugs placed in climate chambers, and from the measured concentrations of VOC in the climate chamber, the concentration in a standard children's room can be calculated. As a starting point for a standard children's room, as specified in section 3.4.1, a floor area of the room of 7 m^2 and a room volume of 17.4 m^3 and an average air change rate of 0.5 per hour are used.

Then, the following algorithm can be used for calculating the concentration in the children's room (prEN 16516, 2015; Kolarik, 2015):

$$C_M = E_c \cdot \frac{A}{V \cdot n}$$

Where:
C_M: concentration of a chemical substance in the room air (mg/m^3)
E_c: the area specific emission rate (SER) from the rug (mg/m^2 h)
A: the area of the rug in the room (m^2)
V: volume of the children's room (m^3)
n: the air exchange of the children's room (h^{-1})

3.4.3 Routes of exposure

Inhalation exposure, VOC substances

The calculated concentration in the children's room can be immediately used as an exposure measurement for children staying in the room, and thus subsequently be compared in a risk assessment with the tolerable exposure levels (in mg/m^3) for *hydrocarbons, aldehydes and carboxylic acids* (see Section 3.2).

Oral and inhalation exposure to dust, non-volatile substances

NCM (2012) examined data on children's exposure to house dust. When reviewing this material, it was assessed that realistic standard estimates for inhalation/ingestion of house dust are around 2 mg inhaled dust and 100 mg ingested dust. Dust that is inhaled (inhalable dust) is typically caught in the upper respiratory mucous layer, and then the dust will be swallowed together with the mucous that is continually transported to the throat as a result of the brush movements of the cilia in the respiratory surfaces. On this background, it seems appropriate to use an overall oral exposure to dust of 100 mg/day as a rounded value. This value was also used in an earlier project on exposure assessment for 2-year-old children (Danish EPA 2009).

Dermal exposure, non-volatile substances

While oral exposure to dust and inhalation of vapours can be considered relevant exposure routes, it may be difficult to immediately assess whether dermal exposure will be a relevant route of exposure. If the focus of the substance groups and their effects had been on skin irritation and dermal sensitisation and allergic skin reactions, the dermal exposure route would obviously be a route of interest. This is however not the case for this project, where the risk assessment is based on the dose absorbed into the body (for phthalates, fluorinated compounds and hydrocarbons) and the concentration in the air n relation to respiratory irrritation and eye irritation.

Below, the extent of dermal exposure is compared with the oral route and inhalation of the substances, in order to assess whether the dermal exposure will play an important role in exposure to the substance groups.

3.4.4 Assessment of the relative importance of the exposure routes

Hydrocarbons

In a relatively recent article by Lim *et al.* (2014), the content of BTEX (benzene, toluene, ehtyl benzene and xylenes) was determined in 59 consumer products (divided into 18 product types). From the measured content, the contribution of each of the 18 types of products for the indoor environment was calculated for a 20 m^3 room with a ventilation rate of 1.34 times per hour. Lim *et al.* (2014) then calculated partly the inhaled dose of BTEX and partly the dose achieved through dermal contact, as a dermal absorption of between 0.05% and 3% was used for the four substances on the basis of available data. Calculations indicated that dermal exposure was many orders of magnitude (often 10^6 times) lower than through inhalation and thus contributed only insignificantly to the total exposure.

On this background, it is not relevant to further include dermal exposure for this substance group, as inhalation is estimated to be the predominant route of exposure.

Aldehydes and carboxylic acids

The critical effects of these substance groups are respiratory and eye irritation, as a direct result of the concentration of vapours in the room and thus the inhalation concentration. I.e. dermal exposure and ingestion are not relevant routes of exposure for these substances in relation to their toxic effects.

Phthalates

ECHA (2012A) assessed the oral absorption of DEHP, DBP, BBP and DIBP to be 100% for all the substances in relation to oral exposure of children. The dermal absorption of DEHP and BBP was based on data considered to be 5%, while the dermal absorption of DBP and DIBP was estimated to be 10%.

The degree of dermal exposure is assessed to a greater extent to be dependent on the migration of phthalates from the products rather than the actual content in the product. Data show that phthalates in particular can migrate from plastic materials to fat-containing media, such as skin lotion, while the migration to clean aqueous media, such as artificial sweat, is very limited. On this background, the Risk Assessment Committee of ECHA found it extremely difficult to establish accurate exposure scenarios for dermal contact with the plastic materials (ECHA 2012B).

Xu *et al.* (2010) assessed the overall exposure to DEHP in a scenario that included a home with DEHP-containing vinyl floor. They found that the dermal exposure represented a relatively small proportion (around 6%) of the total exposure, the oral exposure was dominant (about 90%).

In connection with this project, it seems most relevant to focus on the oral exposure, because assumptions by dermal exposure will be subject to great uncertainty, and also the exposure will be of modest size in relation to the oral exposure.

Fluorinated compounds
In the reviewed literature, concrete data on dermal absorption of these substances were not found. Based on the relatively high molecular weight of the substances, their low water solubility and their high fat solubility, it is assumed that the dermal absorption is very limited and lower than that of the phthalates. As the substances are stated to be highly absorbed after oral administration, a possible contribution from the dermal exposure is therefore considered to be negligible compared to the oral exposure.

3.5 Conclusion for the generation of exposure scenarios

Based on the above values from NCM (2012), the following exposure relevant parameters can be set for the use of relevant exposure scenarios related to children's exposure to chemical substances from rugs.

Target group:	1-3 year-olds
Body weight:	11.6 kg (as an average for the age group)
Inhalation volume, air:	0.6 m^3/kg bw/day
Ingestion of dust:	100 mg/day

Children i.e. toddlers aged 1-3 years have been chosen because it is considered a particularly vulnerable age group due to high oral intake of dust and due to the high inhalation volume per kg body weight. Thus, children in this age group are considered to be the group at the highest risk.

Children's room, area/volume:	7 m^2/ 17.4 m^3
Air change rate, average:	0.5 times per hour

For respiratory and eye irritant substances, as well as acutely toxic substances, it will also be relevant to assess a scenario without ventilation.

The rug load of the children's room:
The area of the rug will be assessed case-by-case depending on the type of rug scenario.

Table 11 below indicates the most significant exposure routes that are to be considered in the risk assessment.

TABLE 11
MOST RELEVANT EXPOSURE ROUTES IN CONNECTION WITH THE EXPOSURE OF CHILDREN TO RUGS

	Exposure routes		
	Oral	**Inhalation**	**Dermal contact**
Hydrocarbons	-	+	-
Aldehydes and carboxylic acids	-	+	-
Phthalates	+	-	(-)
Perfluorinated compounds	+	-	(-)

(-) the dermal exposure is implicitly included in the oral exposure, with oral exposure due largely to toddlers sucking their fingers and ingesting dust particles from this.

4. Analyses of children's rugs

4.1 Selection of children's rugs for analysis

On basis of the survey carried out, 21 different children's rugs have been selected and purchased for analysis of VOC, phthalates and PFAS. The selection is based on the following criteria, which were laid down in the initial examination:

- Manufactured outside the EU
- Pile/Textile surface materials: nylon, polyolefines (PP, PE), acrylic, natural (wool, cotton)
- Backing: Different materials, but preferably "rubber" (latex, foam etc.)
- Motive and colours: Appealing to toddlers (0-2 years) and young children (3-7 years)
- Focus on rugs marketed without labelling (e.g. Oeko-Tex®)

In connection with the marketing survey, no actual information was received from suppliers on contents or emission of VOCs, phthalates and PFAS in excess of the rugs that had a label prescribing a threshold limit for these substances. Information on country of production was not available for all rugs.

Summary of the rugs purchased appears from Table 12. The materials and other information about the rugs are stated on basis of the information available. If the backing is made of a rubber-like material, rubber is written stating informed material in brackets (ex. Latex). By visual inspection, it was visible that all rugs were made by tufting, where the pile i.e. textile upperside was fixed to the backing by lamination and/or gluing, whether they had a rubber or textile backing or not. Rugs with no attached backing looked as if they had been laminated in the woven substrate.

By purchase it appeared that 5 of the rugs were Oeko-Tex® labelled. But as they were produced in non-EU countries, they were still included in the survey. The producer country would be informed for all rugs, and reference is instead made to the European country, in which the retailer bought the rug. None of the rugs were CE-marked.

TABLE 12
SUMMARY OF RUGS AND MATERIALS

Rug	Upper side	Backing	Country	Area (m^2)	Weight/area (kg/m^2)
T01	PA	Rubber (Latex)	China	1,9	1,1
T02	PES	Rubber	China	0,3	1,8
T03	PES	Cotton lm.	China	1,0	1,6
T04*	Acrylic	Tx lm.	China	1,8	2,9
T05	PP	Rubber	China/India	1,5	1,8
T06	PA	Rubber (Latex)	-	1,3	1,6
T07	PA	Rubber (Latex)	-	1,3	1,5
T08	PA	Rubber (Latex)	China	0,5	1,4
T09	PP heatset	lm.	Turkey	1,5	2,2
T10	Wool	lm.	China/India	1,1	4,3
T11	PA	Rubber (Foam)[3]	Egypt	1,5	1,0
T12	Wool	Cotton	Egypt	2,16	4,1
T13*	98% Acrylic, 2% PES	lm.	China	1,3	3,2
T14*	Synthetic wool	Jute	Turkey	2,8	2,4
T15	91% Acrylic, 9% Viscose	60% PES, 40% Cotton lm.	China	1,7	3,4
T16[2]	PA	Felt-lm.	-	-[2]	-[2]
T17	PA	Rubber (Latex)	Turkey	2,1	1,2
T18*	85% PP, 15% PES	Rubber	Egypt/Belgium	1,3	1,2
T19*	PA	Rubber (Foam)[3]	Egypt	1,2	1,1
T20	PA	Rubber	Belgium[1]	1,3	1,2
T21	PA	Rubber	Belgium[1]	1,3	1,2

*Oeko-Tex®

[1]Producer country is not stated on the label attached to the rug. Informed by distributor after the purchase, but it could be the country of the EU retailer

[2]Even though the rug designated T16 is a wall-to-wall carpet and thereby not a rug, it was selected for the survey, because it is marketed as anti-dirt treated

[3]The backing looks like rubber and is not foam in spite of vendor data

Material abbreviations: Laminated and/or glued (lm.)

Upperside: Nylon (PA), Acrylic (Ac), Polypropylene (PP), Wool (W), Polyester (PES), Synthetic wool (AW), Viscose (Vi)

Backing: Rubber (R), Textile (Tx), Laminated/glued (lm), Jute (J), Cotton (C)

4.2 Analysis programme

The analysis programme is based on the three substance groups in focus: VOC, phthalates and PFAS. The purpose of the analysis programme is to measure the VOCs emitted from the rugs including which rugs emit odours, and if there is a health risk connected thereto. Emission of PFAS and phthalates to the air and the content in dust should also be measured.

The initial literature study indicates that the rugs can emit volatile fluorinated substances PFAS (including fluortelomers FT-OH) and phthalates (DEP, DEHP, DIBP, BBP), thus the air samples from the rugs in the climate chamber were analysed for content of these VOC and SVOC. The selected 21 rugs were screened for content of fluorine in the textile upperside as indication of content of PFAS and a sensory evaluation of odour for indication of emission of VOC. As the budget only included funds for analysis of 20 rugs, one rug was deselected, as it did not give rise to odour or contained fluorine. The other 20 rugs were analysed for emission of volatile substances under controlled conditions in climate chambers (Figure 3).

Volatile organic compounds (VVOC, VOC and SVOC) including volatile phthalates and PFAS were collected on TA® with subsequent analysis on GC-MS according to ISO 16000-6. The C1-C4 aldehydes formaldehyde, acetaldehyde, propanal and butanal are VVOCs and cannot be analysed by GC-MS, they were quantified by collection and derivatization with dinitrophenylhydrazine (DNPH) with subsequent extraction and analysis of HPLC according to ISO 16000-3. The analyses are elaborated in section 4.3.

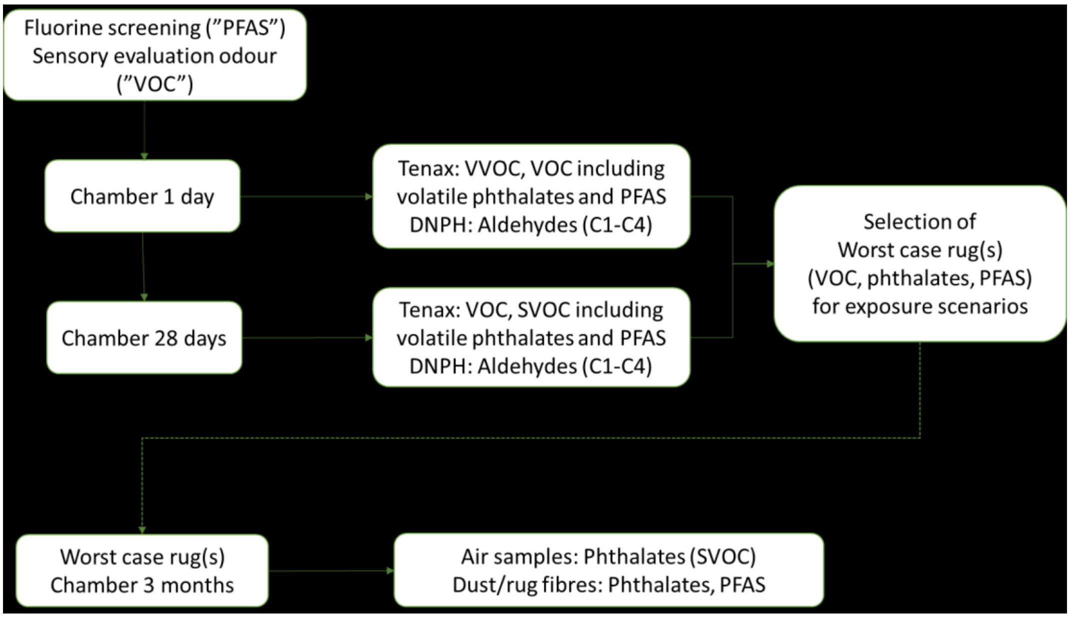


FIGURE 3. FLOWDIAGRAM OF PLANNED SAMPLING AND ANALYSIS FOR VOC, PHTHALATES, PFAS, AND C1-C4 ALDEHYDES. THE DOTTED LINE FOR WORST-CASE RUGS STATES PLAN FOR DUST MEASUREMENTS

It was originally planned to carry out dust measurements for worst-case exposure scenarios for the rugs that emitted volatile phthalates and PFAS in the highest concentrations cf. the dotted line in Figure 3. Content analyses will be given priority instead of dust measurements, if there was no content of SVOC phthalates or PFAS in the emissions.

4.3 Methods

4.3.1 Sampling

To avoid contamination and cross contamination by sampling, the rugs were treated separately with gloves, the cutting board was covered, and cleaned tools for measurement and cutting were used. For the samples, labelled food-grade, clear PE plastic bags were used, which did not contain phthalates, fluorine substances or VOC.
Two areas on the rug were selected from the middle to the inner part of the coiled rug. Samples for climate chamber and sensory evaluation were selected from the inner part of the rug, which was expected to have the highest content of volatile compounds. To obtain a representative sample of the rugs for emission tests, an edge cf. the principles stated in prEN 16516 was included.
For the chemical content analysis (phthalates and fluorine compounds), a sample was taken from each area, so that the samples represented the rug in full on basis of colours and materials. The edges were not included in the content analyses, as they are inhomogeneous and no increased content of phthalates and fluorine compounds can be expected.

4.3.2 Analysis of total fluorine

The entire textile upperside of a piece of rug with a known surface area of (1-12 cm^2) and known mass has been scraped off with a scalpel and analysed by the following method: A known part sample was burned in a flask containing oxygen. The combustion gas containing fluorine as hydrogenfluoride was collected in a wash bottle with demineralized water. The collection liquid was analysed for fluoride by ion-selective electrode. The content of fluorine was determined in relation to a calibration curve. The analysis was performed as a determination in duplicate. The detection limit of the method applied is 20 mg/kg. The method was validated by analysis of the reference material BCR 734, which has a certified value of 12.07% fluorine. By the analysis 11.8% fluorine and 11.9% fluorine in the reference respectively were demonstrated, which gives a retrieval of 98%.

4.3.3 Sensory evaluation of odour

Test specimens were sampled for sensory evaluation. The test specimens (220 cm^2) were conditioned at 23°C during the night in cylindrical glasses with a volume of 1.6 L, height: 28 cm and diameter: 9 cm. The diameter of the glasses are of the same size as the funnels normally used for inhalation by determination of odours from test specimens in Climpaq[5]. As the glasses are high and narrow, the odour will not disappear, when the lid is lifted shortly during the odour determination.

The sensory evaluation was carried out by an untrained panel of min. 20 persons, who determined the odour intensity and acceptance of the air in the glass on basis of the same scale and criteria for approval, which is used according to routine in the laboratory in connection with testing in Climpaq according to Indoor Climate Labelling (Test method 2005) (Figure 4). The panel is skilled in using the evaluation scale of the Indoor Climate Labelling (2005), in which both median values for acceptance> 0.1 and intensity> 2.0 should be fulfilled to approve an odour. As there is no air change in the cylindrical glasses, the test conditions are not according to the standard test method, and, therefore, the results are not directly usable for indoor climate labelling.

The scale for acceptance is very close to the scale prescribed in ISO 16000-28 (2005), but has been improved in the version applied, as no "either – or" "null" determination is accepted. The panellists have to decide, whether the odour is just acceptable or just unacceptable. Sensory evaluation cf. Figure 4 is measured and treated on basis of the coding for acceptance from -1 (corresponding to "clearly unacceptable") to +1 (corresponding to "clearly acceptable"), and an odour intensity from 0 (corresponding to "no odour") to 5 (corresponding to "overwhelming odour"). The height of the scale is 5 cm.

[5] Climate chamber of glass with constant air change

The following questions are listed, on which panel should determine the odour:
Imagine that you in the daily would be exposed to the air in the funnels.

- *How acceptable do you find the odour?*
- *How intense do you find the odour?*

Mark with horizontal lines on the scales below.

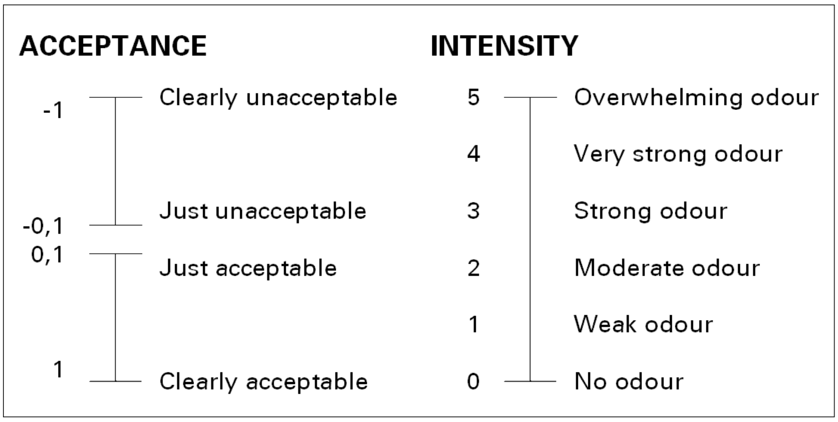


FIGURE 4. SCALE FOR DETERMINATION OF THE ODOUR PERCEPTION BY SENSORY EVALUATION

The panel should, furthermore, state a description of the odour, and, if possible describe the perceived odour.

The following criteria have been applied for the panel: Age under 50 years, no food and drink ½ hour before the evaluation (water is acceptable), instruction in the evaluation scale and supervision during evaluation with the motto that the "first impression" should be recorded. If a person feels that his/her sense of smell is reduced (e.g. by a cold), this person should be excluded on this day. The room, in which the sensory evaluation takes place, has a room temperature of 23°C ± 2°C and a relative humidity of 50% ± 5% RH. The room is free of odour and noise, and the air quality was assessed by sensory evaluation by the panel.

Maximum 5 rugs are determined at an hour per day in a period of 4 hours by 20-28 panellists. Prior to each evaluation of a rug, an empty cylindrical glass (reference) is determined to give the nose a rest before evaluating the next material sample. For each individual evaluation, it was controlled, whether the reference was evaluated as a clearly acceptable odour and an intensity lower than "weak odour". The scales were measured, the values were keyed in, and the median for acceptance and intensity was calculated for the reference and the rug respectively.

4.3.4 Analysis of volatile compounds (VOC)

A representative sample of the rug of 32 cm x 38 cm, including 32 cm edge for rugs with a straight edge is placed on the bottom of the climate chamber of polished stainless steel under the following conditions according to ISO 16000-9:

Chamber volume:	0,113 m^3
Sample size:	0,113 m^2
Material load:	1 m^2/m^3
Air change rate:	1 ± 0.05 h^{-1}
Air flow rate:	0.1-0.3 m/s
Temperature:	23°C ± 1°C
Relative humidity:	50 % ± 5 % RH

The area specific ventilation rate is q=1.0 m^3/m^2h. Measured concentrations of compounds in the air c (µg/m^3) are therefore at the test conditions equal to the area specific emission rate (SER) µg/m²h, which can be used for conversion of different areas of rugs to the standard room. As rugs do not cover the entire floor, these conditions give a good base for comparison of the emissions of the rugs.

Air samples were collected after 1 and 28 days. Documentation was carried out for the purity of the chamber at test start. Blind tubes were likewise analysed in connection with all chemical analyses.

GC-MS analysis of volatile organic compounds (VOC)
Two air samples of 3 and 6 L were collected on glass tubes with Tenax TA® spiked with internal standards at a flow of 80 ml/min. VOC was analysed with GC-MS according to ISO 16000-6. Identification of VOC was carried out by use of mass spectre from Wiley and NIST MS-databases, and retention time and mass spectre of reference substances. The substances were quantified by means of clean reference substances by calibration of spiked Tenax tubes and the rest was quantified as toluene equivalents. Prior to addition of internal standard, the Tenax tubes were checked for purity and background by GC-MS.

Limits of detection (LOD) and limits of quantification (LOQ) are dependent on substance. For 6 L air sample it applies LOD <1 µg/m³ and LOQ of approx. 1-3 µg/m³ for most VOCs. Acetic acid has a LOQ of approx. 10 µg/m³. LOD of fluorinated telomers 6:2 – 12:2 FT-OH was 0.4-0.8 µg/m³ and LOD of the phthalates was 0.4 µg/m³ (DEP, DEHP) and 1.4 µg/m³ (DBP). Even though ISO 16000-6 states that substances of 2 µg/m³ and above should be reported, there is at the same time a requirement for statement of volatile CMR-substances above 1 µg/m³ according to GUT. VOCs were quantified and reported by concentrations above 1 µg/m³. TVOCs are cf. ISO 16000-9 quantified as the area of the chromatogram of the sample minus blind tubes, and are a total sum of VOCs that eluate between hexane and hexadecane as toluene equivalents.

HPLC analysis of volatile C1-C4 aldehydes (VVOC)
40-60 L air samples are taken on DNPH-tubes with a flow of 650 ml/min. The aldehydes formaldehyde, acetaldehyde, propanal, acrolein (2-propenal) and butanal were after elution with acetonitrile analysed by HPLC (liquid chromatography) with UV detection according to ISO 16000-3. Limits of detection for aldehydes collected on DNPH tubes were 0.03 µg (formaldehyde, acetaldehyde, butanal, acrolein) and 0.05 µg (propanal). Limit of detection in air by a volume of 40 litres is 0.75 µg/m³ (formaldehyde, acetaldehyde, butanal, acrolein) and 1.25 µg/m³ (propanal).

4.3.5 Analysis of content of phthalates
Precisely weighed part samples representing the rug in full including backing were extracted with hexane/acetone (80:20) spiked with deuterated viz. deuterium marked, internal standards of DBP-d4 and DEHP-d4. The analysis of the extracts were carried out by capillary gas chromatography with mass selective mass detection (GC-MS). The identification of the phthalates was carried out using mass spectre from the NIST-database, reference substances and retention time. The limits of detection analysed for the 7 phthalates were 5 mg/kg for DEHP, DBP, DIBP, BBP and DNOP respectively, while it was 20 mg/kg for DINP and DIDP.

4.3.6 Analysis of fluorinated single substances (PFAS)
The analyses of per- and polyfluorinated alkylated fluorine compounds (PFAS) were carried out by Fraunhofer IVV (Freising, Germany). The rug fibres were separated from the backing with a sharp knife. Precisely weighed samples from the rugs representing the rug in full were analysed according to the beneath methods.

Screening of volatile PFAS with gas chromatography (P&T-GC-EPED)
Material corresponding to an area of 50 cm² rug was extracted directly in purge & trap (P&T) headspace vials at 120°C and purged for 60 minutes until freezing trap. Gas chromatographic (GC)

analysis with detection of fluorinated volatile substances with a fluorine selective echelle plasma emission detector (EPED).

Volatile PFAS with gas chromatography (GC-PCI-MS)
Material corresponding to an area of 10 cm^2 rug was extracted with n-hexane with addition of internal isotope labelled standard with ultrasound for 15 minutes. The extracts were purified with silica, and 1 ml was sampled for analysis, in which the volatile PFAS, including fluortelomers were quantified by gas chromatography separation, positive chemical ionization and mass spectrometry (GC-PCI-MS) with methane as reaction gas in SIM-mode. FT-OH (4:2, 6:2, 8:2, 10:2), N-Me-FOSA (N-methylperfluoro-1-octansulfonamide), N-Et-FOSA (N-ethylperfluoro-1-octansulfonamide), N-MeFOSE (N-methylperfluoro-1-octansulfonamidoethanol), N-EtFOSE (N-ethylperfluoro-1-octansulfonamidoethanol).

Other PFAS with liquid chromatography (LC-MS/MS)
Material corresponding to an area of 10 cm^2 rug was extracted with methanol with addition of internal isotope labelled standards with ultra sound for 15 minutes. The extracts were purified with fast phase extraction, in which PFAS, including perfluorinated acids and sulfonates were quantified by LC-MS/MS in MRM-mode. All substances with acid groups (acids and salts) were extracted and analysed as free acids. The expanded measurement uncertainty (U, k=2) is given in paranthesis: PFOS + iso-PFOS (34,5%), PFBA (15,3%), PFBS (43,7%), PFDA (44,2 %), PFDoDA (15,6%), perfluorodecane sulfonic acid (PFDS) (15,7%), PFHpA (18,9%), perfluoroheptane sulfonic acid (PFHpS) (40,0%), PFHxA (39,4%), PFHxS (26,4%), PFNA (61,6%), PFOA (30,5%), PFPeA (20,1%), PFUnDA (30,3%), 7H-DODFHpA (24,7%).

4.4 Results from initial examinations for odour and content of fluorine

The purpose of the initial examination was to find out, which rugs gave cause to odour nuisances, and which contained fluorine. The results appear from Table 13.

4.4.1 Screening by sensory evaluation of odour

The rugs were placed in closed containers for 16-24 hours prior to the sensory evaluation of the odour of the rugs. The results from the sensory evaluation of the 21 rugs appear from Table 13. The rugs are assigned numbers T01 to T21 for the reporting and discussion of the results.

The sensory evaluation of the rugs showed that the odour was acceptable for 9 out of 21 rugs (Table 13). Other methods and scales for evaluation of rugs and textile materials are used by GUT and Oeko-Tex®, however, use of these scales would require a thorough instruction and training of the panel, which is beyond the frames of this project.

The panel was asked to describe their perception of the odour and this resulted in many more words than those mentioned in Table 13. A description is included by minimum 3 identical replies. It was necessary to divide the odour on basis of synonymous designations as mentioned in brackets: Rubber (plastic, latex, rubbery, rubber odour), Rug (new car, new rugs, rug odour, matt), Chemical (synthetic), Sour (sourish, citrus, fruit, acetic acid), Fish (fishy, mackerel, herring), Stuffy (sweetish, sweet), Rot/mould (stale, old holiday cottage).

The odour of the rugs is mainly described as rubber, rug, chemical, sour, fish. The odour description of the two wool rugs rot/mould are not chemical, but simply reflects that wool is a biological material. Most of the rugs with rubber backing (9 of 13) are evaluated to smell of rubber, except T17 and T19, which have a PA upperside. The odour of fish is associated to 4 out of totally 9 rugs with nylon upperside and rubber backing (PA-R), and the odour of the 3 of 4 rugs with fish odour is not acceptable.

For most rugs, where the odour is not acceptable, the odour intensity is in the moderate area.

Sensory evaluations of odour vary very much due to the biological variation in humans and associations with odour perceptions. When calculating the result of sensory determination using median and not the arithmetic mean value, the advantage is the median is stable towards extreme evalations.

TABLE 13
SENSORY EVALUATION OF ODOUR PERCEPTION

Rug	Material	Acceptance	Intensity	n	Description (n≥3)
T01	PA-Rl	Not acceptable (-0,15)	Moderate (2,3)	29	Sour, rubber, fish
T02	PES-R	Neutral (0,0)	Moderate (1,8)	24	Rubber
T03	PES-R	Acceptable (0,1)	Moderate (2,0)	29	Rubber, chemical, rug
T04	Ac-Tx	Not acceptable (-0,2)	Moderate (2,6)	29	Rubber, sour, rug
T05	PP-R	Acceptable (0,30)	Moderate (1,5)	29	Rubber, rug
T06	PA-Rl	Not acceptable (-0,18)	Moderate (2,0)	22	Rubber, chemical
T07	PA-Rl	Neutral (0,0)	Moderate (1,8)	22	Rubber
T08	PA-Rl	Not acceptable (-0,25)	Moderate-strong (2,5)	22	Rubber
T09	PP-lm	Not acceptable (-0,10)	Moderate (2,0)	22	Rubber, sour
T10	W-lm	Acceptable (0,15)	Weak-Moderate (1,5)	22	Rot/mould
T11	PA-R	Not acceptable (-0,10)	Moderate (2,0)	20	Fish, rug, rubber
T12	W-C	Not acceptable (-0,05)	Moderate (2,0)	20	Rot/mould, sour
T13	Ac/PES-lm	Neutral (0,0)	Moderate-strong (2,5)	20	Rug, rubber, chemical
T14	AW-J	Acceptable (0,20)	Moderate (1,8)	20	(Rug, rubber)
T15	Ac/Vi-PES/C lm	Not acceptable (-0,15)	Moderate-strong (2,5)	20	Rug, sour
T16	PA-Wf lm	Acceptable (0,10)	Moderate (2,0)	29	Rug, chemical, sharp
T17	PA-Rl	Acceptable (0,13)	Moderate (1,8)	20	Sweet/stuffy, fish
T18	PP/PES-R	Acceptable (0,42)	Weak (1,2)	20	Rubber
T19	PA-R	Not acceptable (-0,10)	Moderate (1,9)	20	Fish, sour
T20	PA-R	Acceptable (0,47)	Weak (0,9)	20	Rubber
T21	PA-R	Acceptable (0,40)	Weak (1,0)	20	Rubber

n: No. of panellists
n≥3: Three or more panellists have described the odour perception with identical words.
Material abbreviations:
Upperside: Nylon (PA), Acrylic (Ac), Polypropylene (PP), Wool(W), Polyester (PES), Synthetic wool (AW), Viscose (Vi)
Backing: Rubber (R), Rubber-latex (Rl), Textile (Tx), Laminated/glued (lm), Jute (J), Felt (Wf), Cotton (C)

4.4.2 Initial test of content of fluorine

21 rugs were analysed for content of fluorine, out of which fluorine was found in 5 rugs. For 3 rugs of polyamide and 2 rugs of polypropylene a content of fluorine was demonstrated in the textile upperside of the rug, and the results are shown in Table 14. The results can be stated as weight of fluorine per mass or per area, in which both figures are shown for all rugs. It is the amount of

fluorine per area that gives the best basis for comparison of the rugs. The results show that the content of fluorine is similar in the evaluations in duplicate with two samplings at different spots of the rug (samples A and B), this implies therefore that the impregnation is evenly distributed in all rugs.

TABLE 14
CONTENT OF FLUORINE IN RUGS IN DUPLICATE EVALUATION

Rug	Sample	Area (cm^2)	Fluor (mg/kg)	Fluor (mg/m^2)	Upperside Material	Backing Material
T05[a]	A	9,1	28	5	PP	Rubber
	B	9,8	29	5		
T06	A	12,16	95	11	PA	Rubber
	B	12,6	95	11		(latex)
T18[a]	A	9,18	104	104	85% PP,	Rubber
	B	10,71	95	98	25% PES	
T20[a]	A	10,4	122	17	PA	Rubber
	B	11,44	125	16		
T21[a]	A	10,8	137	19	PA	Rubber
	B	12,5	151	19		

4.4.3 Conclusion of initial screening for odour and content of fluorine
Five rugs contained fluorine and the odour was determined to be acceptable for 4 out of 5 rugs with content of fluorine. The odour of T06 was not perceived as acceptable and the only immediate difference of the backing material is that it was informed that the rubber backing was made of latex.

T16 is a wall-to-wall rug and it is, therefore in principle, not included in this survey of children's rugs. The rug was, however, included because the supplier markets it as dirt treated. In spite of this, the analysis result showed no content of fluorine. As the odour of T16 is also acceptable, no further chemical examination was carried out on this rug.

4.5 Results from analysis of volatile compounds (VOCs)

4.5.1 Very volatile C1-C4 aldehydes (VVOC)
The emission of C1-C4 aldehydes from the rugs was measured after 1 day for 20 rugs and repeated after 28 days for the 5 rugs with the highest emission of aldehydes to see, whether the emission was increasing or decreasing. The air samples were analysed for formaldehyde, acetaldehyde, acrolein, propanal and butanal. The results appear from Table 15.

The emissions of C1-C4 aldehydes from children's rugs are very low. The measured concentrations have not been corrected for background concentrations in an empty chamber, which appears from the bottom of the Table, cf. ISO 16000-9/3. Formaldehyde and acetaldehyde were found in very low concentrations in the background measurements from the empty chamber, and most of the rugs do not emit significantly more than the background.

Only two rugs T10 and T12 emitted acetaldehyde, they are both wool rugs. Half of the rugs emitted formaldehyde in concentrations between 2-5 µg/m^2h.
All rugs emitted less than 6 µg/m^2h formaldehyde and 5 µg/m^2h acetaldehyde except for rug T12, which emitted 25 µg/m^2h acetaldehyde, 14 µg/m^2h acrolein and 1 µg/m^2h butanal.

A check measurement for C1-C4 aldehydes was carried out after 28 days of five rugs (T12, T15, T18, T19, and T20), a decrease was observed in the emission of the low C1-C4 aldehydes from 1 to 28 days.

TABLE 15
EMISSION OF C1-C4 ALDEHYDES AFTER 1 DAY (28 DAYS), STATED AS AREA SPECIFIC EMISSION RATE (µg/m²h)

Rug	Material	Formaldehyde	Acetaldehyde	Acro-leine	Propanal	Butanal
T01	PA-Rl	0,9	2,8	< 1	< 0,8	< 0,8
T02	PES-R	1,9	2,1	< 1	< 0,8	< 0,8
T03[a]	PES-R	1,6	2,8	< 1	< 0,8	< 0,8
T04	Ac-Tx	2,4	2,6	< 1	< 0,8	< 0,8
T05[a]	PP-R	1,3	1,2	< 1	< 0,8	< 0,8
T06	PA-Rl	3,4	2,5	< 1	< 0,8	< 0,8
T07	PA-Rl	3,1	2,2	< 1	< 0,8	< 0,8
T08	PA-Rl	1,9	2,4	< 1	< 0,8	< 0,8
T09	PP-lm	3,4	2,7	< 1	< 0,8	< 0,8
T10[a]	W-lm	2,7	4,8	< 1	< 0,8	< 0,8
T11	PA-R	0,7	1,6	< 1	< 0,8	< 0,8
T12	W-C	1,8 (2,1)	25 (4,7)	14 (< 1)	<0,8 (<0,8)	1,1 (<0.8)
T13	Ac/PES-lm	1,5	2,0	< 1	< 0,8	< 0,8
T14[a]	AW-J	0,9	1,8	< 1	< 0,8	< 0,8
T15	Ac/Vi-PES/C lm	2,4 (1,0)	1,5 (1,5)	< 1 (< 1)	<0,8 (<0,8)	<0,8 (<0,8)
T17[a]	PA-Rl	0,9	2,0	< 1	< 0,8	< 0,8
T18[a]	PP/PES-R	5,3 (1,4)	1,5 (1,5)	< 1 (< 1)	<0,8 (<0,8)	<0,8 (<0,8)
T19	PA-R	0,8	1,4	< 1	< 0,8	< 0,8
T20[a]	PA-R	3,9 (1,1)	1,5 (1,5)	< 1 (< 1)	<0,8 (<0,8)	<0,8 (<0,8)
T21[a]	PA-R	4,3 (1,3)	1,4 (1,5)	< 1 (< 1)	<0,8 (<0,8)	<0,8 (<0,8)
Empty chamber	-	0,8	2,0	< 1	< 0,8	< 0,8

Concentrations stated as "< numerical value" means that the substance has not been detected above the limit of detection (LOD).

Material abbreviations:

Upperside: Nylon (PA, Acrylic (Ac), Polypropylene (PP), Wool(W), Polyester (PES), Synthetic wool (AW), Viscose (Vi)

Backing: Rubber (R), Rubber-latex (Rl), Textile (Tx), Laminated/glued (lm), Jute (J), Felt (Wf), Cotton (C)

[a]Acceptable odour (median)

4.5.2 Volatile organic compounds (VOCs)

The children´s rug emission of VOCs was measured after 1 day and repeated after 28 days. All the analysed VOCs including VVOC and SVOC appear from tables in Appendix 3 for each rug. For the sake of clarity, the VOCs relevant to this survey are selected and shown in the summary tables 16 and 17.

Aldehydes

The emission of higher aldehydes (C5-C10) was highest for the rugs T04 and T12. Butanal (VVOC), hexanal, heptanal and octanal were found in the emissions after 1 day in T12, which was the rug that emitted most low aldehydes (C1-C4) cf. Table 15. Nonanal and decanal emitted from all rugs, but after 28 days, the emission of aldehydes was not measurable except for a small amount of decanal in T08.

Carboxylic acids

Acetic acid emitted from all the rugs after 1 day and for more of the rugs after 28 days. Acetic acid constitutes a large part of the total amount of VOC from the rugs. Propane acid was also found in smaller concentrations 1-3 $\mu g/m^2h$ in the emissions after 1 day in more rugs, but it could not be detected after 28 days.

Hydrocarbons

Hydrocarbons (the sum of aliphatic and aromatic hydrocarbons) constitute a large part of the total VOC-emissions of the rugs, especially, for the rugs T08, T09 and T14.
The linear alkanes, decane (C10), undecane (C11), dodecane (C12), tridecane (C13), tetradecane (C14) and pentadecane (C15) are the most frequently occurring aliphatic hydrocarbons.
Naphthalene and 4-PCH are the most frequently occurring aromatic hydrocarbons, in which naphthalene emits from 10 out of 20 rugs and 4-PCH emits from all the rugs except for T11 and T18.
To this comes the branched isomers, which are quantified individually and added for a sum. The sum of C6-C16 hydrocarbons is constituted by aliphatic and aromatic hydrocarbons, all of which have not been identified. The aromatic hydrocarbons constitute approx. 30-40 % of the total hydrocarbons in 5 of the rugs after 1 day (T03, T06, T07, T08, and T13).

Phthalates VOC and SVOC

The VOC diethyl phthalate (DEP) was found in the emissions after 1 day at low concentrations; 1-3 $\mu g/m^2h$. No SVOC phthalates were detected after 1 or 28 days.

Other VOCs

The alcohol 2-ethyl-1-hexanol was found in the emissions from all the rugs. The rugs T06, T07, T18, T20, T21 emit a dialcohol (2,4,7,9-tetramethyl-5-decyn-4,7-diol) named acetylene glycol, which acts like a softener and antifoam agent in aqueous solutions for dispersal of pigments, surface treatments etc. (PubChem 2016).

TABLE 16
EMISSION OF VOCS (C6-C16) AFTER 24 HOURS AS SUM OF SUBSTANCE GROUPS, MEASURED AS THE CONCENTRATION THAT EMITS PER SURFACE AREA PER HOUR (AREA SPECIFIC EMISSION RATE (µg/m²h))

Rug	Material	Aldehydes ($\geq C5$)	Carboxylic acids	Total hydrocarbons	Aromatic hydrocarbons	DEP	CMR-substances
T01	PA-Rl	6	305	88	15	2	-
T02	PES-R	9	352	99	14	3	DMF
T03[a]	PES-R	6	17	61	18	1	DCM, DMF, styrene
T04	Ac-Tx	12	3	87	14	-	-
T05[a]	PP-R	6	11	168	34	2	Phenol, naphthalene
T06	PA-Rl	7	46	208	73	1	Naphthalene
T07	PA-Rl	4	19	214	60	2	Phenol, naphthalene
T08	PA-Rl	7	15	372	143	2	Phenol, naphthalene
T09	PP-lm	7	502	482	106	1	Benzene, naphthalene
T10[a]	W-lm	6	52	60	11	2	Toluene, naphthalene
T11	PA-R	6	302	161	15	-	Naphthalene
T12	W-C	13	8	98	21	1	Toluene, naphthalene
T13	Ac/PES-lm	7	46	73	27	1	Toluene, phenol
T14[a]	AW-J	4	62	768	78	1	DCM, toluene, naphthalene
T15	Ac/Vi-PES/C lm	1	5	93	12	1	-
T17 [a]	PA-Rl	6	367	108	12	1	-
T18[a]	PP/PES-R	5	42	148	10	1	Naphthalene
T19	PA-R	7	264	129	10	1	DCM, phenol
T20[a]	PA-R	5	58	103	3	1	DCM, phenol
T21[a]	PA-R	5	26	119	4	1	-

Material abbreviations:
Upperside: Nylon (PA, Acrylic (Ac), Polypropylene (PP), Wool(W), Polyester (PES), Synthetic wool (AW), Viscose (Vi)
Backing: Rubber (R), Rubber-latex (Rl), Textile (Tx), Laminated/glued (lm), Jute (J), felt (Wf), Cotton (C)
’Total hydrocarbons are including aromatic hydrocarbons
[a]Acceptable odour (median)

TABLE 17
EMISSION OF VOCS (C6-C16) AFTER 28 DAYS AS SUM OF SUBSTANCE GROUPS, MEASURED AS THE CONCENTRATION THAT EMITS PER AREA RUG PER HOUR (AREA SPECIFIC EMISSION RATE (µg/m²h))

Rug	Material	Aldehydes ($\geq C5$)	Carboxylic acids	Total hydrocarbons	Aromatic hydrocarbons	DEP	CMR-substances
T01	PA-Rl	-	127	3	1	-	-
T02	PES-R	-	191	1	-	-	-
T03[a]	PES-R	-	5	1	1	-	-
T04	Ac-Tx	-	-	9	2	-	-
T05[a]	PP-R	-	12	9	-	-	-
T06	PA-Rl	-	1	8	8	-	-
T07	PA-Rl	-	14	5	-	-	-
T08	PA-Rl	5	10	20	5	-	Naphthalene
T09	PP-lm	-	61	105	5	-	-
T10[a]	W-lm	-	25	-	-	-	-
T11	PA-R	-	84	2	-	-	-
T12	W-C	-	5	-	-	-	-
T13	Ac/PES-lm	-	5	8	5	-	-
T14[a]	AW-J	-	1	132	15	-	-
T15	Ac/Vi-PES/C lm	-	-	6	2	-	-
T17[a]	PA-Rl	-	169	-	-	-	-
T18[a]	PP/PES-R	-	1	-	-	-	-
T19	PA-R	-	38	5	-	-	-
T20[a]	PA-R	-	-	-	-	-	-
T21[a]	PA-R	-	-	2	-	-	-

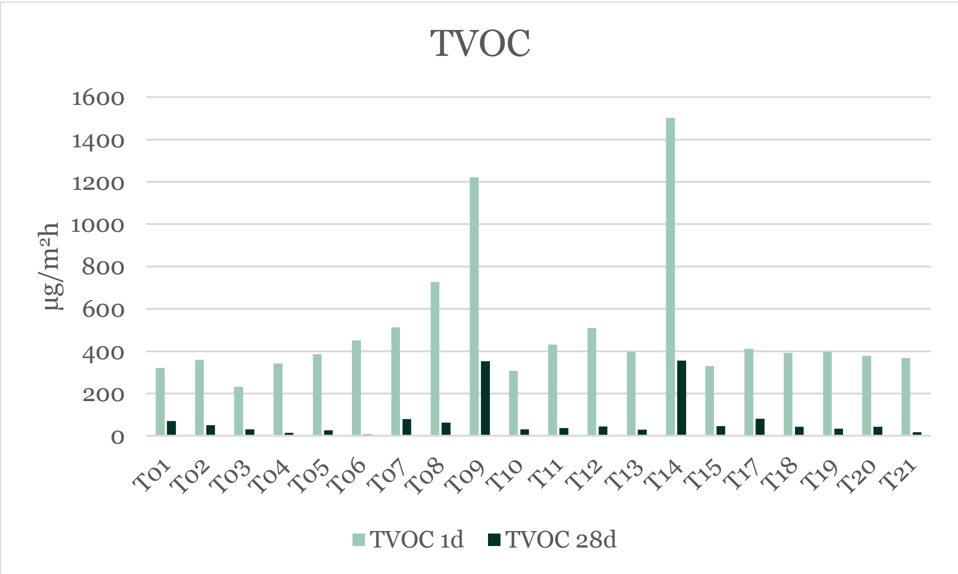
Material abbreviations:
Upperside: Nylon (PA, Acrylic (Ac), Polypropylene (PP), Wool(W), Polyester (PES), Synthetic wool (AW), Viscose (Vi)
Backing: Rubber (R), Rubber-latex (Rl), Textile (Tx), Laminated/glued (lm), Jute (J), felt (Wf), Cotton (C)
'Total hydrocarbons are including aromatic hydrocarbons
[a]Acceptable odour (median)

4.5.3 Total emissions of VOC and SVOC

The total emission of VOC (TVOC) is measured according to ISO 16000-6 as the total area of the chromatogram between C6 to C16, and labelling schemes for rugs have threshold limits for TVOC (Oeko-Tex®, GUT).

The total amount of VOC emitting after 1 day is reduced by 71-99 % after 28 days. The three rugs (T02, T09 and T14) that emit SVOC consist of different materials and emit different VOCs. However, not all rugs emit lower concentrations of TSVOC after 28 days than after 1 day. TSVOC for T09 and T14 decrease 6% and 59% respectively. The emission of TSVOC from T09 is higher than TVOC after 28 days, which is consistent with a former examination of other rugs (Wilke *et al.*, 2004).

For rug T14 the TVOC drops to almost the same level as for TSVOC. This appears clearly from the GC-MS chromatograms for T14 shown in Figure 6, in which the intensity (abundance) of TIC (total ion chromatogram) the peaks for VOC with short retention times decrease less, while SVOCs with long retention times (higher boiling point) do not change level from day 1 to 28 days.



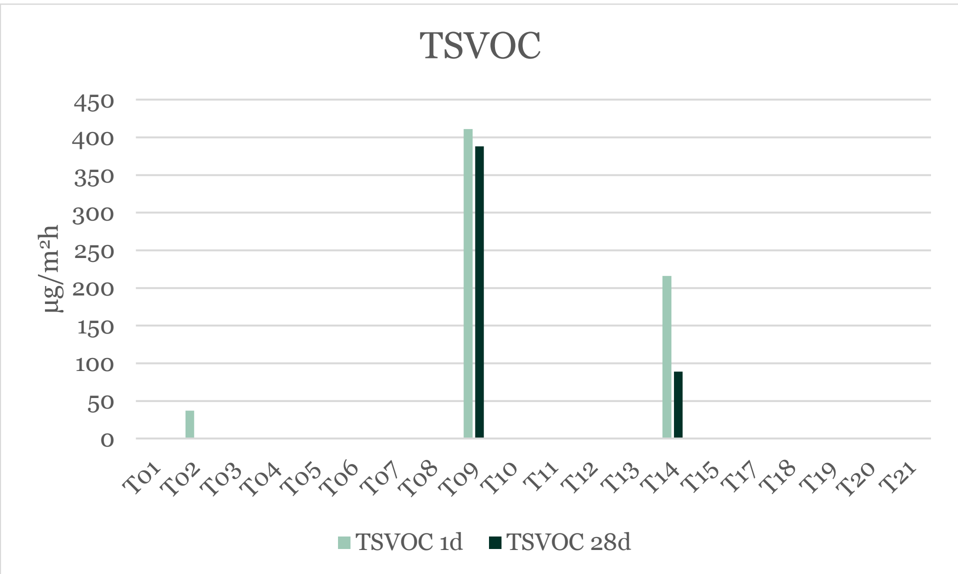
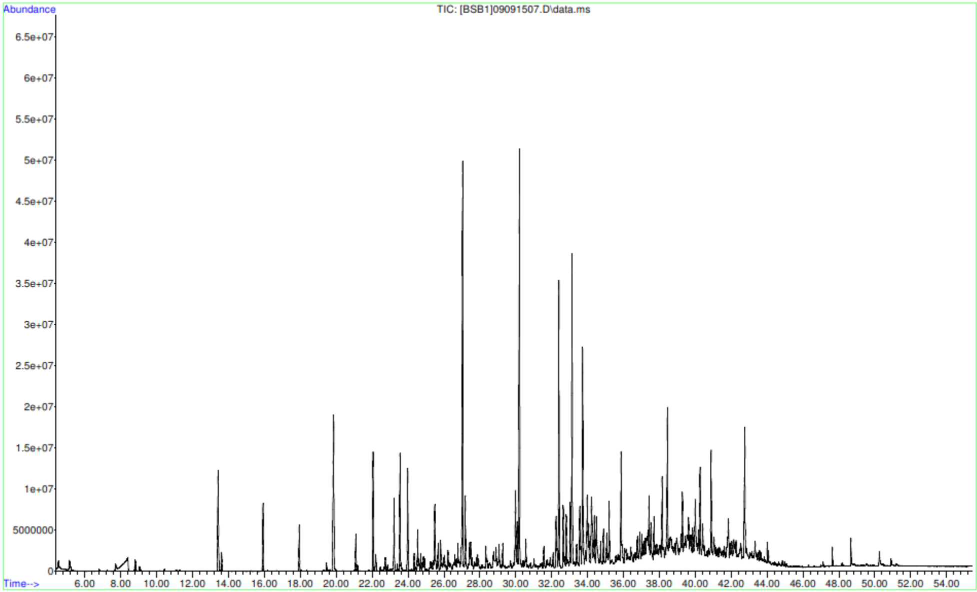


FIGURE 5. CONCENTRATION OF TVOC AND TSVOC AFTER 1 DAY AND 28 DAYS RESPECTIVELY FOR T14.

TIC: T14 VOC 1 day:



TIC: T14 VOC 28 days:

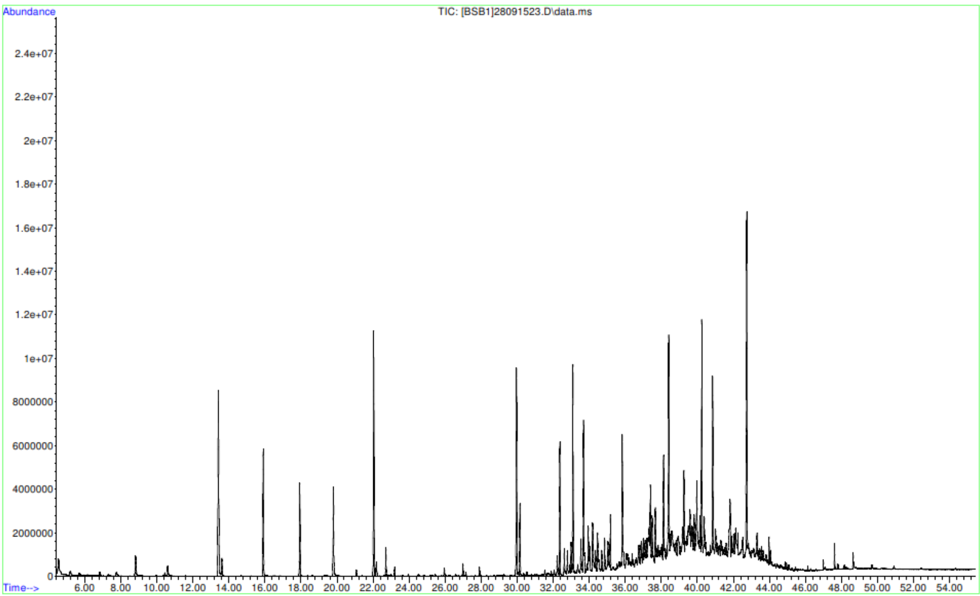


FIGURE 6. RUG T14. GC-MS TOTAL ION CHROMATOGRAM (TIC) OF VOC SAMPLED ON TENAX AFTER 1 DAY AND 28 DAYS RESPECTIVELY

4.6 Content of Phthalates

Apart from DEP, no other volatile phthalates were identified in the emissions such as VOC or SVOC. All the rugs including the backings were analysed for content of the phthalates DEHP, DBP, BBP, DINP, DIDP, DNOP and DIDP. DBP was found in one rug T12 with a content of 22 mg/kg corresponding to 0.0022 weight percentage (w/w %). T12 is the only wool rug, which is laminated or glued with cotton backing in the examination. The rest of the rugs appeared not to contain phthalates. A supplier is obliged to inform about content of candidate list compounds (SVHC) in articles (including rugs) cf. REACH with a threshold limit of 0.1 weight percentage, and rug T12 is far below this limit.

4.7 Content of fluorinated substances (PFAS)

By the VOC analyses no volatile PFAS were identified in the emission from the rugs. Analyses were carried out for content of volatile fluorinated substances, fluortelomer alcohols (FT-OH) by GC-EPED and non-volatile fluorinated substances (PFCA, PFSA etc.) by LC-MS/MS of the textile surface of rugs T05, T06, T18, T20, and T21. The results are stated as concentration per weight of the textile fibres appear from Table 18. The results stated as concentration per area of the rug including a list of all the analysed substances are stated in appendix 4.

TABLE 18

DEMONSTRATED CONTENT OF FLUORINATED SUBSTANCES (PFAS) IN THE TEXTILE UPPERSIDE OF THE RUGS, STATED AS CONCENTRATION PER WEIGHT (ng/g)

Substance	CAS-no.	T05extra (ng/g)	T05 (ng/g)	T06 (ng/g)	T18 (ng/g)	T20 (ng/g)	T21 (ng/g)
Total fluor[1]	-	-	***28500***	***95000***	***99500***	***123500***	***144000***
Perfluoroalkyl Carboxylic acids (PFCA)							
PFBA	375-22-4	0,39	**0,36**	<0,10	<0,16	<0,13	<0,13
PFPeA	2706-90-3	0,36	**0,42**	<0,17	<0,16	<0,16	<0,17
PFHxA	307-24-4	0,43	**0,68**	<0,17	<0,18	<0,33	<0,23
PFHpA	375-85-9	0,54	**0,77**	<0,11	<0,35	<0,19	<0,18
PFOA	335-67-1	3,53	**5,90**	**0,17**	**0,25**	**0,22**	**0,18**
Perfluoroalkane sulfonic acids (PFSA)							
PFHxS	355-46-4	0,25	**0,22**	<0,22	<0,22	<0,22	<0,22
PFOS	1763-23-1	<0,39	**0,42**	<0,13	<0,17	<0,30	<0,13
iso-PFOS	-	<0,40	**0,59**	<0,14	<0,17	<0,15	<0,14
Fluortelomer sulfonates (FTSA)							
6:2 FTSA[p] **(4H-PFOS)**	27619-97-2	<0,04	<0,03	**2,01**	**1,19**	**1,27**	<0,05
Total PFAS	***-***	***5,50***	***9,36***	***2,18***	***1,44***	***1,49***	***0,18***
Ratio [PFAS: Fluorine] (%)		-	*0,0328%*	*0,0023%*	*0,0014%*	*0,0012%*	*0,0001%*

[1]Values transferred from Table 14.

[p] Partly fluorinated, analysed by LC-MS/MS.

Values stated in **bold** are the concentrations demonstrated above the limit of quantification LOQ.

Analyses were carried out for PFAS to the extent that reference substances and methods were available. Acrylates could not be analysed by the method applied. Lassen *et al.* (2014) demonstrated fluoromethacrylates (FMAC, FTMAC) in textiles, but in concentrations, which are a factor 10 lower than the corresponding acids (PFCA) and telomers (FTOH), and the acrylates have not been demonstrated alone without presence of other PFAS. Rug T05 was at first not analysed for content of PFAS, because the initial screening (Table 14) showed the lowest content of fluorine. The rugs T06, T18, T20 and T21 contained very low concentrations of the PFAS examined, and therefore the last rug T05 was subsequently analysed (Table 18).

Most of the analysed PFAS were demonstrated in rug T05, and most are C8-fluorinated substances i.e. PFOA, PFOS, iso-PFOS, which indicates that C8-chemical was used for impregnation.

PFOA was found in all the rugs in low concentrations, but in the highest concentration in rug T05. Rug T05 had the lowest content of fluorine, and it contained the highest concentrations of PFAS (0.0328 weight % PFAS of total fluorine), and rug T21 had the highest content of fluorine, but the lowest concentration of PFAS (0.0001 weight % PFAS of total fluorine). A high total content of fluorine can therefore not be correlated to a high content of PFAS cf. data shown in Table 18 and Appendix 4.

No volatile fluortelomers (FTOH) or other volatile fluorine compounds (VFOC) were found in any of the rugs, which is surprising, as they are always present in both new and used rugs[6]. To verify this finding, a new rug T05 was bought from the same supplier, but still, no volatile compounds were found in this rug (se Appendix 4). A lower PFAS concentration was found in the extra rug T05, this may be due to different batches, storage and age of the two rugs T05 (extra) and T05. Data for PFAS from the originally purchased rug T05 will be used for further evaluation, as PFAS was found in the highest concentrations in this rug.

4.8 Conclusions, chemical analysis of VOC, phthalates and PFAS

Emission of VOC

Most VOCs identified in the survey (Table 17, Table 18, Appendix 1) were found in the emission from the rugs (Appendix 3). There are findings of more different VOCs, which may origin from solvents used in the production of the rugs both as ingredients in the textile upperside, the dyeing, backing, gluing and lamination. Finally, lubricants and oils from the machines can settle in the rugs during the production. There is no clear relation between the materials and VOCs found in the emissions.

After 1 day the VOCs (naphthalene, phenol, styrene, toluene, dimethylformamide, dichlormethane, and benzene) were measured with CMR hazard classification in 15 out of 20 rugs. After 28 days, however, naphthalene was measured in the emission from only one out of 20 rugs.

VOCs still emitting after 28 days are either highly volatile or emit from the backing of the rug, through which the VOCs can diffuse via the textile surface. By ageing of materials under the influence of oxygen, heat, moisture and light, a chemical destruction can take place, so that new VOC's are formed. As examination of VOCs was carried out by constant climate conditions with no influence of light and heat, these reactions will be limited, however, reaction with atmospheric air may occur.

Evaluation according to Labelling Schemes

The emission of the rugs was measured with a loading factor (material load) of 1 m^2/m^3, i.e. a 2,5 times larger area of rug was used, than if a loading factor of 0,4 m^2/m^3 had been applied corresponding to a rug covering the entire floor in a standard room (ISO 16000-9, GUT, Oeko-Tex®). The air change in the climate chamber is at the same time twice a large (1 h^{-1}), as in the standard room (0.5 h^{-1}). This implies overall that during testing, that there is a lower area specific ventilation rate of q=1.0 m^3/m^2h in the climate chamber, while it is q=1.25 m^3/m^2h in the standard room. Thereby, better limits of detection are obtained of the test conditions applied.

The measured VOC concentrations at q=1.0 m^3/m^2h can be converted to the concentrations at q=1.25 m^3/m^2h using the following formula:

$$C_{Model} = C_{Measured} \cdot \frac{q_{Measured}}{q_{Model}} = C_{Measured} \cdot 0{,}8$$

[6] Personal communication, Ludwig Gruber, Fraunhofer IVV (November 2015).

By multiplying the measured concentrations of C1-C4 aldehydes (Table 15) and VOC concentrations (Table 16, Table 17, Appendix 3) respectively with a factor 0.8, it can, therefore, be deduced whether the rugs fulfil the requirements of the labelling schemes cf. Table 6.

Oeko-Tex® has threshold values for emission of VOC after 16 hours, which can be compared with the corrected values after 1 day: The rugs T09 (TVOC 977 µg/m³) and T14 (TVOC 1201 µg/m³) do not fulfil the requirements of Oeko-Tex® for TVOC less than 500 µg/m³. Both rugs emit high concentrations of especially aliphatic hydrocarbons, and T09 also emits acetic acid in a high concentration. Butadiene was not measured, as it requires another measurement method. Rug T14 marketed as Oeko-Tex® labelled does not meet the TVOC threshold value.

The threshold values of GUT and Blauer Engel after 28 days were compared with the corrected measured values after 28 days. The rugs T09 (TVOC 282 µg/m³) and T14 (TVOC 284 µg/m³) exceeded the threshold value for TVOC of 100 µg/m³. The rugs T09 (TVOC 282 µg/m³) and T14 (TVOC 284 µg/m³) exceeded the threshold value for TVOC of 100 µg/m³. The rugs T09 (TSVOC 310 µg/m³) and T14 (TSVOC 71 µg/m³) exceeded the threshold value for TSVOC of 30 µg/m³.

It applies to all rugs that concentrations of aldehydes and aromatic hydrocarbons including 4-PCH do not exceed the threshold values after 1 day (Oeko-Tex) and 28 days (GUT, Blauer Engel). There are no threshold values for carboxylic acids in the labelling schemes.

Odour Perception and VOC
A qualitative, sensory evaluation of the rugs was carried out, in which acceptance is used as the most significant evaluation parameter. The odours were described as: Rubber, chemical, rug, sour, sweet/stuffy, rot/mould and fish. There were many odour relevant VOCs in the emissions after 1 day including aldehydes, carboxylic acids and hydrocarbons. The VOCs found had a characteristic odour, and this can in cases be correlated with the description of the odour. Descriptions of the odour of individual substances can be found on the Internet in the databases ”PubChem Compound”, ”OSHA”, ”The good scents company”, ”The pherobase”. A recent examination of odorants in consumer products refers to these databases and to own measurements by GC connected with olfactometer (Bartsch *et al*, 2016).

Substances, which are added to consumer products as odorants are found in the emissions from some of the children’s rugs in this survey (Appendix 3) and they have also formerly been found in rugs (Appendix 1). Benzylalcohol has a flowerish odour and was found in two rugs (T03 and T08). Terpenes are naturally occurring odorants, where limonene has a citrus odour and was found in three rugs (T08, T14, T17), and 3-carene has a sweetish odour and was found in 14 rugs. Even though these substances have odours, perceived as pleasant, the rugs emit other substances, which imply that the odour perception cannot be perceived as acceptable.

The two wool rugs T10 and T12 have the sensory perception of rot/mould to some of the panellists. They are at the same time the only two rugs, in which acetaldehyde was found in the emissions. The odour of acetaldehyde is described as that of green apples and slightly sticky, which when connected to other substances can give rise to an unacceptable odour. Butanal found in T12 has a sharp and stuffy odour. Wool surface treated with wax emits different volatile compounds depending on temperature and relative humidity including: Ethanol, acetone, aliphatic hydrocarbons and volatile sulphurous substances; carbonylsulfide, dimethylsulfone, carbondisulfide and methanethiol identified by special GC methods (Lisovac *et al.* 2003). Ethanol and acetone were found in the emissions from both wool rugs T10 and T12.

The result of this survey is that the odour of 12 out of 21 children’s rugs is not acceptable, which corresponds with a former examination carried out on 51 different rugs, which showed a distinct to strong odour in 25 rugs after 1 day and 20 rugs after 28 days (Oeko-Test, 2002). All 6 wool rugs included in the examination had the evaluation ”distinct to strong odour” after both 1 and 28 days. The other 4 rugs made of natural materials sisal, sea grass, coconut, natural latex also had the evaluation ”distinct to strong odour” after both 1 and 28 days. It is unknown whether the natural material itself smells or if the odour is from the chemicals used for production of the rugs made of natural materials.

Naphthalene (”tar, oil”) and 4-PCH (”new rug”) are aromatic hydrocarbons found in the emissions from more of the rugs, which were given the evaluations “chemical and rug”.

Acetic acid has a sourish odour and emits in high concentrations from 6 rugs (T01, T02, T09, T11, T17, T19) and rugs that emit high concentrations of acetic acid had the description ”sour” and the 5 rugs do not have an acceptable odour. One rug T17 has a just acceptable odour, which can be due to other VOCs modifying the perceived odour. It is evaluated that the emission of acetic acid in high concentrations contribute to the odour being perceived as not acceptable.

The sensory perception of the rugs is not quite consistent neither what regards the materials, nor the VOCs identified nor C1-C4 aldehydes in the emissions. This is due to the odour perception being composed of many different substances, and therefore it is difficult to conclude on single substance level. It is impossible to correlate the measured concentrations of VOC in climate chamber directly with the sensory evaluations for odour, because the concentrations are not the same as those used for the evaluation. There are many more substances than the analysed VOCs, which are odour relevant at low concentrations, e.g. by nitrogenous amines (fishy odour) and sulphurous mercaptans (rotten odour).

More VOCs (naphthalene, phenol, styrene, toluene, dimethylformamide, dichlormethane, benzene) with CMR hazard classification were identified in the initial emissions after 1 day. Naphthalene emitted from 8 of the rugs and it was the CMR substance that emitted in the highest concentrations. VOCs with CMR classification emitted from 5 out of 9 rugs with an acceptable odour, it can thus not be assessed on basis of odour acceptance, whether a rug emits CMR-substances.

In the emissions after 1 day, several VOCs on the Danish LOUS list were identified: Formaldehyde, hexane, phenol, styrene, toluene and DMF.

The emission of aldehydes decreased between 1 and 28 days for five rugs (T12, T15, T18, T19, and T20). It can be concluded that no glues emitting aldehydes have been used, as was demonstrated in former examinations of glues for rugs (Wilke *et al.*, 2004). The emissions of C1-C4 aldehydes from children’s rugs are very low and confirm the results from former examinations of rugs, performed by the Danish Technological Institute (Table 2) and in the literature (Appendix 1).

Hydrocarbons constitute a large part of the total VOC emission from the rugs. The linear alkanes; decane (C10), undecane (C11), dodecane (C12), tridecane (C13), tetradecane (C14) and pentadecane (C15) are the most frequently occurring aliphatic hydrocarbons. Naphthalene and 4-PCH are the most frequently occurring aromatic hydrocarbons, where naphthalene emits from 10 out of 20 rugs and 4-PCH emits from 18 rugs.

Five rugs contained PFAS and the odour was determined as acceptable for 4 of the rugs with content of PFAS (T05, T18, T20, and T21). As the impregnation forms a layer over the textile surface of the rugs making it dirt and water repellent, it is possible that impregnation could also encapsulate odour by blocking emission of VOCs from a rug. The emission of odour relevant carboxylic acids was low for these rugs cf. Table 17 and Appendix 3, and common for these rugs was odour perception ”rubber”, which indicates emissions from the rubber backing.

Content of Phthalates and PFAS

As no phthalates or volatile PFAS were found in the emissions, it was impossible to select a rug for worst-case exposure scenario for long term test of dust and fibres in climate chamber cf. the analysis programme in Figure 3. If there had been a high content in the rugs, it would have been possible to measure phthalates and possibly PFAS in the emissions, and it would have been easy to select worst-case rugs for dust analysis. Phthalates and PFAS can occur in very low concentrations <1 µg/m^3. The fact that no phthalates or fluorinated substances were found in VOC analyses, does not mean that the rugs do not contain them. Therefore, content analyses were carried out instead of tests with dust.

All rugs including backing were analysed for content of phthalates. The only rug that contained phthalate was T12, which is a wool rug with cotton backing, in which DBP was demonstrated. 4-PCH was found in the emission, which can indicate that SBR based glue may have been used. Glues for rugs have formerly been suspected for content of phthalates (Tønning *et al*, 2010; Kaberlah *et al*, 2011).

The 5 rugs with demonstrated content of fluorine in the textile upperside were analysed for content of PFAS. One rug T05 had a higher content of PFAS than the other 4 rugs, even though the rug had the lowest total-fluorine content in the upperside. Rug 21 with the highest content of fluorine showed the lowest content of PFAS. PFOA was found in all 5 rugs. Detection of the fluorinated substances in more of the rugs PFOA, PFOS, iso-PFOS and 6:2 FTSA indicate that C8-chemical is still used for impregnation of rugs. None of the 5 rugs contained volatile fluorine compounds including fluortelomers (FT-OH).

The results with demonstrated content of fluorine and PFAS in the rugs with a textile upperside made of materials PA and PP confirm former findings of PFAS in rugs with these synthetic textile materials cf. Table 4 in section 2.5.2.

Textiles or other materials with coating may not contain more than 1 µg PFOS/m^2 due to the Stockholm Convention[7]. Rug T05 contains 0.54 µg/m^2 PFOS and 0.73 µg/m^2 iso-PFOS. As the Stockholm Convention only applies to linear PFOS and not branched isomers such as iso-PFOS, the concentration of this rug is under the tolerated limit. The measured concentrations are above the detection limit and by repeated measurement, where the equipment had a detection limit of 0.48 µg/m^2 for PFOS, no PFOS were found and this corresponds with the expanded degree of accuracy being 34.5%.

Less than 0.03 weight percentage of the total content of fluorine are identified PFAS single substances, and therefore there must be new fluorine compounds present, for which no reference substances exist due to the current industrial development of fluorine chemical products[8]. There are still traces of PFOA in the rugs, this could be a destruction product from these new impregnation agents. Another explanation for the lacking analysis finding of PFAS is that fluorine is built-in in polymers, which are insoluble and are analysed as single substances. Fluorine compounds with functional groups (e.g. fluoracrylates or fluorosilanes), which can form covalent bonds to the surface of the materials, are not released. For verification of these, solid substance chemical and other methods intended for polymers should be applied.

It is possible that the American stewardship programme[9] and the coming EU restriction[10] already now have forced the raw material producers to produce cleaner fractions of PFAS active ingredients

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[7] Stockholmkonventionen: http://chm.pops.int/default.aspx

[8] Personal communication, Ludwig Gruber, Fraunhofer IVV and Xenia Trier, DTU (December 2015).

[9] https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/perfluorooctanoic-acid-pfoa-perfluorooctyl-sulfonate (March 2016)

[10] http://echa.europa.eu/view-article/-/journal_content/title/rac-concludes-on-pfoa-restriction (March 2016)

(including acrylates and silanes and other unknown substances), so that they are “only” contaminated to a small degree by the examined, problematic PFAS.

Substances were identified in the childrens rugs, which are on the LOUS and SVHC lists of problematic aubstances; the phthalate DBP, the PFAS PFOA and the VOC dimethylformamide (DMF).

5. Health based risk assessment

5.1 Methods for risk assessment

The risk assessment is based on the guidelines used in connection with the REACH chemicals regulation (ECHA, 2008).

Assessment of risk of exposure from rugs

Risk assessment is made by calculating the risk characterisation ratio (RCR) for the individual substances, where RCR is defined by:

$$RCR(1) = \frac{Calculated\ exposure\ (1)}{DNELvalue(1)}$$

If the calculated exposure to a substance exceeds the tolerable level of exposure (the DNEL-value) the RCR value will be above 1 and the exposure scenario is considered to pose an unacceptable risk.

Then, in order to evaluate the risk of concurrent exposure to several substances (a group of substances) with the same mode of action, summation of the individual RCR-values is used:

$$RCR(grp) = RCR(1) + RCR(2) + \ \dots RCR(n)$$

If $RCR_{(grp)}$ exceeds 1, the total exposure to the substances is considered to constitute an unacceptable risk.

5.2 Selection of rugs for risk and exposure assessments

Based on the analytical results given in Section 4 and in Appendix 3, the rugs with the highest emission of *hydrocarbons, aldehydes and carboxylic acids* are identified. The risk assessment initially focuses on the 'worst' rugs to determine whether the risk due the emissions from these causes concern for children staying in the room. Similarly, the rugs with the highest content of the problematic *phthalates and PFAS* are used for risk assessment.

5.2.1 Emission and calculation of room concentration of VOC substances

The rugs with the most extensive emission of hydrocarbons, aldehydes and carboxylic acids were selected for further assessment. Based on review of analytical data in Section 4 and Annex 3, rug T14 had the highest emission of hydrocarbons, rug T12 had the highest emission of aldehydes and rug T15 had the highest emission of carboxylic acids.

Table 19 indicates the emission values for these rugs, and calculation has been made of the VOC concentration in a standard children's room (calculation method specified below the table). It should be noted that the measured VOC concentrations that are given in µg/m^3 in Annex 3, as a result of the selected test conditions have the same numerical value as the area-specific emission rate for the substances.

Furthermore, rugs were selected with the highest emissions for a number of specific substances, which based on their classification as carcinogenic or low tolerable exposure levels could be regarded as particularly critical (e.g. acrolein, benzene, naphthalene, formaldehyde).

TABLE 19
EMISSION OF CRITICAL COMPONENTS AND SUBSTANCE GROUPS FROM SELECTED RUGS, EMISSION RATE AND CONCENTRATION IN A CHILDREN'S ROOM

Critical components, Selected rugs	Area specific emission rate, 24 hours E_c (µg/m²h)	Concentration in the room, 24 hours C_M (µg/m³)
Hydrocarbons		
Rug T14, artificial wool/jute, area 2.8 m² (data Table B3.14)		
Heptane	1	0.32
Toluene	2	0.64
Sum, C7-C12 hydrocarbons	209	66.6
Sum of aliphatic hydrocarbons C7-C12	191	61.1
Sum of aromatic hydrocarbons C7-C12	17	5.44
Total sum, all hydrocarbons (C6-C16)	768	246
Aldehydes		
Rug T12, wool/cotton, area 2.16 m² (data Table B3.12)		
Formaldehyde	1.8	0.45
Acetaldehyde	25	6.21
Acrolein (2-propenal)	14	3.48
Butanal	3	0.74
Hexanal	1	0.25
Heptanal	1	0.25
Octanal	1	0.25
Nonanal	6	1.49
Decanal	2	0.50
Benzaldehyde	5	1.24
Sum aldehydes	60	14.8
Carboxylic acids		
Rug T09, polypropylene, area 1.5 m² (data Table B3.9)		
Acetic acid	498	84.7
Sum carboxylic acids	502	85.3
Other rugs with the highest content of critical individual components (highest levels found)		
Benzene (rug T09, area 1.5 m², Table B3.9)	2	0.34
Naphtalene (rug T08, area 0.5 m², Table B3.8)	71	4.06
Formaldehyde (rug T18, area 1.3 m², Table 15)	5.3	0.80

Air concentration and exposure from rugs in the children's room
In addition to the emission rate indicated in Table 19, the concentrations in a model children's room have been calculated. These calculations take into account the area of the rug and a "standard children's room" of 17.4 m³ with a floor area of 7 m² (see Section 3.5), and with an air change rate of

0.5 times per hour (h^{-1}). Loose rugs cover only a smaller part of the floor and form a smaller area than wall to wall carpeting in the standard room.

Example of calculation, rug T14:
With knowledge of the area-specific emission rate (Ec), the concentration in a children's room is calculated:

$$C_M = E_c \cdot \frac{A}{V \cdot n}$$

Where,
C_M: concentration of a chemical substance in the air of the model children's room (µg/m³)
E_C: the area specific emission rate from the object in the climate chamber (µg/m²h)
A: the area of the object in the children's room: Here set to 2.8 m² rug.
V: volume of the model room (m³). Here set to 17.4 m³
n: the air change in the model room (h^{-1}). Here set to 0.5 h^{-1} (minimum demand according to the Danish Building Regulation BR10)

$$C_M\left(\frac{\mu g}{m3}\right) = E_c \cdot \frac{2{,}8\ m2}{17{,}4\ m3 \cdot 0.5\ \mathrm{h}{-1}} = E_c \cdot 0.32\ h/m$$

That is, all the measured area specific emission rates for rug T14 are to be multiplied by a factor of 0.32 h/m to obtain the concentration in the children's room (µg/m³).

Correspondingly, the room concentrations for the other rugs are calculated considereing surface area of the rug, i.e. the concentrations in the room are generally calculated with one rug per room.

As the calculations are based on a standard room with a relatively good ventilation (0.5 h^{-1}), an essentially higher concentration of volatile substances after 24 hours could be imagined at lower air change rates. The Danish EPA (2016) has thus found essentially lower air change in numerous childrens rooms, in which this was measured. In 14 children´s rooms with no mechanical ventilation and with closed doors and windows, the measurements thus showed an average air change rate of 0.18 h^{-1} (interval from 0.05 to 0.38 h^{-1}).

Therefore, it is not unrealistic with a worst-case concentration about 5 times higher concentrations of volatile components in the air during the periods in which windows and doors are closed, and where the air exchange rate may be about 0.1 h^{-1}. Such a worst-case scenario is mostly realistic for shorter periods in the room (maximum one day), as common activity in the home with opening of doors and windows will increase the air exchange significantly.

5.2.2 Selection of rugs with content of critical phthalates and PFAS

For the critical non-volatile phthalates and PFAS, the following content as indicated in Table 20 can found as the highest from the available analyses:

TABLE 20
HIGHEST MEASURED CONTENT OF PHTHALATES AND PERFLUORINATED SUBSTANCES

Critical component	Analysed content in the rug
Phthalates **Rug T12 (wool/cotton) area 2.16 m²**	
Dibutyl phthalate (DBP)	22 µg/g

Fluorinated compounds (PFAS) Rug T05 (PP/rubber) area 1.5 m²	
PFBS (perfluorobutane sulfonic acid)	-
PFHxS (perfluorohexane sulfonic acid)	0.22 ng/g
PFOS (perfluorooctane sulfonic acid) + iso-PFOS	1.01 ng/g
PFOSA (perfluorooctane sulfonamide)	-
6:2 FTS (6:2 fluorotelomer sulfonic acid)	-
PFBA (perfluorobutanoic acid)	0.36 ng/g
PFPeA (perfluoropentanoic acid)	0.42 ng/g
PFHxA (perfluorohexanoic acid)	0.68 ng/g
PFHpA (perfluoroheptanoic acid)	0.77 ng/g
PFOA (perfluorooctanoic acid)	5.90 ng/g
PFNA (perfluorononanoic acid)	-
PFDA (perfluorodecanoic acid)	-
Sum	9.36 ng/g

Exposure
As stated in Section 3.10, the oral exposure route is considered to be the most significant in relation to exposure to phthalates and PFAS. In this context, it is assumed that a 1-3 year old child of 11.6 kg body weight ingests 100 mg dust per day.

For *DBP*, the exposure will be
22 µg/g x 0.1 g/day / 11.6 kg = 0.19 µg/kg day

For *the sum of the perfluorinated compounds (PFAS)*, the exposure will be
9.36 ng/g x 0.1 g/day / 11.6 kg = 0.08 ng/kg day (corresponding to 0.00008 µg/kg day)

For *PFOA*, the exposure will be
5.9 ng/g x 0.1 g/day / 11.6 kg = 0.05 ng/kg day (corresponding to 0.00005 µg/kg day)

For *PFOS + iso PFOS*, the exposure will be
1.01 ng/g x 0.1 g/day / 11.6 kg = 0.009 ng/kg day (corresponding to 0.000009 µg/kg day)

These exposures must definitely be regarded as worst-case regarding contribution from the rug, as it is assumed that the child ingests all the daily dust intake during a stay on the rug, and that all ingested dust comes from the rug. Typically, the average dust intake per day is the sum of many different microenvironments in which the child is staying.

5.3 Risk assessment

5.3.1 Risk assessment for emission from the rugs (VOC)

When assessing the risk of the volatile substances, the exposure values stated in Table 19 are compared with the tolerable levels specified in Section 3.2, and risk characterisation ratios (RCRs) are calculated for the exposures, as indicated in Section 5.1.

The RCR-values for the emission of VOCs from the selected rugs have been calculated and are shown in Table 21.

Risk assessment of the rug with the highest emission of hydrocarbons (T14, artificial wool/jute)
For the hydrocarbon content, it is seen that the levels are well below critical levels of neurotoxic effects, as the RCR-value for the sum of C7-C12 hydrocarbons is 0.004.

Risk assessment of the rug with the highest emission of aldehydes (T12, wool/cotton and T18, polypropylene/polyester/rubber)
For the total emission of aldehydes (except acrolein, see below), it is seen that the levels are well below critical levels of irritative effects, as the RCR-value for the sum of aldehydes is 0.02 for T12 when acrolein is not included.
For formaldehyde, an RCR-value of 0.008 for rug T18 could be calculated from the highest calculated concentration in the indoor environment. The rug therefore gives no cause for concern as to the emission of formaldehyde.

For acrolein, an RCR-value of 0.50 is achieved for short-term exposure for rug T12. If in relation to this value a worst-case situation is applied where the air exchange in the room is low, for example 0.1 times per hour, the RCR value would, however, be five times higher, and there would be a risk of respiratory irritation caused by emission of acrolein.
It should also be noted that the tolerable exposure level for long-term exposure to acrolein is very low (0.1 µg/m³). The detection limit of acrolein was approximately 0.75 µg/m²h, so it is not possible to assess whether the tolerable exposure level for long-term exposure has been exceeded for the rug T12 or the other rugs.

For rug T14 having the highest RCR-value, it may be relevant to look at whether the emission of other respiratory irritant substances, such as carboxylic acids, could contribute significantly to respiratory irritation. An emission of acetic acid was measured for the rug corresponding to a room concentration of 11 µg/m³, and therefore the irritation contribution from acetic acid, corresponding to an RCR-value of 0.04, is very low and thus does not play any decisive role.

TABLE 21
RISK ASSESSMENT OF EMISSION FROM SELECTED RUGS WITH THE MOST EXTENSIVE VOC EMISSION. INDICATION OF EXPOSURE LEVELS, TOLERABLE EXPOSURE LEVEL AND RCR-VALUES

Critical components, Selected rugs, area*	Concentration in children's rooms 24 hrs* (µg/m³)	Tolerable exposure level (µg/m³)	RCR
Hydrocarbons (data Table B3.14)			
Rug T14 (artificial wool/jute) area 2.8 m²			
Heptane	0.32	-*	
Toluene	0.64	700	0.0009
Sum, C7-C12 hydrocarbons	6.6	-	
Sum of aliphatic hydrocarbons C7-C12	61.1	-	
Sum of aromatic hydrocarbons C7-C12	5.44	1400	0.004
Aldehydes (data Table B3.12)			
Rug T12 (wool/cotton) area 2.16 m²			
Formaldehyde	0.45	100	0.0045
Acetaldehyde	6.21	1200	0.005
Acrolein (2-propenal)	3.48	7	0.50
Butanal	0.74	650	0.001
Hexanal	0.25	900	0.0003
Heptanal	0.25	900	0.0003
Octanal	0.25	900	0.0003
Nonanal	1.49	900	0.002
Decanal	0.50	900	0.0006
Benzaldehyde	1.24	90	0.014

Sum aldehydes	14.8	-	-
Sum RCR			0.528
Sum without acrolein			0.028
Carboxylic acids (data Table B3.9) **Rug T09 (PP/rubber) area 1.5 m²**			
Acetic acid	84.7	300	0.282
Sum carboxylic acids	85.3	300	0.284
Other rugs with the highest content of critical individual components (highest levels found)			
Benzene (T09, PP/laminated, area 1.5 m², Table B3.9)	0.34	0.17	2
Naphtalene (T08, PA/rubber, area 0.5 m², Table B3.8)	4.06	10	0.406
Formaldehyde (T18, PP-PES/rubber, area 1.3 m², Table 15)	0.80	100	0.008

*Tolerable exposure level not determined

Risk assessment of the rug with the highest emission of carboxylic acids (T09, PP/rubber)
For carboxylic acids, primarily acetic acid has been found, where an RCR-value for irritative effects of 0.28 is seen. This is of no immediate concern for the rug. For the rug with the highest RCR-value for irritation from carboxylic acids, it may be relevant to look at the contribution from the respiratory irritative aldehydes. The emission of aldehydes from this rug, however, was extremely low (corresponding to a calculated room concentration of 1.2 µg/m³ for the sum of nonanal and decanal), and therefore the irritation contribution of the aldehydes (corresponding to an RCR-value of 0.001) is insignificant.

But if for instance three rugs of 1.5 m² each are used in the room and the room is unventilated, the RCR-value could exceed 1, and 24 hours after unpacking the rugs there will be a risk of irritative mucosal effects. After 28 days, the emission and thus the RCR-value will be reduced by approximately 8-fold (Table B3.9).

Risk assessment of the rug with the highest emission of naphthalene (T08, PA/rubber)
WHO (2013) has for this substance established a tolerable level of 10 µg/m³ in order to protect against cancer and irritating effects in the respiratory system. The substance is classified as carcinogenic (Carc 2) in the EU. The substance is known from its use in mothballs (not allowed anymore in the EU) and may therefore have been used as protection of the rugs during storage especially from overseas countries. However, emission from the examined rugs does not give rise to concern, as the RCR-value for the rug was calculated to 0.4.
If several rugs are used in the room or at reduced air exchange (for example an exchange of 0.1 times per hour), the RCR value could exceed 1 in connection with the start of the use of the rugs. However, the levels are markedly reduced over a shorter period of time, as the emission of naphthalene from the rug from day 1 to day 28 was decreased to 3% compared to the level at day 1. As WHO's tolerable value is established as an annual average value, exceeding a level of 10 µg/m³ over a shorter period of time is not assessed to give cause for concern.

5.3.2 Risk assessment of content of phthalates

Table 22 below shows the risk assessment of phthalates.

TABLE 22
RISK ASSESSMENT OF PHTHALATES FOR RUGS WITH THE HIGHEST CONTENT. INDICATION OF CONTENT, EXPOSURE BY INGESTION OF 100 MG DUST DAILY, DNEL-VALUE AND CALLCULATED RCR-VALUE

Critical component	Analysed content in the rug	Exposure of a child (µg/ kg /day)	DNEL (µg/ kg/ day)	RCR
Rug T12, wool/cotton				
Dibutyl phthalate (DBP)	22 µg/g	0.19	6.7	0.028

As it appears from the calculated RCR-value of 0.028 for dibutyl phthalate, the content of the substance in the rug does not pose a health risk to children.

5.3.3 Risk assessment of perfluorinated substances

Table 23 below shows the risk assessment of perfluorinated substances.

TABLE 23
RISK ASSESSMENT OF PERFLUORINATED SUBSTANCES FOR RUGS WITH THE HIGHEST CONTENT. INDICATION OF CONTENT, EXPOSURE BY INGESTION OF 100 MG DUST DAILY, DNEL-VALUE AND CALLCULATED RCR-VALUE

Critical component	Analysed content in the rug	Exposure of a child (µg/ kg day)	DNEL (µg/ kg day)	RCR
Rug T05, PP/rubber				
PFOS (perfluorooctane sulfonic acid) + iso-PFOS	1.01 ng/g	0.000009	0.03	0.0003
PFOA (perfluorooctanoic acid)	5.9 ng/g	0.00005	0.1	0.0005
Sum perfluorinated compounds	9.36 ng/g	0.00008	0.03	0.0026

As it appears from the calculated RCR-value of 0.0026 for the sum of perfluorinated substances, the content of the substances in the rug does not pose a health risk to children.

5.4 Overall health assessment and perspectivation

Conclusions

From the stated analyses of the emission from 20 selected rugs for chronic neurotoxic hydrocarbons and respiratory irritant aldehydes and carboxylic acids, as well as from analysis of the rugs' content of phthalates and perfluorinated substances, the exposure scenarios for infants showed no reason for health concerns using the rugs in children's rooms.

Under worst-case circumstances (e.g. when using several rugs of the same kind simultaneously, or where the air exchange is very low due to closed doors and windows for a prolonged period), it is assessed that two rugs may pose a risk of acute respiratory irritation caused by emission of acetic acid and acrolein.

For the substance acrolein, a very low tolerable exposure level of 0.1 µg/m³ for long-term exposure has been established, which is below the detection limit of 0.75 µg/m²h at 40 liter air sample (according to 4.3.4). Rug T12 emitted 14 µg/m²h acrolein after 24 hours corresponding to 3.5 µg/m³ in the children´s room, and is therefore above the tolerable exposure limit for long terme exposure and below the 7 µg/m³ limit for exposure of less than 14 days. Acrolein was not measured in the emissions of rug T12 after 28 days.
As the acceptable exposure level for long-term exposure for acrolein is below the detection limit, it cannot be clearly defined on basis of the performed measurements of children’s rugs, whether there is a risk of exceeding levels of 0.1 µg/m³ acrolein during a longer time in the children’s room. As acrolein is very volatile, and the areas of children’s rugs are small, it is likely that acrolein disappears from the indoor air after a while. To verify this, more air samples should have been collected to obtain a better detection limit. However, acrolein was not idenfied by the survey as a possible substance in the emission from rugs, thus no hazard assessment with subsequent analyses of acrolein in very small concentrations was carried out.

Uncertainties and limitations
One should be cautious to draw a general conclusion based on the above conclusions.The findings of the present study should be seen in the context that the random samples of rugs consisted of 21 childrens rugs selected following a strategy to most probably to select rugs containing critical substances. Although the study does not include all types of rugs, which might be used in children's rooms, the study suggests that generally health problems will not occur from the use of rugs in children's rooms.

As the analyses were directed towards measuring a relatively limited number of substances and substance groups, a number of other components have not been identified and quantified. As it appears from the analyses, a number of non-identified substances contribute to the TVOC and TSVOC, and for the individual rugs the sum of the unknown substances is about 30-60% of the total emission.

Assessment of other substance groups that may be present in children's rugs as chemical residues, such as biocides (may be added as a preservative), dyes, flame retardants, or other nitrogen and sulphur-containing compounds that may be problematic in relation to health and odour, are not covered by this survey.

There is an ongoing development in the field of fluorinated substances and agents for surface treatment agents and thus these “new” substances may be difficult to detect. In this study fluorine in the rugs was detected, however volatile fluorinated substances (FT-OH, VFOC) were not found and only very low concentrations of fluorinated acids as PFOA and PFOS were found. The measured concentrations of PFAS represented less than 0.03 weight percent of the total fluorine content in the rug fibers. So, in this survey, it was not possible to identify which fluorinated substances the rugs contained, apart from the PFAS identified in the survey, due to lack of reference substances and methods for identification of new fluorine chemicals.

6. Resource assessment

6.1 Introduction

The resource assessment is based on the materials forming part of the children's rugs and the results of the analyses carried out for VOC, phthalates, and perfluorinated substances. The assessment thus includes, whether finding of these substances can prevent reuse of the rugs.

A brief examination of the possibility of collecting the rugs for reuse was also carried out (that is where the rug is used directly as a rug – after cleansing) and recycling (when the rug is segregated and the parts will be used for new production – e.g. new rugs or other). What regards recycling, it is assessed whether by segregation of the rugs and separation of rug fibres from the rug backsides, fractions may appear that can be distributed commercially on the market for secondary materials.

6.2 Composition of material

The structure and composition of material of the 21 rugs examined are described in Table 12, section 6. The information is based on information from the shops, in which the rugs were purchased. As appears from Table 12, the rugs are very different both as to composition of the fibres and the back of the rugs.

The fibres are made of polypropylene (PP), polyamide (PA), acrylic and polyester (PES). In some of the rugs the fibres form part as a mixture including a mixture between acrylic and viscose. Viscose is modified cellulose. In two of the rugs, the rug fibres are natural fibres of wool. The children's rugs are mainly very colourful and often with motives, which is why there is such a large variation in the colours of the fibres. As for the rug backs, many different materials have been applied both synthetic and natural materials.

For most of the rugs, the back is described either as latex or rubber. This is in principle the same, as latex is a rubber dispersion of natural rubber or synthetic rubber. The synthetic latex is SBR-rubber (Styrene butadiene rubber), the properties of which are similar to natural rubber. It was developed industrially during the World War II by the USA. At vulcanization, the latex develops into firm rubber at simultaneous evaporation of water and solvent. If a blowing agent is added, it results in foam rubber. The backs of the rugs T11 and T19 are described as foam. Foam is not a material description, but an expression of air cells in the material. The back of the two rugs described as foam looks rather to be rubber/latex.

6.3 The significance of the analysis results on reuse or recycling

Common for all the assessments in the section is that it must be expected that the rugs are used longer than 28 days, and an ongoing reduction of the volatile substances in the entire utilization phase will take place, but of course mostly in the beginning, where the concentrations are highest. What regards the sensory evaluation, it should expected that odour due to chemical substances likewise will decrease in time. Likewise odour cannot not immediately be applied to assess, whether there are health or environmental effects from the substances causing odour. In the beneath assessment, we have solely considered the analyses performed and the results produced. This means that no assessment of e.g. the properties of the pigments or chemicals is forming part of the vulcanization of the backs of the rugs e.g. vulcanization agents in latex/rubber, and which are not volatile (thiuramenes, benzothiazoles etc.). In addition, reference is made to E. Hansen and N. Nilsson (2014), where the waste perspective is included in relation to environmental and health alarming substances in plastic. As the children's rugs have strong colours, it means that if the rugs should be recycled, it can only be the dark or black products.

Volatile substances
The analyses show that the emission of VOC (TVOC) is reduced by 71-99% after 28 days in a climate chamber. For the three rugs emitting semi-volatile VOC (TSVOC), a reduction in TSVOC also takes place after 28 days (see Figure 5), but due to the lower vapour pressure it is of course not to the same degree as for the VOCs. On basis of the low results found for the total emission, it is assessed that neither TVOC nor TSVOC are problematic in relation to reuse or recycling of the rugs. This is also the case for the rug made of artificial wool with jute back (T14), which is Oeko-Tex labelled, but exceeding the threshold value for TVOC for this labelling. It should be noted that it is included in the assessment that CMR substances after 28 days no longer can be detected in the emissions except for a very low concentration from rug T08.

The emissions of aldehydes are very low and the five rugs with the highest content of formaldehyde after 28 days in climate chamber show no increase in the values. The very volatile C1-C4 aldehydes are thus not problematic in relation to reuse or recycling of the rugs.

It cannot be left out that by processing under mechanical impact with heat and the oxygen of the air that volatile substances from the rugs can be emitted – both very volatile aldehydes and other VOCs.

Phthalates
Content of the phthalates DEHP, DBP, BBP, DINP, DIDP, DNOP and DIDP was analysed. Only in a wool rug with jute back (T12), a very low content of DBP (0.0022 w/w %) was found. No content of these phthalates was found in the other rugs.

The VOC diethylphthalate (DEP) was found in low concentrations at emission after 1 day from 18 out of 20 rugs. After 28 days in climate chamber, no emission of VOC or SVOC phthalates was detected.

Phthalates are not problematic in relation to reuse or recycling of the children's rugs examined.

PFAS
Analyses were performed for content of volatile PFAS (VFOC) and other C6-10 PFAS, which were found problematic in the initial hazard assessment and Appendix 4 including the groups FTOH, FTCA, FTSA and PFOS in the children's rugs.

In rug T05, which is a rug with PP-fibres and rubber back, most of the PFAS forming part of the analysis programme were demonstrated. Most of them were C8-fluorinated substances (PFOA, PFOS and iso-PFOS). Other rugs analysed contained only traces PFOA. No volatile PFAS (FT-OH, VFOC) were found in of the rugs.

On basis of this, PFAS does not constitute a problem in relation to reuse or recycling.

6.4 Possibilities for resource utilization

Recycling
As appears from the above section, the ingredients and emissions measured are not considered to prevent reuse and recycling of the rugs. There are, however, other essential circumstances that play a part. These apply mainly to recycling.

The large difference in composition of the rugs and the very different materials forming part is an obstacle for recycling. A lot of the fibres forming part of the rugs, are not compatible, as they have different melting points and solubility parameters. A mix-up of wool and synthetic fibres will also prevent recycling, if they are not fully separated from each other, as the wool will carbonize at the temperatures, at which most synthetic fibres melt. As strong colours have been applied in the rug fibres, it will have the impact that a fibre fraction, if any, will become black or very dark brown. The amount of rugs will also be low in relation to recycling of fibres and rug backs – there is thus a logistics and a tonnage problem

It is assessed that the highest content of fluorine of 24.7 mg in rug T21 (0.0016 weight %) and the highest content of PFAS of 19.7 µg in rug T05 is so low that the content of these is no hindrance for recycling. As an example it could be stated that fluorine containing plastic or rubber materials have a far higher content of fluorine. The highest content is found in Teflon with 76% fluorine in the plastic.

It is known that the Danish carpet manufacturer Egetæpper has introduced a recycling scheme for their own carpets (Egetæpper, 2016). But in this case, the company knows the chemistry in their carpets and has in excess of the uniformity, a much larger tonnage. It is a matter of large carpets – not necessarily wall-to-wall carpets, which, besides, are not easy to recycle, as the latex back tends to adhere to the floor.

DESSO, a company distributing carpet tiles, has recycling system for their carpet tiles. The carpet tiles are made of PA6 (polyamide 6/Nylon 6). According to DESSO the fibres are recycled and used for new carpet fibres. The back of the carpets are after division used in the road sector and roof industry (DESSO 2016). It is assessed that the use in these sectors are as fill.

The possibility of recycling children's rugs as a valuable waste fraction, which can be distributed commercially, has been subject to discussion with Danbørs[11], which is a firm of brokers within waste. Danbørs found that it is not realistic to produce a marketable carpet fraction in the same way as for other sources for textile and for other waste fractions such as plastic, glass and metals. Dansk Affald agrees with Danbørs in this assessment[12]. Dansk Affald is, however, also very interested in recycling large amounts of textile disintegrating as waste and they see options for new collection systems that handle these.

It should be noted that by recycling of car tires, a large fraction of textile arise, especially, by volume. The textile fraction consists mainly of fibres of polyester, polyamide and rayon. Danish Technological Institute holds knowledge about development work carried out to utilize the fibre fraction for recycling. Until this development succeeds, the material with energy recycling will be incinerated.

Reuse
Contrary to the above, there is a potential in reuse, if the rugs are cleaned either prior to collection by charitable organizations or in free exchange schemes among receivers of the rugs. It is possible e.g. to exchange, rent, borrow, lease or switch the carpets and rugs as described in "Undgå affald, stop spild nr. 3, 2014" (*Avoid waste, stop loss no. 3, 2014)*. The report does not treat children's rugs specifically, and, therefore, it is unknown, whether there is a potential in this. Children's rugs as found during the survey are small, typically from 100 cm to 160 cm either in length or width or for the circular as a radius. It is possible that the schemes are intended for larger and more expensive carpets. This was not examined closer.

Reuse can take place by the consumers directly exchanging rugs with each other, or by giving the rugs to the many charitable organizations specialized in reuse on a non-profit basis. Collection for

[11] Personal communication with Danbørs 2016

[12] Personal communication with Dansk Affald, Jesper Henzel 2016.

charity takes place via Danish Recycling centres. Charitable organizations are typically Red Cross, the Church Army and the Salvation Army.

Combustion with energy utilization
In case children's rugs are very dirty and worn, combustion with energy utilization could be a possibility and can therefore be delivered as small combustible waste at the recycling centre. According to Dansk Affald, the instructions at the recycling centres are that small rugs/carpets should go in the small combustible waste fraction, while larger carpets go in large combustible fractions.

Due to a low content of fluorine and PFAS in the children's rugs, at combustion small amounts of hydrofluoric acid can be developed, which, however, will be neutralized by waste gas purification.

7. Abbreviations

BBP	-	Benzylbutyl phthalate
DBP	-	Dibutyl phthalate
DEHP	-	Di(2-ethylhexyl)phthalate (or diehylhexyl phthalate)
DEP	-	Diethyl phthalate
DIBP	-	Diisobutyl phthalate
DIDP	-	Diisodecyl phthalate (isomers)
DINP	-	Diisononyl phthalate (isomers)
DIPP	-	Diisopentyl phthalate
DMF	-	n,n-dimethyl formamide
DMEP	-	Bis(2-methoxyethyl)phthalate
DNEL	-	Derived No Effect Levels
DNOP	-	Di-n-octyl phthalate
DPHP	-	Bis(2-propylheptyl)phthalate)
DTI	-	Danish Technological Institute
EVA latex	-	Ethylene-vinyl acetate co-polymer
FTAC	-	Fluortelomer acrylat
FTCA	-	Fluortelomer carboxylic acids
FTSA	-	Fluortelomer sulfonic acids
FTOH	-	Fluortelomer alcohol
LCI	-	Lowest Concentration of Interest
PA	-	Polyamide, nylon
4-PCH	-	4-phenylcyclohexene
PE	-	Polyethylene (polyolefin)
PES	-	Polyester
PFAS	-	Perfluoroalkyl substances
PFBA	-	Perfluorobutan acid
PFBS	-	Perfluorbutan sulphonic acid
PFC	-	Per-/polyfluorinated substance
PFCA	-	Perfluoroalkyl carboxylic acids
PFDA	-	Perfluordecan acid
PFHpA	-	Perfluorheptan acid
PFHxA	-	Perfluorohexan acid
PFHxS	-	Perfluorohexan sulphonic acid
PFOA	-	Perfluorooctan acid
PFOS	-	Perfluoroctan sulphonic acid
PFOSA	-	Perfluoroctan sulphonamide
PFNA	-	Perfluornonan acid
PFPeA	-	Perfluorpentan acid
PFSA	-	Perfluoralkan sulphonic acids
Polyolefin	-	Polymers of propene (PP) and ethylene (PE)
PP	-	Polypropylene (polyolefin)
SBR	-	Styrene butadiene rubber
SVOC	-	Semi volatile organic compound
TVOC	-	Total volatile organic compounds
VVOC	-	Very volatile organic compound

VOC	-	Volatile organic compound

References

Andersen D N, Slothuus T, Larsen PB (2014). Survey of Formaldehyde - Part of the LOUS review. Environmental project No 1618, The Danish Environmental Protection Agency.

Bartsch J, Uhde E, Salthammer T (2016). Analysis of odour compounds from scented consumer products using gas chromatography-mass spectrometry and gas chromatography-olfactometry. Analytica Chimica Acta 904:98-106.

Berkeley Center for Green Chemistry (2011). Semivolatile Organic Compounds (proposed project). Green Chemistry: An Interdisciplinary Approach to Sustainability. http://bcgc.berkeley.edu/

Buck R C, Franklin J, Berger U, Conder J M, Cousins I T, de Voogt P, Jensen A A, Kannan K, Mabury S A, van Leeuwen S P (2011). Perfluoroalkyl and polyfluoroalkyl substances in the environment: terminology, classification, and origins. Integr Environ Assess Manag. Oct, 7(4):513-41.

prEN 16516 (2015). Construction products — Assessment of release of dangerous substances — Determination of emissions into indoor air. Brussels.

Clausen G, Høst A, Toftum J, Bekö, G, Weschler C, Callesen M, Buhl S, Ladegaard M B, Langer S, Andersen B, Sundell J, Bornehag C-G, Sigsgaard T (2012). Children's health and its association with indoor environments in Danish homes and daycare centres – methods. Indoor Air 22, 467-475.

Clausen P A, Hansen V, Gunnarsen L, Afshari A, Wolkoff P (2004). Emission of di-2-ethylhexyl phthalate from PVC flooring into air and uptake in dust: Emission and sorption experiments in FLEC and CLIMPAQ. Environ. Sci. Technol. 38, 2531-2537.

CRI (1997). Carpet and the environment. Carpet and Rug Institute, Dalton, GA, USA.

Dansk Selskab for Indeklimamærkning (2005). Standard Test Method for Determination of the Indoor-Relevant Time-Value by Chemical Analysis and Sensory Evaluation. 3rd edition.

Dansk Standard (1994). DS/INF 90 Anvisning for bestemmelse og vurdering af afgasning fra byggevarer. Dansk Standard, København.

DESSO (2016). Desso's carpet Take Back™ programme. http://www.desso-businesscarpets.com/corporate-responsibility/refinityr

ECHA (2008). Guidance on information requirements and chemical safety assessment. Part E: Risk Characterisation. May 2008.

ECHA (2011). Committee for Risk Assessment: Opinion proposing harmonised classification and labelling at Community level of white spirit, 18pp.

ECHA (2012A). Opinion on an Annex XV dossier proposing restrictions on four phthalates. Committee for Risk Assessment (RAC). ECHA/RAC/RES-O-0000001412-86-07/F. Adopted 15 June 2012.

ECHA (2012B). Background document to the opinion on an Annex XV dossier proposing restrictions on four phthalates. Committee for Risk Assessment (RAC). Committee for Socio-economic Analysis (SEAC). ECHA/RAC/RES-O-0000001412-86-07/S1. 11 July 2012.

ECHA (2012c). Guidance on information requirements and chemical safety assessment. Chapter R.8: Characterisation of dose [concentration]-response for human health. Version 2.1.

ECHA (2013). SVHC support document - Substance Name: Pentadecafluorooctanoic Acid (PFOA)

EUROPA-PARLAMENTETS OG RÅDETS FORORDNING (EF) Nr. 850/2004 af 29. april 2004 om persistente organiske miljøgifte og om ændring af direktiv 79/117/EØF.

EUROPA-PARLAMENTETS OG RÅDETS FORORDNING (EF) Nr. 1907/2006 af 18. december 2006 om registrering, vurdering og godkendelse af samt begrænsninger for kemikalier (REACH), om oprettelse af et europæisk kemikalieagentur og om ændring af direktiv 1999/45/EF og ophævelse af Rådets forordning (EØF) nr. 793/93 og Kommissionens forordning (EF) nr. 1488/94 samt Rådets direktiv 76/769/EØF og Kommissionens direktiv 91/155/EØF, 93/67/EØF, 93/105/EF og 2000/21/EF.

EUROPA-PARLAMENTETS OG RÅDETS DIREKTIV 2004/42/EF af 21. april 2004 om begrænsning af emissioner af flygtige organiske forbindelser fra anvendelse af organiske opløsningsmidler i visse malinger og lakker samt produkter til autoreparationslakering og om ændring af direktiv 1999/13/EF.

Egetæpper (2016). https://groenomstilling.erhvervsstyrelsen.dk/egetæpper-a013-retursystem-taepper

EU-LCI values (2016) via the website of the EC Subgroup on EU-LCI Values www.eu-lci.org

Greenpeace (2001). Hazardous Chemicals in Carpets, Greenpeace Research Laboratories Technical Note 01/2001, January 2001, Greenpeace Research Laboratories, Department of Biological Sciences, University of Exeter, Exeter EX4 4PS, UK.

Guo H, Murray F, Lee S C, Wilkinson S (2004). Evaluation of emissions of total volatile organic compounds from carpets in an environmental chamber Building and Environment 39 179 – 187.

Guo Z, Liu W, Krebs K A, Roache N F (2009). Perfluorocarboxylic Acid Content in 116 Articles of Commerce. National Risk Management Research Laboratory, US EPA.

GUT (2014). GUT Carpets tested for a better living environment. http://www.pro-dis.info/about_gut.html?&L=0, besøgt 2015.05.20.

Hansen E, Nilsson E (2014). Hazardous substances in plastics, Survey of chemical substances in consumer products No. 132, 2014. The Danish Environmental Protection Agency.

Haug L S, Huber S, Becher G, Thomsen C (2011). Characterisation of human exposure pathways to perfluorinated compounds – comparing exposure estimates with biomarkers of exposure. Environment International 37, 687–693.

Herzke D, Olsson E, Posner S (2012). Perfluoroalkyl and polyfluoroalkyl substances (PFASs) in consumer products in Norway – A pilot study, Chemosphere 88: 980–987.

Huber S, Haug L S, Schlabach M (2011). Per- and polyfluorinated compounds in house dust and indoor air from northern Norway – A pilot study. Chemosphere 84: 1686–1693.

Høibye L, Maag J, Hansen E (2011). Background data for Annex XV dossier – DEHP, BBP, DBP and DIBP. Environmental project No. 1362. The Danish Environmental Protection Agency

ISO 16000-3 (2011). Indoor air – Part 3: Determination of formaldehyde and other carbonyl compounds in indoor air and test chamber air - Active sampling method.

ISO 16000-6 (2011). Indoor air – Part 6: Determination of volatile organic compounds in indoor and test chamber air by active sampling on Tenax TA sorbent, thermal desorption and gas chromatography using MS/FID.

ISO 16000-9 (2006). Indoor air – Part 9: Determination of the emission of volatile organic compounds from building products and furnishing – Emission test chamber method.

ISO 16000-28 (2012). Indoor air – Part 28: Determination of odour emissions from building products using test chambers.

Jahnke A, Berger U (2009). Trace analysis of per- and polyfluorinated alkyl substances in various Matrices — How do current methods perform? J. Chromatogr. A 1216, 410–421.

Jensen A A, Knudsen H N (2006). Total health assessment of chemicals in indoor environment from various consumer products. Survey of chemical substances in consumer products, No. 75, The Danish Environmental Protection Agency.

Jensen A A, Poulsen P B, Bossi R (2008). Survey and environmental/health assessment of fluorinated substances in impregnated consumer products and impregnating agents. Survey of chemical substances in consumer products, No. 99, The Danish Environmental Protection Agency.

Jensen T K, Andersen L B, Kyhl H B, Nielsen F, Christesen H T, Granjean P (2015). Association between Perfluorinated Compound Exposure and Miscarriage in Danish Pregnant Women. PLoS One. 2015, 10(4): e0123496.

JRC / EU-Commission (2013). Harmonisation framework for health based evaluation of indoor emissions from construction products in the European Union using the EU-LCI concept. EUROPEAN COLLABORATIVE ACTION URBAN AIR, INDOOR ENVIRONMENT AND HUMAN EXPOSURE. Environment and Quality of Life Report No 29.

Kalberlah F, Augustin R, Bunke D, Schwarz M, Oppl R (2011). Substances classified as carcinogenic, mutagenic and toxic for reproduction (CMR) and other substances of concern in consumer products. Umweltsbundesamt UBA-FB 001434. https://www.umweltbundesamt.de/sites/default/files/medien/461/publikationen/4092.pdf

Kanchongkittiphon W, Gaffin J M, Phipatanakul W (2014). The indoor environment and inner-city childhood asthma. Asian Pacific journal of Allergy and Immunology June 32 (2): 103–110.

Katsoyiannis A, Leva P, Kotzias D (2008). VOC and carbonyl emissions from carpets: A comparative study using four types of environmental chambers. Journal of Hazardous Materials 152: 669–676.

Kjølholt J, Warming M, Maag J, Mikkelsen S H, Nielsen E, Nilsson N H (2014A). Survey of styrene - Part of the LOUS review, Environmental project No. 1612, The Danish Environmental Protection Agency.

Kjølholt J, Warming M, Maag J, Mikkelsen S H, Nielsen E, Nilsson N H (2014B). Survey of toluene - Part of the LOUS review, Environmental project No. 1613, The Danish Environmental Protection Agency.

Kjølholt J, Warming M, Lassen C, Mikkelsen S H, Brinch A, Nielsen I B, Jacobsen E (2015). Chemical substances in car safety seats and other textile products for children. Survey of chemical substances in consumer products, No. 135, The Danish Environmental Protection Agency

Knepper T P, Frömel T, Gremmel C, Driezum I, Weil H, Vestergren R, Cousins I (2014). Understanding the exposure pathways of per- and polyfluoralkyl substances (PFASs) via use of PFASs-Containing products – risk estimation for man and environment. Report No. (UBA-FB) 001935/E. Umweltbundesamt, Dessau-Roßlau, Tyskland.

Kolarik B, Gunnarsen L, Funch L W (2010). Afgivelse af formaldehyd fra byggevarer og forbrugerprodukter, Statens Byggeforskningsinstitut, Aalborg Universitet.

Kolarik B (2015). Emissionprøvning af byggevarer – skalering. Præsentation. Statens Byggeforskningsinstitut, Aalborg Universitet København.

Larsen P B, Slothuus T, Giovalle E (2014). Survey of N,N-dimethylformamide,DMF, Part of the LOUS review, Environmental project No. 1615, The Danish Environmental Protection Agency.

Larsen P B, Giovalle E (2015). Perfluoroalkylated substances: PFOA, PFOS and PFOSA. Evaluation of health hazards and proposal of a health based quality criterion for drinking water, soil and ground water. Environmental project No. 1665. The Danish Environmental Protection Agency.

Larsen P B, Kolarik B, Gunnarsen L, Lam H R (2016). Survey and risk assessment of toluene and other neurotoxic substances in children's rooms. Survey of chemical substances in consumer products No. 145. The Danish Environmental Protection Agency.

Lassen C, Jensen A, Potrykus A, Christensen F, Kjølholt J, Jeppesen C N, Mikkelsen S H, Innanen S (2013). Survey of PFOS, PFOA and other perfluoroalkyl and polyfluoroalkyl substances - Part of the LOUS-review, Environmental Project No. 1475, The Danish Environmental Protection Agency.

Lassen C, Kjølholt J, Warming M, Astrup Jensen A, Bossi R, Bondgaard Nielsen I (2015) Polyfluoralkylforbindelser (PFAS) i tekstiler til børn. The Danish Environmental Protection Agency.

Liang Y, Xu Y (2014). Emission of phthalate and phthalate alternatives from vinyl flooring and crib mattress covers: The influence of temperature. Environmental Science & Technology 48 (24), 14228-14237.

Lim S K et al. (2014). Risk Assessment of Volatile Organic Compounds Benzene, Toluene, Ethylbenzene, and Xylene (BTEX) in Consumer Products. Journal of Toxicology and Environmental Health, Part A, 77, 1502–1521.

Lisovac A M, Shooter D (2003). Volatiles from sheep wool and the modification of wool odour. Small Ruminant Research, 49, 115-124.

Little J C, Hodgson A T, Gadgil A J (2013). Modelling Emissions of Volatile Organic Compounds from New Carpets, Lawrence Berkeley National Laboratory, University of California.

Liu X, Guo Z, Krebs K A, Pope R H, Roache N F (2014). Concentrations and trends of perfluorinated chemicals in potential indoor sources from 2007 through 2011 in the US, Chemosphere 98, 51–57.

Liu X, Guo Z, Folk E E, Roache N F (2015). Determination of fluorotelomer alcohols in selected consumer products and preliminary investigation of their fate in the indoor environment, Chemosphere 129, 81–86.

McIntyre J E, Daniels P N (1995). Textile Terms and Definitions - Tenth Edition. Textile Institute.

Mikkelsen, S H, Maag J, Kjølholt J, Lassen C, Nyander Jeppesen C, Clausen A J (2014A). Survey of selected phthalates - Part of the LOUS-review. Environmental Project No. 1541. The Danish Environmental Protection Agency.

Mikkelsen S H, Warming M, Syska J, Voskian A (2014B). Survey of n-hexane, Part of the LOUS review, Environmental Project No. 1628, The Danish Environmental Protection Agency.

Miljøstyrelsen (2006). Metoder til fastsættelse af kvalitetskriterier for kemiske stoffer i jord, luft og drikkevand med henblik på at beskytte sundheden. Vejledning fra Miljøstyrelsen Nr. 5.

Miljøstyrelsen (2008). Supplement til B-værdivejledningen 2008. Miljøprojekt Nr. 1252.

Miljøstyrelsen (2009). 2-åriges udsættelse for kemiske stoffer. Kortlægning af kemiske stoffer i forbrugerprodukter Nr. 103.

Miljøstyrelsen (2010) Listen over uønskede stoffer 2009. Orientering fra Miljøstyrelsen Nr. 3.

Miljøstyrelsen. (2011). Background data for Annex XV dossier – DEHP, BBP, DBP and DIBP. Miljøprojekt nr 1362.

Müller A K, Nielsen E, Ladefoged O (2003). Human exposure to selected phthalates in Denmark. Fødevaredirektoratet. Ministeriet for fødevarer, landbrug og fiskeri.

Nagata Y (2003). Measurement of odor threshold by triangle odor bag method. Odor measurement review. Tokyo (Japan): Office of Odor, Noise and Vibration, Environmental Management Bureau, Ministry of Environment, p 118-127.

Nielsen G D, Hansen L F, Nexø B A, Poulsen O M (1998). Indoor air guidelines levels for formic, acetic, propionic and butyric acid. Indoor Air Suppl 5, 8-24.

NMR (2012) Existing Default Values and Recommendations for Exposure Assessment. A Nordic Exposure Group Project 2011. Nordisk Ministerråd, København. Series Tema Nord, ISSN 0908-6692:505. 177 p.

OECD. OECD Portal on Perfluorinated Chemicals. http://www.oecd.org/ehs/pfc/ (2015.03.30).

Öko-Test (2002) Gerüche aus Teppichböden. Mir stinkts. 7, 62-66.

Ôko-Test (2015) Test Kinderteppiche. Das Spiel ist aus. 9, 113-117.

Oeko-Tex® Standard 100. OEKO-TEX ® Zürich. Edition 04, 2015.

OSHA (2016) Occupational Safety & Health Administration: https://www.osha.gov/

Pors J, Fuhlendorff R (2002). Kortlægning af kemiske stoffer i forbrugerprodukter. Kortlægning No. 15, Miljøstyrelsen.

Poulsen P B, Jensen A A, Wallström E (2005). More environmentally friendly alternatives to PFOS-compounds and PFOA. Miljøprojekt No. 1013 2005, Miljøstyrelsen.

PubChem Compound (2016) National Center for Biotechnology Information Search database: www.ncbi.nlm.nih.gov/pccompound

RIVM (2007) Non-food products: How to assess children's exposure? RIVM report 320005005. 75 pp.

Schoeib M, Harner T, Wilford B H, Jones K C, Zhu J (2005). Environmental Science & Technology 39, 6599-6606.

SFT (2004). Bruken av PerFluorAlkylStoffer (PFAS) i produkter i Norge – Materialstrømsanalyse, SFT.

Sollinger S, Levsen K, Wunsch G (1993). Indoor air pollution by organic emissions from textile foor coverings: climate chamber studies under dynamic conditions. Atmospheric Environment, 27B (2):183–92.

The good scents company (2016) http://www.thegoodscentscompany.com/

The pherobase (2016) http://www.pherobase.com/

Tsitonaki K, Jepsen T S, Larsen T H (2014). Screeningsundersøgelse af udvalgte PFAS-forbindelser som jord- og grundvandsforurening i forbindelse med punktkilder. Miljøprojekt nr. 1600, Miljøstyrelsen.

Tønning K, Jacobsen J, Pedersen E, Nilsson N H (2010). Phthalates in products with large surfaces, Survey of Chemical Substances in Consumer Products, No. 108, Danish Environmental Protection Agency.

Undgå affald stop spild (2014): 2014/3 jf. http://norubbish.dk/2014/04/undga-affald-stop-spild/

Watson D, Kiørboe N, Kjær B, Lindblad B, Dammand K, Nielsen R (2014). Mindre affald og mere genanvendelse i tekstilbranchen, Ideer fra aktørerne på tekstilområdet. Miljøstyrelsen Undgå affald, stop spild nr. 03. 2014, ISBN 978-87-93178-78-6.

Weschler C J, Nazaroff W W (2008). Semivolatile organic compounds in indoor environments. Atmos. Environ. 42, 9018-9040.

Weschler C J, Nazaroff W W (2010). SVOC partitioning between the gas phase and settled dust indoors. Atmos. Environ. 44, 3609-3620.

WHO (1989). Indoor air quality: organic pollutants, EURO Reports and Studies, Vol. 111, Copenhagen, WHO.

WHO (2010). Selected Pollutants, WHO Guidelines for indoor air Quality. WHO Regional Office for Europe, Copenhagen.

Wilke O, Jann O, Brödner D (2004). VOC- and SVOC-emissions from adhesives, floor coverings and complete floor structures Indoor Air, 14 (Suppl 8): 98–107.

Xu Y, Cohen Hubal E A, Little J C (2010). Predicting residential exposure to phthalate plasticiser emitted from vinyl flooring: sensitivity, uncertainty, and implications for biomonitoring. Environmental Health Perspectives, 118(2):253-258.

Xu Y, Zhang Y (2003). An improved mass transfer based model for analyzing VOC emissions from building materials. Atmospheric Environment 37, 2497-2505.

Øien T B, Kolarik B, Gunnarsen L (2015). Byggematerialers bidrag til indeluftens indhold af phthalater, SBi:04, 1. udgave, Statens Byggeforskningsinstitut, Aalborg Universitet.

Appendix 1 Outline of identified substances in rugs and carpets

Table B1.1-12 of the appendix lists the substances where sources have pointed at content, stated emission data or content analysis for the individual substance/the individual substance group. The tables are divided into the three substance groups that are dealt with in the main report: phthalates, fluorinated compounds and VOCs. Furthermore, the VOCs were divided into sub groups according to the chemical structure of the substance.

Square brackets state sources that can be found in the reference list of the main report with a few exceptions:
[DTI's own data] refers to Danish Technological Institute's own emission data
[CB] refers to data found on Chemical Book; http://www.chemicalbook.com/
MW refers to molecular weight

Table B1.1: Identified phthalates

Substance	CAS No.	Concentration	MW (g/mol)	Boiling point (°C)	Log Pow	Water-solubility (mg/L)	Vapour pressure (mm Hg)	Comments	Material
Diisobutyl phthalate (DIBP)	84-69-5	0.27-0.30 g/m² [Tønning et al 2010]	278.35	296	4.11	6.2 at 24°C	6.65E-03 at 25°C	Substance was found in one out of eight analysed carpets. The carpets differs from the other carpets by being in tiles and having glue on the reverse side. [Tønning et al 2010]	
Bis(2-ethylhexyl) phthalate (DEHP)	117-81-7		390.56	384	7.6	0.27 at 25°C	1.42E-07 at 25°C	Source is probably the self-adhesive backing [Kalberlah et al 2011]. No content stated, only that the substance probably is found in carpets [Müller et al 2003]	[Kalberlah et al 2011]: Material: wool
Diisononyl phthalate (DINP)	28553-12-0		418.61		9.37	0.2 at 20°C	5.40E-07 at 25°C	Source states content of phthalate in rugs.	
Dibutyl phthalate (DBP)	84-74-2		278.35	340	4.5	11.2 at 25°C	2.01E-05 at 25°C	Source states content of phthalate in rugs.	

Table B1.2: Identified fluorinated compounds

Substance	CAS No.	Concentration	MW (g/mol)	Boiling point (°C)	Log Pow	Water-solubility (mg/L)	Vapour pressure (mm Hg)	Comments	Material
6:2 fluorotelomer-sulfonat (6:2 FTS)	29420-49-3 [Lassen et al 2013]	1.35 µg/m^2 [Herzke et al 2012]	338.19					In connection with survey of PFAS in Norway, analyses were carried out for 24 PFASs in two carpets (no info about type). Interval states that substances were identified in both products, one marked with Teflon® [Herzke et al 2012]	
Perfluorohexane sulfonate (PFHxS)	355-46-4 [Lassen et al 2013]	0.08 µg/m^2 [Herzke et al 2012]	400.11	238.5				In connection with survey of PFAS in Norway, analyses were carried out for 24 PFASs in two carpets (no info about type). Interval states that substances were identified in both products, one marked with Teflon® [Herzke et al 2012]	
Perfluorobutan acid (PFBA)	375-22-4 [Lassen et al 2013]	4.1-131 ng/g [Liu et al 2014]	214.04	121	2.43			Substance found in 6 out of 9 American carpets purchased in the period 2007-11 [Liu et al 2014]Source states that the substance was detected in substance from carpet in Norwegian home [Herzke et al 2012]	[Liu et al 2014]: Material: nylon, maize-based polymer, PP
Perfluorohexan acid (PFHxA)	307-24-4 [Lassen et al 2013]	1.11 µg/m^2 [Herzke et al 2012] 3.7-40.1 ng/g [Liu et al	314.05	157 [CB]				In connection with survey of PFAS in Norway, analyses were carried out for 24 PFASs in two carpets (no info about type). Interval states that	[Liu et al 2014] Material: nylon, maize-based polymer, PP

Table B1.2: Identified fluorinated compounds

Substance	CAS No.	Concentration	MW (g/mol)	Boiling point (°C)	Log Pow	Water-solubility (mg/L)	Vapour pressure (mm Hg)	Comments	Material
		2014]						substances were identified in both products, one marked with Teflon® [Herzke et al 2012] Substance found in 7 out of 9 carpets from the USA, purchased in the period 2007-2011 [Liu et al 2014]	
Perfluoro-heptan acid (PFHpA)	375-85-9 [Lassen et al 2013]	0.51 µg/m² [Herzke et al 2012] 14.1-146 ng/g [Liu et al 2014]	364.06	175 [CB]				In connection with survey of PFAS in Norway, analyses were carried out for 24 PFASs in two carpets (no info about type). Interval states that substances were identified in both products, one marked with Teflon® [Herzke et al 2012] Substance found in 4 out of 9 carpets from the USA purchased in the period 2007-2011 [Liu et al 2014]	[Liu et al 2014] Material: nylon, PP

Table B1.2: Identified fluorinated compounds

Substance	CAS No.	Concentration	MW (g/mol)	Boiling point (°C)	Log Pow	Water solubility (mg/L)	Vapour pressure (mm Hg)	Comments	Material
Perfluorooctan acid (PFOA)	335-67-1 [Lassen et al 2013]	1.67 µg/m² [Herzke et al 2012] <0.2-23. 28-50 ng/cm² [Astrup og Knudsen 2006] 3.5-226 ng/g [Liu et al 2014]	414.06	189 [ECHA. 2013]	2.69/6.3 [ECHA2013]	9.5 g/L [ECHA. 2013]	4.2 Pa at 25°C [ECHA. 2013]	In connection with survey of PFAS in Norway, analyses were carried out for 24 PFASs in two carpets (no info about type). Interval states that substances were identified in both products, one marked with Teflon® [Herzke et al 2012] Moth-proof carpet and "carpet care" treated carpet, respectively [Astrup and Knudsen 2006]. Substance found in 6 out of 9 carpets from the USA purchased in the period from 2007-2011 [Liu et al 2014]	[Liu et al 2014] Material: nylon, PP
6:2 Fluorotelomer alcohol (6:2 FTOH)	647-42-7 [Lassen et al 2013]	17.0-220 µg/m² [Herzke et al 2012]	364.1	88-95 [CB]	3.6-5.3 v 25°C [Jensen et al, 2008]	<1.2-1.7 x 10-2 - 1.9 x 10-2 v 22°C [Jensen et al, 2008]	713 Pa [Jensen et al, 2008]	In connection with survey of PFAS in Norway, analyses were carried out for 24 PFASs in two carpets (no info about type). Interval states that substances were identified in both products, one marked with Teflon® [Herzke et al 2012]	
8:2 Fluorotelomer alcohol (8:2 FTOH)	678-39-7 [Lassen et al, 2013]	22.0-368 µg/m² [Herzke et al 2012]	464.12	113 [CB]	4.8-5.5 v 25°C [Jensen et al, 2008]	6.0 x 10-6- 8.9 x 10-4 v 22°C [Jensen et al, 2008]	144 Pa [Jensen et al, 2008]	In connection with survey of PFAS in Norway, analyses were carried out for 24 PFASs in two rugs (no info about type). Interval states that substances were identified in	

Table B1.2: Identified fluorinated compounds

Substance	CAS No.	Concentration	MW (g/mol)	Boiling point (°C)	Log Pow	Water solubility (mg/L)	Vapour pressure (mm Hg)	Comments	Material
								both products, one marked with Teflon® [Herzke et al 2012]	
10:2 Fluorotelomer alcohol (10:2 FTOH)	865-86-1 [Lassen et al, 2013]	13.7-169 μg/m² [Herzke et al 2012]	564.13	145 [CB]	4.2-5.6 v 25°C [Jensen et al, 2008]	1.40 x 10-4 - 1.1 x 10-5 at 22°C [Jensen et al, 2008]	254 Pa [Jensen et al, 2008]	In connection with survey of PFAS in Norway, analyses were carried out for 24 PFASs in two carpets (no info about type). Interval states that substances were identified in both products, one marked with Teflon® [Herzke et al 2012]	
Perfluorpentan acid (PFPeA)	2706-90-3 [CB]	11.5-22.6 ng/g [Liu et al 2014]	264.05 [CB]	140 [CB]				Substance found in 2 out of 9 American carpets purchased in the period 2007-11 [Liu et al 2014]	[Liu et al 2014]: Material: PP
Perfluoro-nonan acid (PFNA)	375-95-1 [Lassen et al, 2013]	6.3-236 ng/g [Liu et al 2014]	464.07	218 [CB]				Substance found in 4 out of 9 American carpets purchased in the period 2007-11 [Liu et al 2014]	[Liu et al 2014]: Material: nylon, PP
Perfluoroctanoat (PFOS)	1763-23-1 [Lassen et al, 2013]	5-900 ug/kg PFOA. 0.2-2 mg PFO/kg. 232 mg fluor/kg [Kalberlah et al 2011] 0.71-1.04 μg/m² [Herzke et al 2012]	500.12	260 [CB]				Country of origin stated to be unknown, USA, D for the three concentrations, respectively. [Kalberlah et al 2011] In connection with survey of PFAS in Norway, analyses were carried out for 24 PFASs in two carpets (no info about type). Interval states that substances were identified in both products, one marked	[Kalberlah et al 2011]: No information about material

Table B1.2: Identified fluorinated compounds

Substance	CAS No.	Concentration	MW (g/mol)	Boiling point (°C)	Log Pow	Water solubility (mg/L)	Vapour pressure (mm Hg)	Comments	Material
								with Teflon® [Herzke et al 2012]	
Perfluorodecan acid (PFDA)	335-76-2 [Lassen et al, 2013]	5.2-179 ng/g [Liu et al 2014]	514.08	218 [CB]		0.26 at 24°C [Jensen et al, 2008]	10 mm HG (0°C) [CB]	Substance found in 5 out of 9 American carpets purchased in the period 2007-11 [Liu et al 2014]	[Liu et al 2014]: Material: nylon, PP
Perfluoroundecan acid (PFUnA or PFUnDA)	4234-23-5 [Lassen et al, 2013]	2.3-160 ng/g [Liu et al 2014]	564.09 [CB]	160 [CB]				Substance found in 4 out of 9 American carpets purchased in the period 2007-11 [Liu et al 2014] Source states that the substance was detected in material collected on carpet in a Norwegian home. [Herzke et al 2012]	[Liu et al 2014]: Material: nylon, MPP
Perfluoro-dodecan acid (PFDoDA)	307-55-1 [Lassen et al, 2013]	3.4-129 ng/g [Liu et al 2014]	614.09	249				Substance found in 4 out of 9 American carpets purchased in the period 2007-11 [Liu et al 2014]	[Liu et al 2014]: Material: nylon, PP

Table B1.3: Identified aldehydes (VVOC, VOC)

Substance	CAS	Emission	MW (g/mol)	Boiling point (°C)	Log Pow	Water-solubility (mg/L)	Vapour pressure (mm Hg)	Comments	Material

Table B1.3: Identified aldehydes (VVOC, VOC)

Substance	CAS	Emission	MW (g/mol)	Boiling point (°C)	Log Pow	Water-solubility (mg/L)	Vapour pressure (mm Hg)	Comments	Material
Formaldehyde	50-00-0	2.8-24 µg/m³ [Katsoyiannis et al 2008] 10 µg/m³ [DTI's own data] 2-5 µg/m²h [DTI's own data] 14 µg/m³ [Kalberlah et al 2011]	30.03	-19.1	0.35	4.00E+05 at 20°C	3886 at 25°C	Four carpets were analysed in four types of chambers and the substance was found in all carpets in at least one chamber after either 24h or 72h [Katsoyannis et al 2004] Substance was found in 1 out of 28 carpets (emission) and in 3 out of 7 samples where the emission rate was determined [DTI's own data] Chamber concentration after 72 hours [Kalberlah et al 2011] Substance found in 10 out of 10 wall carpets purchased in Denmark [Pors og Fuhlendorff 2002] Found in 6 out of 8 carpets purchased in the UK [Greenpeace 2001]	[Katsoyannis et al 2004]: Material upper side: nylon, wool, PP Material backing: SBR, synthetic (not SBR) [DTI's own data]: Emission: material: used rug Emission rate: material upper side: Nylon material backing: PP, textile, latex. [Kalberlah et al 2011]: material upper side: wool material backing: synthetic. [Pors and Fuhlendorff 2002]: material upper side: PP, nylon, wool, sisal material backing: foam, textile, felt [Greenpeace 2001]: Material: 80% wool/20% nylon (4) – one with jute backing, polyester, PP and EVA latex, 80% wool /10% PP / 10% PES and PP backing (1), rug of 100% PP (1)

Table B1.3: Identified aldehydes (VVOC, VOC)

Substance	CAS	Emission	MW (g/mol)	Boiling point (°C)	Log Pow	Water-solubility (mg/L)	Vapour pressure (mm Hg)	Comments	Material
Acetaldehyde	75-07-0	1.0-14 µg/m³ [Katsoyiannis et al 2008] 4 µg/m³ [DTI's own data] 3-5 µg/m² h [DTI's own data]	44.05	20.1	-0.34	1.00E+06 at 25°C	902 at 25°C	Four carpets were analysed in four types of chambers and the substance was found in all carpets except for one chamber after 24h and 72h [Katsoyiannis et al 2004] Substance found in 1 out of 28 analysed samples (emission) and 6 out of 7 samples where the emission rate is determined [DTI's own data]	[Katsoyannis et al 2004]: material upper side: nylon, wool, PP material backing: SBR, synthetic (not SBR) [DTI's own data]: Emission: Material: used rug - unknown Emission rate: Material upper side: Polyamide Material backing: PP, textile, latex
Propanal	123-38-6	0.85-5.5 µg/m³ [Katsoyiannis et al 2008] 1 µg/m² h [DTI's own data]	58.08	48	0.59	3.06E+05 at 25°C	317 at 25°C	Der er analyseret fire tæpper i fire kammertyper og stoffet er fundet i alle tæpper i mindst et kammer efter enten 24h eller 72 h [Katsoyiannis et al 2004] Stoffet er fundet i 1 ud af 7 prøver (hvor emissionsrate er bestemt) [DTI's own data]	[Katsoyannis et al 2004]: material upper side: nylon, wool, PP material backing: SBR, synthetic (not SBR) [DTI's own data]: Emission rate: Material upper side: used rug - unknown Material backing: Latex
Benzaldehyde	100-52-7	2 µg/m³ [Wilke et al 2004] 2-4 µg/m³ [DTI's own data] 1-3 µg/m² h [DTI's own data]	106.12	179	1.48	6570 at 25°C	0.127 at 25°C	Stoffet er fundet i et ud af 14 analyserede tæpper [Wilke et al 2004] Stoffet er fundet i 5 prøver ud af 28 (emission) samt i 4 ud af 7 tæpper, hvor emissionsraten er bestemt [DTI's own data]	[DTI's own data]: Emission: Material upper side: used rug, nylon, olefin, Material backing: latex, Action Bac Emission rate: Material upper side: nylon, used rug

Table B1.3: Identified aldehydes (VVOC, VOC)

Substance	CAS	Emission	MW (g/mol)	Boiling point (°C)	Log Pow	Water-solubility (mg/L)	Vapour pressure (mm Hg)	Comments	Material
									Material backing: PP, latex
Pentanal	110-62-3	3 μg/m³ [DTI's own data]	86.13	103	1.31	1.17E+04 at 25°C	26 at 20°C	Substance found in 1 out of 28 analysed samples (emission) [DTI's own data]	[DTI's own data]: Emission: Material upper side: nylon Material backing: latex
Heptanal	111-71-7	2 μg/m³ [DTI's own data] 1 μg/m² h [DTI's own data]	114.19	152.8	2.29	1250 at 25°C	3.52 at 25°C	Substance found in 1 out of 28 analysed samples (emission) and in 1 out of 7 samples where the emission rate was determined [DTI's own data]	[DTI's own data]: Emission: Material upper side: nylon Material backing: latex Emission rate: Material upper side: nylon Material backing: latex
Decanal	112-31-2	1-4 μg/m³ [DTI's own data] 1-4 μg/m² h [DTI's own data]	156.26	208.5	3.76	60.8 at 25°C	0.103 at 25°C	Substance found in 9 out of 28 analysed samples (emission) and in 2 samples out of 7 where the emission rate was determined [DTI's own data]	[DTI's own data]: Emission: Material upper side: used rug, olefin, nylon Material backing: latex, Action Bac Emission rate: Material upper side: used rug - unknown Material backing: latex

Table B1.3: Identified aldehydes (VVOC, VOC)

Substance	CAS	Emission	MW (g/mol)	Boiling point (°C)	Log Pow	Water-solubility (mg/L)	Vapour pressure (mm Hg)	Comments	Material
Dodecanal	112-54-9	1 µg/m³ [DTI's own data] 1 µg/m² h [DTI's own data]	184.32		4.75	4.650 at 25°C	0.0153 at 25°C	Substance found in 1 out of 28 analysed samples (emission) and in 1 sample out of 7 where the emission rate was determined [DTI's own data]	[DTI's own data]: Emission: Material upper side: nylon Material backing: latex Emission rate: Material upper side: nylon Material backing: latex
Octanal	124-13-0	1-3 µg/m³ [DTI's own data] 1-2 µg/m² h [DTI's own data]	128.2134	171	2.78	560 at 25°C	2 mm Hg (20°C) [CB]	Substance found in 3 out of 28 analysed samples (emission) and in 3 out of 7 samples where the emission rate was determined [DTI's own data]	[DTI's own data]: Emission: Material upper side: nylon Material backing: latex Emission rate: Material upper side: nylon, used rug Material backing: latex
Nonanal	124-19-6	1-20 µg/m³ [DTI's own data] 3-4 µg/m² h [DTI's own data]	142.24	191	3.27	96 at 25°C	0.37 at 25°C	Substance found in 17 out of 28 analysed samples (emission) and in 3 out of 7 samples where the emission rate was determined [DTI's own data]	[DTI's own data]: Emission: Material upper side: used rug, nylon, olefin Material backing: latex, Action Bac Emission rate: Material upper side: nylon, used rug Material backing: latex
trans-2-Nonenal	18829-56-6	1-2 µg/m³ [DTI's own data]	140.22	88-90 [CB]	3.060 (est.) [ChemIDPlus]			Substance found in 2 out of 28 analysed samples (emission) [DTI's own data]	[DTI's own data]: Emission: Material upper side: nylon Material backing: latex

Table B1.3: Identified aldehydes (VVOC, VOC)

Substance	CAS	Emission	MW (g/mol)	Boiling point (°C)	Log Pow	Water-solubility (mg/L)	Vapour pressure (mm Hg)	Comments	Material
Trans-2-decanal	3913-81-3	1-2 µg/m^3 [DTI's own data]	154.25	78-80 [CB]		insoluble [CB]		Substance found in 1 out of 28 analysed samples (emission) [DTI's own data]	[DTI's own data]: Emission: Material upper side: nylon Material backing: latex
Hexanal	66-25-1	2-9 µg/m^3 [DTI's own data] 1-3 µg/m^3 [DTI's own data]	100.16	131	1.78	5640 at 30°C	11.3 at 25°C	Substance found in 2 out of 28 analysed samples (emission) and in 2 out of 7 samples where the emission rate was determined [DTI's own data]	DTI's own data: Emission: Material upper side: nylon Material backing: latex Emission rate: Material upper side: nylon, used rug Material backing: PP, textile
2-ethyl-hexanal	123-05-7		128.21	163	2.71	400 at 25°C	1.8 at 20°C	Source states that the substance was identified by emission of up to 130 days from glue used to fasten rugs to floor surfaces	
2-octenal	2363-89-5		126.20		2.57	613 at 25°C	0.86 at 25° C	Source states that the substance was identified by emission of up to 130 days from glue used to fasten rugs to floor surfaces	
2-nonenal	2463-53-8		140.22					Source states that the substance was identified by emission of up to 130 days from glue used to fasten rugs to floor surfaces	
3-isopropyl-benzalde-hyde	34246-57-6							Source states that the substance was identified by emission of up to 130 days from glue used to fasten rugs to floor surfaces	

Table B1.4: Identified Alcanes (VOC)

Substance	CAS	Emission	MW (g/mol)	Boiling point (°C)	Log Pow	Water-solubility (mg/L)	Vapour pressure (mm Hg)	Comments	Material
Tridecan	629-50-5	1-4 µg/m³ [Wilke et al 2004] 1-5 µg/m³ [DTI's own data]	184	235.4	6.73	0.0047 at 25° C	0.0558 at 25° C	Substance found in four out of 14 analysed carpets and is the second most frequent substance identified by Wilke et al in carpets [Wilke et al 2004] Substance found in 3 out of 28 samples (emission) [DTI's own data]	[DTI's own data]: Emission: Material upper side: nylon, polypropene, wool Material backing: latex, synthetic rubber
2-methyl pentan	107-83-5	7 µg/m³ [DTI's own data]	86.18	60.2	3.21	14 at 25° C	211 at 25° C	Substances found in 1 out of 28 analysed samples (emission) [DTI's own data]	[DTI's own data]: Emission: Material upper side: olefin Material backing: Action Bac
Hexane	110-54-3	2-12 µg/m³ [DTI's own data]	86.18	68.7	3.9	9.5 at 25° C	151 at 25° C	Substances found in 3 out of 28 analysed samples (emission) [DTI's own data]	[DTI's own data]: Emission: Material upper side: nylon, olefin Material backing: latex, Action Bac
Undecane	1120-21-4	0-10 µg/m³ [DTI's own data] 1 µg/m² h [DTI's own data]	156.31	195.9	6.5	0.0044 at 25° C	0.412 at 25° C	Substances found in 4 out of 28 analysed samples (emission) and in 2 samples where the emission rate was determined [DTI's own data]	DTI's own data: Emission: Material upper side: nylon, polypropene, olefin Material backing: latex Emission rate: Material: unknown

Table B1.4: Identified Alcanes (VOC)

Substance	CAS	Emission	MW (g/mol)	Boiling point (°C)	Log Pow	Water-solubility (mg/L)	Vapour pressure (mm Hg)	Comments	Material
Dodecan	112-40-3	1-5 µg/m^3 [DTI's own data] 1-2 µg/m^2 h [DTI's own data]	170.34	216.3	6.1	0.0037 at 25° C	0.135 at 25° C	Substances found in 6 out of 28 analysed samples (emission) and in 2 out of 7 samples where the emission rate was determined [DTI's own data]	[DTI's own data]: Emission: Material upper side: nylon, olefin, wool Material backing: latex, Action Bac, synthetic rubber Emission rate: Material upper side: used rug Material backing: latex
Decan	124-18-5	2-4 µg/m^3 [DTI's own data]	142.28	174.1	5.01	0.052 at 25° C	1.43 at 25° C	Substance found in 1 out of 28 analysed samples (emission) [DTI's own data]	[DTI's own data]: Emission: Material upper side: olefin Material backing: Action Bac
3-methyl-hexane	589-34-4	5 µg/m^3 [DTI's own data] 2 µg/m^2 h [DTI's own data]	100.20	91	3.71	4.95 at 25° C	61.5 at 25° C	Substance found in 1 out of 28 samples (emission) and in 1 out of 7 samples where the emission rate was determined [DTI's own data]	[DTI's own data]: Emission: Material upper side: olefin Material backing: Action Bac Emission rate: Material upper side: used rug - unknown Material backing: latex
2-methyl-hexane	591-76-4	3 µg/m^3 [DTI's own data]	100.20	90	3.71	2.54 at 25° C	66 at 25° C	Substance found in 1 out of 28 analysed samples (emission) [DTI's own data]	[DTI's own data]: Emission: Material upper side: olefin Material backing: Action Bac

Table B1.4: Identified Alcanes (VOC)

Substance	CAS	Emission	MW (g/mol)	Boiling point (°C)	Log Pow	Water-solubility (mg/L)	Vapour pressure (mm Hg)	Comments	Material
3-methyl-pentane	96-14-0	16 µg/m³ [DTI's own data]	86.1766	63.2	3.6	17.9 at 25° C	190 at 25° C	Substance found in 1 out of 28 analysed samples (emission) [DTI's own data]	[DTI's own data]: Emission: Material upper side: olefin Material backing: Action Bac
Methyl-cyclopentane	96-37-7	13 µg/m³ [DTI's own data]	84.1608	71.8	3.37	42 at 25° C	138 at 25° C	Substance found in 1 out or 28 analysed samples (emission) [DTI's own data]	[DTI's own data]: Emission: Material upper side: olefin Material backing: Action Bac
Methylhexane	108-87-2	2 µg/m² h [DTI's own data]	98.1876	100.9	3.61	14 at 25° C	46 at 25° C	Substance found in 1 out of 7 samples (here the emission rate was determined) [DTI's own data]	[DTI's own data]: Emission rate: Material: unknown
Nonan	111-84-2	2 µg/m² h [DTI's own data]	128.257	150.8	4.76	220 at 25° C	4.45 at 25° C	Substance found in 1 out of 7 samples (where the emission rate was determined) [DTI's own data]	[DTI's own data]: Emission rate: Material upper side: used rug Material backing: latex
2,2,6,6-tetramethyl-4-methylideneheptane	141-70-8		168.322					Source refers to modelling of emission data of the substance from the carpet	
	629-78-8 [Wilke et al 2004]	1 - 5 µg/m³ [Wilke et al 2004]						Substance found in 3 out of 14 analysed carpet [Wilke et al 2004]	

Table B1.5: Identified alcohols – VOCs

Substance	CAS	Emission	MW (g/mol)	Boiling point (°C)	Log Pow	Water-solubility (mg/L)	Vapour pressure (mm Hg)	Comments	Material
Ethyl hexanol (2-ethyl-1-hexanol)	104-76-7	1-23 µg/m³ [Wilke et al 2004] 1-237 µg/m³ [DTI's own data] 1-175 µg/m² h [DTI's own data]	130	184.9	2.730	880 at 25° C	0.136 at 25° C	Substance found in 2 out of 14 analysed carpets [Wilke et al 2004] Substance found in 11 samples out of 28 (emission) and in 5 out of 7 carpets where the emission rate was determined [DTI's own data]	[DTI's own data]: Emission: 1-237 ug/m3h: Material upper side:PP, nylon, olefin, wool Material backing: latex, Action Bac, synthetic rubber Emission rate: SER 3-175 ug/m2h: Material upper side: nylon, used rug Material backing: PP, textile, latex
Cyclohexanol	108-93-0	1-2 µg/m³ [Wilke et al 2004] 1-2 µg/m³ [DTI's own data] 3-88 µg/m² h [DTI's own data]	100	160.8	1.23	4.20E+04 at 10° C	0.8 at 25° C	Substance found in 2 out of 14 analysed carpets [Wilke et al 2004] Substance found in 1 out of 28 samples (emission) and in 3 out of 7 carpets where the emission rate was determined [DTI's own data]	[DTI's own data]: Emission: Material upper side: wool Material backing: synthetic rubber Emission rate: SER 14-88 ug/m2h: Material upper side: nylon, used rug Material backing: PP, textile, latex
Phenoxyethanol	122-99-6 [Wilke et al 2004]	3 µg/m³ [Wilke et al 2004]	138.17	245	1.16	2.67E+04 at 20° C	0.007 at 25° C	Substance found in 1 out of 14 analysed carpets [Wilke et al 2004]	

Table B1.5: Identified alcohols – VOCs

Substance	CAS	Emission	MW (g/mol)	Boiling point (°C)	Log Pow	Water-solubility (mg/L)	Vapour pressure (mm Hg)	Comments	Material
Butanol	71-36-3	3-5 µg/m³ [DTI's own data] 2 µg/m² h [DTI's own data]	74.12	117.7	0.88	6.32E+04 at 25° C	6.7 at 25° C	Substance found in 1 out of 28 analysed samples (emission) and in 1 out of 7 samples where the emission rate was determined [DTI's own data]	[DTI's own data]: Emission: Material upper side: nylon Material backing: latex Emission rate: Material upper side: used rug
Isobutanol	78-83-1	35-49 µg/m³ [DTI's own data]	74.12	107.8	0.76	8.50E+04 at 25° C	10.5 at 25° C	Substance found in 1 out of 28 analysed samples (emission) [DTI's own data]	[DTI's own data]: Emission: Material upper side: wool Material backing: synthetic rubber
Benzyl alcohol	100-51-6	5-18 µg/m² h [DTI's own data]	108.14	205.3	1.1	4.29E+04 at 25° C	0.094 at 25° C	Substance found in 3 out of 7 samples (where the emission rate was determined) [DTI's own data]	[DTI's own data]: Emission rate: Material upper side: nylon, used rug Material backing: PP, textile, latex
Phenol	108-95-2	1-2 µg/m² h [DTI's own data]	94.11	181.8	1.46	8.28E+04 at 25° C	0.35 at 25° C	Substance found in 2 out of 7 samples (where the emission rate was determined) [DTI's own data]	[DTI's own data]: Emission rate: Material upper side: nylon Material backing: PP, textile

Table B1.6: Other identified substances – VOCs

Substance	CAS	Emission	MW (g/mol)	Boiling point (°C)	Log Pow	Water-solubility (mg/L)	Vapour pressure (mm Hg)	Comments	Material
2-butanol 3,3'-oxybis	54305-61-2 [Wilke et al 2004]	2 μg/m³ [Wilke et al 2004]	162.23					Substance found in 1 out of 14 analysed carpets [Wilke et al 2004]	
di-n-butylamin	111-92-2	7-8 μg/m³ [DTI's own data]	129.25	159.6	2.83	3500 at 25° C	2.59 at 25° C	Substance found in 1 out of 28 analysed samples (emission) [DTI's own data]	[DTI's own data]: Emission: Material upper side: olefin Material backing: Action Bac
2-Ethyl-thiazolidin	24050-09-7	5-7 μg/m³ [DTI's own data]	117.22					Substance found in 1 out of 28 analysed samples (emission) [DTI's own data]	[DTI's own data]: Emission: Material upper side: nylon Material backing: latex
Carbondisulphide	75-15-0	1-2 μg/m³ [DTI's own data]	76.14	46 [CB]		2.9 g/L at 20° C [CB]	5.83 psi at 20° C [CB]	Substance found in 1 out of 28 analysed samples (emission) [DTI's own data]	[DTI's own data]: Emission: Material upper side: nylon Material backing: latex
n,n-dibutyl formamide	761-65-9	3-4 μg/m³ [DTI's own data]	157.25 [CB]	240 [CB]	2.18 [CB]	Insoluble [CB]	0.04 at 25° C [CB]	Substance found in 1 out of 28 analysed samples (emission) [DTI's own data]	[DTI's own data]: Emission: Material upper side: nylon Material backing: latex
Cyclohexane, 1,1"-oxybis	4645-15-2	3-8 μg/m² h [DTI's own data]	182.31	242.5	5			Substance found in 1 out of 7 samples (where the emission rate was determined) [DTI's own data]	[DTI's own data]: Emission rate: Material upper side: nylon Material backing: PP

Table B1.6: Other identified substances – VOCs

Substance	CAS	Emission	MW (g/mol)	Boiling point (°C)	Log Pow	Water-solubility (mg/L)	Vapour pressure (mm Hg)	Comments	Material
2-butanonoxim	96-29-7	1 μg/m² h [DTI's own data]	87.12	152.5	0.63	1.00E+05 at 25° C	0.904 at 25° C	Substance found in 1 out of 7 samples (where the emission rate was determined) [DTI's own data]	[DTI's own data]: Emission rate: Material upper side: used rug Material backing: latex

Table B1.7: Identified aromatic hydrocarbons - VOCs

Substance	CAS	Emission	MW (g/mol)	Boiling point (°C)	Log Pow	Water-solubility (mg/L)	Vapour pressure (mm Hg)	Comments	Material
4-vinyl cyclobenzene								Describes that it often is found together with 4-PCH (adhesive)	[Katsoyannis et al 2004]: Typical source stated as glue (adhesive)
Benzene	71-43-2	0.07-4.6 µg/m³ [Katsoyiannis et al 2008]	78.11	80	2.13	1790 at 25° C	94.8 at 25° C	Four carpets were analysed in four types of chambers and the substance was found in all carpets in at least one chamber after 24h or 72h [Katsoyannis et al 2004]	[Katsoyannis et al 2004]: material upper side: nylon, wool, PP material backing: SBR, synthetic (not SBR)
Toluene	108-88-3	0.24-12 µg/m³ [Katsoyiannis et al 2008] 1 µg/m³ [DTI's own data]	92.14	110.6	2.73	526 at 25° C	28.4 at 25° C	Four carpets were analysed in four types of chambers and the substance was found in all chambers after 24h as well as 72h, [Katsoyiannis et al 2004] Substance found in 1 out of 28 analysed samples (emission) [DTI's own data]	[Katsoyannis et al 2004]: material upper side: nylon, wool, PP material backing: SBR, synthetic (not SBR) [DTI's own data]: Emission: Material upper side: nylon Material backing: latex
Ethyl benzene	100-41-4	0.14-2.7 µg/m³ [Katsoyiannis et al 2008] 1-2 µg/m² h [DTI's own data]	106.17	136.1	3.15	169 at 25 C	9.6 at 25° C	Four carpets were analysed in four types of chambers and the substance was found in two carpets in at least one chamber after either 24h or 72h [Katsoyiannis et al 2004] Substance found in 2 out of 7 samples (where the emission rate was determined) [DTI's own data]	[Katsoyannis et al 2004]: material upper side: nylon, wool, PP material backing: SBR, synthetic (not SBR) [DTI's own data]: Emission rate: Material upper side: polyamide Material backing: PP, textile

Table B1.7: Identified aromatic hydrocarbons - VOCs

Substance	CAS	Emission	MW (g/mol)	Boiling point (°C)	Log Pow	Water-solubility (mg/L)	Vapour pressure (mm Hg)	Comments	Material
Styrene	100-42-5	0.27-11 µg/m³ [Katsoyiannis et al 2008] 1-2 µg/m³ [DTI's own data] 3-6 µg/m² h [DTI's own data]	104.15	145	2.95	310 at 25 C	6.4 at 25° C	Four carpets were analysed in four types of chambers and the substance was found in three carpets in at least one chamber after either 24h or 72 h [Katsoyiannis et al 2004] Substance found in 1 carpet out of 28 analysed (emission) and in 4 out of 7 carpets where the emission rate was determined [DTI's own data]	[Katsoyannis et al 2004]: Material upper side: nylon, wool, PP Material backing: SBR, synthetic (not SBR) [DTI's own data]: Emission: Material upper side: nylon Material backing: latex Emission rate: Material upper side: polyamide ,used rug Material backing: PP, textile
4-phenyl-cyclohexen (4-PCH)	4994-16-5	15-140 µg/m³ [Katsoyiannis et al 2008] 1-18 µg/m³ [Wilke et al 2004] 1-13 µg/m³ [DTI's own data] 4-116 µg/m² h [DTI's own data]	158	235 [CB]				Four carpets were analysed in four types of chambers and the substance was found in three carpets (all with SBR) in all chambers after 24h and 72 h. [Katsoyiannis et al 2004] Also mentioned in [Guo et al 2004]. Substance found in 10 out of 14 carpets by Wilke *et al* and is the most frequent (S)VOC [Wilke et al 2004]. Substance found in 16 out of 28 samples (emission) and in 7 samples out of 7 where the emission rate was determined [DTI's own data]	[Katsoyannis et al 2004}: Material upper side: nylon, wool, PP Material backing: SBR [DTI's own data]: Emission: 2-52 ug/m3h: Material upper side: nylon, olefin, PP, polyamide, wool Material backing: latex, Action Bac, PP, synthetic rubber Emission rate: Material upper side: used rug, polyamide Material backing: PP,

Table B1.7: Identified aromatic hydrocarbons - VOCs

Substance	CAS	Emission	MW (g/mol)	Boiling point (°C)	Log Pow	Water-solubility (mg/L)	Vapour pressure (mm Hg)	Comments	Material
									textile, latex
Alkyl benzenes	Flere: ikke opgivet [Wilke et al 2004]	24-40 μg/m3 [Wilke et al 2004]						Substance found in two out of 14 analysed carpets [Wilke et al 2004]	
Benzothiazol	95-16-9	1-2 μg/m3 [Wilke et al 2004] 2-41 μg/m3 [DTI's own data]	135.19	231	2.01	4300 at 25°C	0.014 at 25° C	Substance found in two out of 14 analysed carpets [Wilke et al 2004] Substance found in 8 out or 28 analysed samples (emission) [DTI's own data]	[DTI's own data]: Emission: Material upper side: nylon, olefin Material backing: latex, Action Bac
1,4-Diisopropylbenzene	100-18-5	1-14μg/m3 [DTI's own data]	162.27	210.3	4.9	4.330 at 25° C	0.246 at 25° C	Substances found in 3 out of 28 analysed samples (emission) [DTI's own data]	[DTI's own data]: Emission: Material upper side: nylon, olefin Material backing: Action Bac, latex
Naphthalene	91-20-3	1 μg/m3 [DTI's own data]	128.17	217.9	3.3	31 at 25° C	0.085 at 25° C	Substance found in 1 out of 28 analysed samples (emission) [DTI's own data]	[DTI's own data]: Emission: Material upper side: olefin Material backing: Action Bac

Table B1.7: Identified aromatic hydrocarbons - VOCs

Substance	CAS	Emission	MW (g/mol)	Boiling point (°C)	Log Pow	Water-solubility (mg/L)	Vapour pressure (mm Hg)	Comments	Material
4-vinylcyclohexen	100-40-3	0-3 μg/m² h [DTI's own data]	108.18	128	3.93	50 at 25° C	15.7 at 25° C	Substance found in 4 out of 7 samples (where emission rate was determined) [DTI's own data]	[DTI's own data]: Emission rate: SER 1-ug/m2h: Material upper side: nylon Material backing: PP, textile, latex
m-xylene	108-38-3	1 μg/m² h [DTI's own data]	106.17	139.1	3.2	161 at 25° C	8.29 at 25° C	Substance found in 1 out of 7 samples (where emission rate was determined) [DTI's own data]	[DTI's own data]: Emission rate: Material upper side: nylon Material backing: PP, textile
Diisopropylphenol	Several	3-6 μg/m³ [DTI's own data]						Substance found in 2 out of 28 analysed samples (emission) [DTI's own data]	[DTI's own data]: Emission: Material upper side: nylon Material backing: latex
Xylenes	Several	0.29-4.4 μg/m³ [Katsoyiannis et al 2008]						Four carpets were analysed in four types of chambers and the substances were found in three carpets in at least one chamber after either 24h or 72 h [Katsoyannis et al 2004]	[Katsoyannis et al 2004]: Material upper side: nylon, uld, PP Material backing: SBR, syntetisk (ikke SBR)

Table B1.8: Identified carboxylic acids - VOCs

Substance	CAS	Emission	MW (g/mol)	Boiling point (°C)	Log Pow	Water-solubility (mg/L)	Vapour pressure (mm Hg)	Comments	Material
Acetic acid (Ethanoic acid)	64-19-7	105-3300 µg/m³ [Wilke et al 2004] 8-85108 µg/m³ [DTI's own data] 9-800 µg/m² h [DTI's own data]	60.05	117.9	-0.17	1.00E+06 at 25° C	15.7	Substance found in three out of 14 analysed carpets. Substance was also identified by emission up to 130 days from glue used to fix carpets to floor surfaces [Wilke et al 2004] Substance found in 17 out of 28 samples (emission) and in 5 out of 7 samples where the emission rate was determined [DTI's own data]	[DTI's own data]: Emission: Material upper side: PP, used rug, olefin, nylon, wool, polyamide Material backing: action, PP, latex, synthetic rubber. Emission rate: Material upper side: nylon Material backing: PP, textile, latex
2-propane acid (acrylic acid)	79-10-7	7 µg/m³ [Wilke et al 2004] 2-5 µg/m² h [DTI's own data]	72.06	141.2	0.35	1.00E+06	3.97	Substance found in one out of 14 analysed carpets [Wilke et al 2004] Substances found in 2 samples out of 7, where the emission rate was determined [DTI's own data]	[DTI's own data]: Emission rate: SER 2-5 ug/m2h: Material upper side: Material backing:
Propane acid (propionic acid)	79-09-4	3-22 µg/m³ [DTI's own data]	74.08	141.1	0.33	1.00E+06 at 25° C	3.53 at 25° C	Substance found in 2 out of 28 analysed samples (emission) [DTI's own data] Substance identified by emission followed for 130 days from glue used to fix carpets to floor surfaces [Wilke et al 2004]	[DTI's own data]: Emission: Material upper side: Material backing:
Formic acid (Methane acid)	64-18-6	155-210 µg/m² h [DTI's own data]	46.025	101	-0.54	1.00E+06 at 25° C	42.6 at 25° C	Substance found in 1 out of 6 samples (where emission rate was determined) [DTI's own data] Substances identified in	[DTI's own data]: Emission rate: Material upper side: used rug Material backing: latex

Table B1.8: Identified carboxylic acids - VOCs

Substance	CAS	Emission	MW (g/mol)	Boiling point (°C)	Log Pow	Water-solubility (mg/L)	Vapour pressure (mm Hg)	Comments	Material
								emission test for up to 130 days from a glue used to fit carpets [Wilke et al 2004]	
Heptane acid	111-14-8		130.19	222.2	2.42	2820 at 25° C	0.0107 at 25° C	Source states that the substance was identified by emission for up to 130 days from glue used to fix carpets to floor surfaces	
Butane acid (butanoic acid)	107-92-6		88.11	163.7	0.79	6.00E+04 at 25° C	1.65 at 25° C	Source states that the substance was identified by emission for up to 130 days from glue used to fix carpets to floor surfaces	
Pentane acid	109-52-4		102.13	186.1	1.39	2.40E+04 at 25° C	0.196 at 25° C	Source states that the substance was identified by emission for up to 130 days from glue used to fix carpets to floor surfaces	
Hexane acid	142-62-1		116.16	205.2	1.92	1.03E+04 at 25° C	0.0435 at 25° C	Source states that the substance was identified by emission for up to 130 days from glue used to fix carpets to floor surfaces	

Table B1.9: Identified chlorine compounds - VOCs

Substance	CAS	Emission (unit)	MW (g/mol)	Boiling point (°C)	Log Pow	Water-solubility (mg/L)	Vapour pressure (mm Hg)	Comments	Material
1,4-dichloror-benzene	106-46-7	1-23 µg/m³ [DTI's own data]	147.00	174	3.44	81.3 at 25° C	1.74 at 25° C	Substance found in 4 out of 28 analysed samples (emission) [DTI's own data]	[DTI's own data]: Emission: Material upper side: nylon, olefin Material backing: latex, Action Bac

Table B1.10: Identified esters, ethers and glycols - VOCs

Substance	CAS	Emission	MW (g/mol)	Boiling point (°C)	Log Pow	Water-solubility (mg/L)	Vapour pressure (mm Hg)	Comments	Material
Diethylene glycol mono-n-butyl ether (also Butyl diglycol, 2,2-butoxyethoxyethanol and 2,2-BEE)	112-34-5	1-320 µg/m³ [Katsoyiannis et al 2008] 1 µg/m³ [Wilke et al 2004] 2 µg/m³ [DTI's own data] 5-89 µg/m² h [DTI's own data]	162.23	231	0.56	1.00E+06 at 25° C	0.0219 at 25° C	Four carpets were analysed in four types of chambers and the substance was found in one carpet in all chambers after 24h and 72h. Source refers to previous emission measurement of up to 225 ug/m³ after 1 hour [Katsoyiannis et al 2004] Substance found in one out of 14 analysed carpets [Wilke et al 2004] Substance found in 1 out of 28 samples (emission) and in 6 out of 7 carpets where the emission rate was determined [DTI's own data]	[Katsoyannis et al 2004]: Material upper side: nylon, wool, PP Material backing: SBR, synthetic (not SBR) [DTI's own data]: Emission: Material upper side: nylon, polyamide Material backing: PP, latex. Emission rate: Material upper side: polyamide, used rug Material backing: PP, textile
Ethylene glycol	107-21-1 [Wilke et al 2004]	20-94 µg/m³ [Wilke et al 2004]	62	197.3	-1.36E+00	1.00E+06	0.092 at 25° C	Substance found in two out of 14 analysed carpets [Wilke et al 2004]	
Propylene glycol (1,2-propandiol)	57-55-6	40-83 µg/m³ [Wilke et al 2004] 13-237 µg/m³ [DTI's own data] 14-90 µg/m² h [DTI's own data]	76.09	187.6	-0.92	1.00E+06 at 20° C	0.129 at 25° C	Substance found in two out of 14 analysed carpets [Wilke et al 2004] Substance found in 6 out of 28 analysed samples (emission) and in 5 out of 7 samples where the emission rate was determined [DTI's own	[DTI's own data]: Emission: 24-237 ug/m3h: Material upper side: olefin, nylon Material backing: latex, Action Bac, PP Emission rate: SER 1-90 ug/m²h: Material upper side: nylon

Table B1.10: Identified esters, ethers and glycols - VOCs

Substance	CAS	Emission	MW (g/mol)	Boiling point (°C)	Log Pow	Water-solubility (mg/L)	Vapour pressure (mm Hg)	Comments	Material
								data]	Material backing: PP, textile, latex
Hexylene glycol	107-41-5 [ChemIDplus]	7-10 μg/m³ [DTI's own data] 2 μg/m² h [DTI's own data]	118.18	198	0.58	1.00E+06 at 25° C	0.013 at 25° C	Substances found in 1 out of 28 analysed samples (emission) and in 1 sample out of 7 where the emission rate was determined [DTI's own data]	[DTI's own data]: Emission: 4-10 ug/m3h: Material upper side: nylon Material backing: latex, PP Emission rate: SER 4 ug/m²h: Material upper side: used rug
Propanoic acid, 2-methyl-, 3-hydroxy-2,4,4-trimethylpentyl ester	74367-34-3	1 μg/m³ [DTI's own data]						Substance found in 1 out of 28 analysed samples (emission) [DTI's own data]	[DTI's own data]: Emission: Material upper side: nylon Material backing: latex
2-Ethylhexylacetate	103-09-3	2 μg/m² h [DTI's own data]	172.276	199	3.74		0.23 at 25° C	Substance found in 1 out of 7 samples (where emission rate was determined) [DTI's own data]	DTI's own data: Emission rate: Material upper side: used rug Material backing: latex
1-methoxy-2-propylacetate	108-65-6	0-7 μg/m² h [DTI's own data]	132.16	145-146	0.56	1.98E+05 v 25° C	3.92 at 25° C	Substance found in 2 out of 7 samples (where emission rate was determined) [DTI's own data]	DTI's own data: Emission rate: Material upper side: nylon Material backing: PP, textile
Butyl glycol	111-76-2	2 μg/m² h [DTI's own data]	118.18	168.4	0.83	1.00E+06 at 20°C	0.88 at 25° C	Substance found in 1 out of 7 samples (where emission rate was determined) [DTI's own data]	DTI's own data: Emission rate: Material upper side: used rug Material backing: latex

Table B1.10: Identified esters, ethers and glycols - VOCs

Substance	CAS	Emission	MW (g/mol)	Boiling point (°C)	Log Pow	Water-solubility (mg/L)	Vapour pressure (mm Hg)	Comments	Material
Ethyldiglycol	111-90-0	50 μg/m² h [DTI's own data]	134.17	196	-0.54	1.00E+06 at 20°C	0.126 at 25° C	Substance found in 1 out of 7 samples (where emission rate was determined) [DTI's own data]	DTI's own data: Emission rate: Material upper side: used rug Material backing: latex
Dipropylene glycol butylether (mixture of isomers)	29911-28-2	3 μg/m² h [DTI's own data]	190.28	222-232 [CB]				Substance found in 1 out of 7 samples (where emission rate was determined) [DTI's own data]	DTI's own data: Emission rate: Material upper side: used rug Material backing: latex
(2-methoxymethylethoxy) propanol (DPGMM)	34590-94-8	1-9 μg/m² h [DTI's own data]	150.22	188.3	-0.35	1.00E+06 at 25° C	0.55 at 25° C	Substance found in 2 out of 7 samples (where emission rate was determined) [DTI's own data]	
1,2-propandiol (S-form)	4254-15-3	18-60 μg/m² h [DTI's own data]	76.09	186-188 [CB]		Soluble [CB]		Substance found in 1 out of 7 samples (where emission rate was determined) [DTI's own data]	
Phosphoric acid ester		1 μg/m³ [Wilke et al 2004]						Substance found in two out of 14 analysed carpets [Wilke et al 2004]	
Propylene glycol ether		28 μg/m³ [Wilke et al 2004]						Substance found in one out of 14 analysed carpets [Wilke et al 2004]	

Table B1.11: Identified ketones, terpenes and siloxanes - VOCs

Substance	CAS	Emission	MW (g/mol)	Boiling point (°C)	Log Pow	Water-solubility (mg/L)	Vapour pressure (mm Hg)	Comments	Material
Alpha-isomethylionon	127-51-5	1 μg/m³ [DTI's own data]	206.337	121-122 [CB]				Substance found in 1 out of 28 analysed samples (emission) [DTI's own data]	[DTI's own data]: Emission: Material upper side: nylon Material backing: latex
3-caren	498-15-7	1 μg/m³ [DTI's own data] 1 μg/m² h [DTI's own data]	136.24	170-172 [CB]				Substance found in 1 out of 28 analysed samples (emission) and in 1 out of 7 samples where emission rate was determined [DTI's own data]	[DTI's own data]: Emission: Material upper side: Material backing: Emission rate: Material upper side: used rug, nylon Material backing: latex
Decamethyl cyclopentasiloxane	541-02-6	3-5 μg/m³ [DTI's own data]	370.77	210	5.2	0.017 at 25° C		Substance found in 2 out of 28 analysed samples (emission) [DTI's own data]	[DTI's own data]: Emission: 4-5 ug/m3h: Material upper side: olefin Material backing: latex, Action Bac
Hexamethyl-cyclotriloxane	541-05-9	2-3 μg/m³ [DTI's own data] 3-5 μg/m² h [DTI's own data]	222.46	134	4.47	1.570 at 25° C		Substance found in 2 out of 28 analysed samples (emission) and in 1 out of 7 samples where emission rate was determined [DTI's own data]	[DTI's own data]: Emission: 2 ug/m3h: Material upper side: nylon, olefin Material backing: latex, Action Bac Emission rate: Material upper side: nylon Material backing: PP, textile

Table B1.11: Identified ketones, terpenes and siloxanes - VOCs

Substance	CAS	Emission	MW (g/mol)	Boiling point (°C)	Log Pow	Water-solubility (mg/L)	Vapour pressure (mm Hg)	Comments	Material
Octamethyl-cyclotetrasiloxane	556-67-2	2 µg/m³ [DTI's own data]	296.62	175.8	5.1	0.005 at 25°C		Substance found in 1 out of 28 analysed samples (emission) [DTI's own data]	[DTI's own data]: Emission: Material upper side: olefin Material backing: latex
D-limonene	5989-27-5	1-4 µg/m³ [DTI's own data] 1 µg/m² h [DTI's own data]	136.24	176	4.57	13.8 at 25° C	1.98 at 25° C	Substance found in 2 out of 28 analysed samples (emission) and in 1 out of 7 samples where emission rate was determined [DTI's own data]	[DTI's own data]: Emission: 2-4 ug/m³: Material upper side: olefin Material backing: Action Bac, latex Emission rate: Material upper side: used rug Material backing: latex
Acetone	67-64-1	3.7-15 µg/m³ [Katsoyiannis et al 2008] 3-45 µg/m³ [DTI's own data]	58.08	56	-0.24	1.00E+06 at 25° C	232 at 25° C	Substance found in 5 out of 28 analysed samples (emission) [DTI's own data] Four carpets were analysed in four types of chambers and the substance was found in three carpets in at least one chamber after either 24h or 72h [Katsoyiannis et al 2004]	[DTI's own data]: Emission: 3-23 ug/m³h: Material upper side: used rug, nylon, olefin Material backing: latex, Action Bac
Alfa-pinen	80-56-8	2-3 µg/m³ [DTI's own data] 1-3 µg/m² h [DTI's own data]	136.236 4	155.9	4.83	2.49 at 25° C	4.75 at 25° C	Substance found in 1 out of 28 analysed samples (emission) and in 3 out of 7 samples where the emission rate was determined [DTI's own data]	[DTI's own data]: Emission: Material upper side: olefin Material backing: latex Emission rate: Material upper side: nylon, used rug Material backing: PP,

Table B1.11: Identified ketones, terpenes and siloxanes - VOCs

Substance	CAS	Emission	MW (g/mol)	Boiling point (°C)	Log Pow	Water-solubility (mg/L)	Vapour pressure (mm Hg)	Comments	Material
									textile, latex
Acetophenone	98-86-2	1-2 μg/m² h [DTI's own data]	120.150 2	202	1.58	6130 at 25° C	0.397 at 25° C	Substance found in 1 out of 7 samples (where the emission rate was determined) [DTI's own data]	[DTI's own data]: Emission rate: Material upper side: nylon Material backing: PP
3-heptanone	106-35-4		114.1866	147	1.73	4300 at 20C	2.6 at 20C	Source states that the substance was identified by emission up to 130 days from glue used to fix rugs to floor surfaces	
2-octanon	111-13-7		128.2134	172.5	2.37	900 at 20C	1.35 at 25° C	Source states that the substance was identified by emission up to 130 days from glue used to fix rugs to floor surfaces	

Table B1.12: Data af sum af VOC'er

Substance	CAS	Emission (unit)	Other comments	Material
TVOC - sum, not stated on substance name	Several	11,8-1861 µg/m³ max emission [Guo et al 2004] 21,6-2302 µg/m² /h max emissions rate (model) [Guo et al 2004] 200-2300 µg/m³ max emission [Katsoyiannis et al 2008] 5100-5500 µg/m² /h max emission rate (model of two highest) [Katsoyiannis et al 2008]	The emission from four different carpets was analysed. One carpet differed distinctively with lower emission and only the two highest emission rates are stated [Katsoyiannis et al 2004]	[Guo et al 2004]: 11 rugs distributed on 5 100% oleofin, 2 100% wool, 1 90% wool/10% nylon, 1 80% wool/20% PP, 2 100% nylon. The highest emission rates appeared for 100% nylon and 80% wool/20%PP rugs, respectively, both with PP backing.

Appendix 2 Example of enquiry to retailers

Hej Xx
Dear Xx

Thank you for the pleasant telephone conversation we had with you.

As agreed, we hereby send you a list of the products we have found on your website.

Product 1
Product 2
Etc.

We are investigating rugs for children aged 0 – 15 years. Please let us know, if you sell rugs that are not stated on the list.

The objective of the investigation is to carry out a survey for the Danish Environmental Protection Agency in order to determine which rugs are imported from non-EU countries and which constituents they contain.

We would like to know from which countries the rugs are imported, and if the importing country is not the country of origin, then we kindly ask you to inform us of the country of origin.

Please also state if you know if the rugs:

- have received water or dirt repelling treatment or other surface treatment
- contain substances that are on the EU candidate list
- contain VOCs
- contain phthalates
- contain fluorinated substances

Please send me your reply as soon as possible.

Thank you in advance.

Best regards

Johnny Rodam

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Textiles
Building and Construction
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Kongsvang Allé 29
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http://www.teknologisk.dk[Text]

Appendix 3 VOC results

List of Appendices:

Table B3.1: VOC emissions from rug T01

Sample Name :2003998-2 MST T01			5,56 L	3,06 L	T01 1d Average	5,9 L	3,9 L	T01 28d Average
Name	CAS	CMR	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³
Acetonitrile (Tol eq.)	75-05-8		6	4	5			
Acetone	67-64-1		3	6	4	0	1	1
Acetic acid	64-19-17		237	371	304	123	131	127
1-Butanol	71-36-3		2	1	2			
Propanoic acid	79-09-4		2		1			
Decane	124-18-5		1	1	1			
3-Carene	498-15-7		3	3	3			
2-Ethyl-1-hexanol	104-76-7		9	10	9			
Undecane	1120-21-4		14	15	15			
Nonanal	124-19-6		5	5	5			
Dodecane	112-40-3		25	26	26			
Decanal	112-31-2		0	1	1			
Caprolactame	105-60-2		22	20	21	14	14	14
Tridecane	629-50-5		20	21	21	2	2	2
Tetradecane	629-59-4		2	1	2			
4-Phenylcyclohexene (4-PCH) (Tol eq)	4994-16-5		9	7	8	1	0	1
Butylated Hydroxytoluene (Tol eq)	128-37-0		0	1	1			
Diethyl Phthalate (Tol eq)	84-66-2		2	2	2			
Hexadecane	544-76-3		2		1			
Sum of other aliphatic hydrocarbons	-		10	6	8			
Sum of other aromatic hydrocarbons	-		3	12	8			
Sum of unidentified VOC	-					0	1	1
Sum of unidentified SVOC	-							
Sum of all measured VVOC	-		9	10	10	0	1	1
Sum of all measured VOC	-		367	505	436	139	148	144
Sum of all measured SVOC	-							
Sum of all measured compounds	-		376	515	445	139	150	145
TVOC (Tol eq)	-		320			70		
TSVOC (Tol eq)	-		0			0		
Sum of all aldehydes	-		5	7	6	0	0	0
Sum of all carboxylic acids	-		239	371	305	123	131	127
Sum of all hydrocarbons C6-C16	-		85	91	88	3	2	3
Sum of all aromatic hydrocarbons	-		11	19	15	1	0	1

Table B3.2: VOC emissions from rug T02

Sample name: 2003998-2 MST T02			5,49 L	3,02 L	T02 1d Average	5,9 L	3,9 L	T02 28d Average
Name	CAS	CMR	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3
Acetone	67-64-1		4	5	5	0	1	1
Acetic acid	64-19-7		283	419	351	179	202	191
1-Butanol	71-36-3			1	1			
Propanoic acid	79-09-4		2		1			
Formamide, N,N-dimethyl-	68-12-2	Repr. 1B	1		1			
Decane	124-18-5		1		1			
3-Carene	498-15-7		4	3	3			
1-Hexanol, 2-ethyl-	104-76-7		2	2	2			
Undecane	1120-21-4		17	17	17			
Nonanal	124-19-6		7	7	7			
Dodecane	112-40-3		29	32	30			
Decanal	112-31-2		1	2	1			
Tridecane	629-50-5		23	24	23			
4-Phenylcyclohexene (4-PCH) (Tol eq)	4994-16-5		9	8	8			
Tetradecane	629-59-4		2	2	2			
Diethyl Phthalate (Tol eq.)	84-66-2		3	3	3			
Sum of other aliphatic hydrocarbons	-		5	8	6			
Sum of other aromatic hydrocarbons	-		2	10	6			
Sum of unidentified VVOC	-							
Sum of unidentified VOC	-		7	4	6	0	3	1
Sum of unidentified SVOC	-		8	5	7			
Sum of all measured VVOC	-		4	5	5	0	1	1
Sum of all measured VOC	-		398	541	469	179	205	192
Sum of all measured SVOC	-		8	5	7	0	0	0
Sum of all measured compounds	-		402	546	474	179	207	192
TVOC (Tol eq)	-		359			50		
TSVOC (Tol eq)	-		37			0		
Sum of all aldehydes	-		8	9	9	0	0	0
Sum of all carboxylic acids	-		285	419	352	179	202	191
Sum of all hydrocarbons C6-C16	-		95	104	99	0	3	1
Sum of all aromatic hydrocarbons	-		11	17	14	0	0	0

Table B3.3: VOC emissions from rug T03

Sample: 2003998-2 MST T03			5,35 L	3,02 L	T03 1d Average	5,9 L	3,9 L	T03 28d Average
Name	CAS	CMR	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3
Acetonitrile (Tol eq)	75-05-8		3	2	3			
Acetone	67-64-1		3	6	4			
Methane, dichloro-	75-09-2	Carc.2	1	0	1			
Acetic acid	64-19-17		13	21	17	2	7	5
1-Butanol	71-36-3		0	1	1			
1,2-Propanediol	57-55-6		17	16	17	4	7	5
Formamide, N,N-dimethyl-	68-12-2	Repr.1B	3	3	3			
Hexanal	66-25-1		0	1	1			
Styrene	100-42-5	Repr.2	2	2	2			
alpha.-Pinene	80-56-8		2	2	2			
3-Carene	13466-78-9		3	3	3			
1-Hexanol, 2-ethyl-	104-76-7		2	2	2			
Benzyl alcohol	100-51-6		3	3	3			
Benzaldehyde, 4-methyl-(Tol eq)	104-87-0		0	1	1			
Undecane	1120-21-4		7	7	7			
Nonanal	124-19-6		4	4	4			
Dodecane	112-40-3		15	15	15			
Decanal	112-31-2		1	1	1			
Tridecane	629-50-5		15	15	15			
4-Phenylcyclohexene (4-PCH) (Tol eq)	4994-16-5		10	8	9	2	1	1
Tetradecane	629-59-4		1	2	2			
Pentadecane	629-62-9		1	0	1			
Diethyl Phthalate (Tol eq)	84-66-2		0,9	1,8	1			
Hexadecane	544-76-3		1	1	1			
Sum of other aliphatic hydrocarbons			4	2	3			
Sum of other aromatic hydrocarbons			4	11	7			
Sum of unidentified VVOC				0	0			
Sum of unidentified VOC			22	16	19			
Sum of unidentified SVOC			<1	<1	<1			
Sum of all measured VVOC			7	8	8	0	0	0
Sum of all measured VOC			131	141	135	7	15	11
Sum of all measured SVOC			0	0	0	0	0	0
Sum of all measured compounds			138	149	144	7	15	11
TVOC (Tol eq)			231			31		
TSVOC (Tol eq)			0			0		
Sum of all aldehydes (VOC)			5	6	6	0	0	0
Sum of all carboxylic acids (VOC)			13	21	17	2	7	5
Sum of all hydrocarbons (VOC)			59	63	61	2	1	1
Sum of all aromatic hydrocarbons (VOC)			15	21	18	2	1	1

Table B3.4: VOC emissions from rug T04

Sample Name :2003998-2 MST T04			5,27 L	3,02 L	T04 1d Average	5,9 L	3,9 L	T04 28d Average
Name	CAS	CMR	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3
Acetone	67-64-1		5	7	6	0	3	1
Acetic acid	64-19-7		1	5	3			
1-Butanol	71-36-3		1	1	1			
1,2-Propandiol	57-55-6		4	1	3			
Benzaldehyde	100-52-7		4	5	4			
Octanal	646-07-1		1		1			
3-Carene	13466-78-9		2	2	2			
1-Hexanol, 2-ethyl-	104-76-7		54	48	51			
Undecane	1120-21-4		14	14	14			
Nonanal	124-19-6		6	6	6			
Dodecane	112-40-3		29	26	27			
Decanal	112-31-2		1	1	1			
Tridecane	629-50-5		24	21	23			
4-Phenylcyclohexene (4-PCH) (Tol eq)	4994-16-5		9	8	8	2	2	2
Tetradecane	629-59-4		2	2	2			
Sum of other aliphatic hydrocarbons	-		9	5	7	2	12	7
Sum of other aromatic hydrocarbons	-		2	9	6			
Sum of unidentified VVOC	-		5	0	2			
Sum of unidentified VOC	-		7	6	6	2	0	1
Sum of unidentified SVOC	-		0	0	0			
Sum of all measured VVOC	-		10	7	9	0	3	1
Sum of all measured VOC	-		171	160	165	6	13	9
Sum of all measured SVOC	-		0	0	0	0	0	0
Sum of all measured compounds	-		181	167	174	6	16	11
TVOC (Tol eq)	-		342			14		
TSVOC (Tol eq)	-		0			0		
Sum of all aldehydes (VOC)	-		12	12	12	0	0	0
Sum of all carboxylic acids (VOC)	-		1	5	3	0	0	0
Sum of all hydrocarbons (VOC)	-		89	85	87	4	13	9
Sum of all aromatic hydrocarbons (VOC)	-		11	17	14	2	2	2

Table B3.5: VOC emissions from rug T05

Sample Name :2003998-2 MST T05			5,19 L	3,02 L	T05 1d Average	5,9 L	4,0 L	T05 28d Average
Name	CAS	CMR	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3
Acetonitrile (Tol eq)	75-05-8		6	11	8			
Acetone	67-64-1		3	7	5	0	2	1
Acetic acid	64-19-7		10	9	9	0	18	9
1-Butanol	71-36-3		0	1	1			
Propanoic acid	79-09-4		1	2	2	0	6	3
1,2-Propandiol	57-55-6		2	4	3			
Phenol	108-95-2	Muta.2	1	2	2			
Decane	124-18-5		5	4	4			
3-Carene	498-15-7		2	2	2			
1-Hexanol, 2-ethyl-	104-76-7		5	5	5			
Acetophenone	98-86-2		4	7	6			
Undecane	1120-21-4		30	31	31			
Nonanal	124-19-6		6	4	5			
Naphthalene (Tol eq)	91-20-3	Carc.2	24	19	21			
Dodecane	112-40-3		40	42	41			
Decanal	112-31-2		1	1	1			
Caprolactame	105-60-2		7	6	7	4	9	6
Tridecane	629-50-5		30	31	30	3	3	3
4-Phenylcyclohexene (4-PCH) (Tol eq)	4994-16-5		4	3	3			
Tetradecane	629-59-4		8	7	7	3	3	3
Pentadecane	629-62-9		2	2	2	2	2	2
Diethyl Phthalate (Tol eq)	84-66-2		2	2	2			
Hexadecane	544-76-3		1	1	1	1	1	1
Sum of other aliphatic hydrocarbons			17	15	16			
Sum of other aromatic hydrocarbons			6	13	10			
Sum of unidentified VVOC					0			
Sum of unidentified VOC			2	2	2			
Sum of unidentified SVOC			0	3	2			
Sum of all measured VVOC			9	18	14	0	2	1
Sum of all measured VOC			210	216	213	14	41	28
Sum of all measured SVOC			0	3	2	0	0	0
Sum of all measured compounds			220	234	227	14	44	29
TVOC (Tol eq)	-		385			26		
TSVOC (Tol eq)	-		<1			<1		
Sum of all aldehydes (VOC)	-		7	6	6	0	0	0
Sum of all carboxylic acids (VOC)	-		11	11	11	0	23	12
Sum of all hydrocarbons (VOC)	-		167	168	168	9	10	9
Sum of all aromatic hydrocarbons (VOC)	-		34	35	34	0	0	0

Table B3.6: VOC emissions from rug T06

Sample Name :2003998-2 MST T06			5,0 L	2,98 L	T06 1d Average	5,9 L	4,0 L	T06 28d Average
Name	CAS	CMR	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3
Acetonitrile (Tol eq.)	75-05-8		5	13	9			
Acetone	67-64-1		5	6	6			
Acetic acid	64-19-7		37	52	45			
1-Butanol	71-36-3		2	1	2			
Propanoic acid	79-09-4		2	2	2	0	3	1
Propylene Glycol	57-55-6		15	13	14			
Decane	124-18-5		2	2	2			
3-Carene	498-15-7		1	1	1			
1-Hexanol, 2-ethyl-	104-76-7		3	3	3			
Ethanone, 1-phenyl-	98-86-2		1	1	1			
Undecane	1120-21-4		27	29	28			
Nonanal	124-19-6		4	4	4			
Naphthalene (Tol eq)	91-20-3	Carc.2	51	52	52			
Dodecane	112-40-3		53	56	55			
Decanal	112-31-2		2	3	3			
Caprolactame	105-60-2		2	2	2	0,8	3	2
Tridecane	629-50-5		42	43	43			
4-Phenylcyclohexene (4-PCH) (Tol eq)	4994-16-5		2	1	1	6	10	8
Tetradecane	629-59-4		3	2	2			
2,4,7,9-Tetramethyl-5-decyne-4,7-diol (Tol eq)	126-86-3		50	42	46			
Diethyl Phthalate (Tol eq)	84-66-2		1	1	1			
Sum of other aliphatic hydrocarbons			7	2	5			
Sum of other aromatic hydrocarbons			17	23	20			
Sum of unidentified VVOC			0	0	0			
Sum of unidentified VOC			33	27	30			
Sum of unidentified SVOC			0	0	0			
Sum of all measured VVOC			10	18	14	0	0	0
Sum of all measured VOC			355	366	360	7	16	12
Sum of all measured SVOC			0	0	0	0	0	0
Sum of all measured compounds			365	384	375	7	16	12
TVOC (Tol eq)	-		451			6		
TSVOC (Tol eq)	-		<1			<1		
Sum of all aldehydes (VOC)	-		6	8	7	0	0	0
Sum of all carboxylic acids (VOC)	-		38	54	46	0	3	1
Sum of all hydrocarbons (VOC)	-		204	212	208	6	10	8
Sum of all aromatic hydrocarbons (VOC)	-		69	77	73	6	10	8

Table B3.7: VOC emissions from rug T07

Sample Name :2003998-2 MST T07			4,99 L	2,99 L	T07 1d Average	5,9 L	3,9 L	T07 28d Average
Name	CAS	CMR	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3
Acetonitrile (Tol eq.)	75-05-8		2	0	1			
Acetone	67-64-1		3	6	4			
Acetic acid	64-19-7		22	14	18	0	25	13
1-Butanol	71-36-3		1	1	1			
Propanoic acid	79-09-4		0	1	1	0	3	1
2-Pentanone, 4-methyl-	108-10-1		0	2	1	3	0	2
1,2-Propandiol	57-55-6		2	2	2			
2,4-Pentanediol, 2-methyl- (Tol eq)	107-41-5		34	31	33	4	5	5
Phenol	108-95-2	Muta.2	1	2	2			
Decane	124-18-5		2	2	2			
1-Hexanol, 2-ethyl-	104-76-7		1	2	2			
Ethanone, 1-phenyl-	98-86-2		2	2	2			
Undecane	1120-21-4		21	26	24			
Nonanal	124-19-6		2	3	2			
Naphthalene (Tol eq)	91-20-3	Carc.2	40	47	43			
Dodecane	112-40-3		48	56	52			
Decanal	112-31-2		1	2	1			
Caprolactam	105-60-2		14	14	14	3	7	5
Tridecane	629-50-5		42	49	46			
4-Phenylcyclohexene (4-PCH) (Tol eq)	4994-16-5		2	1	2			
Tetradecane	629-59-4		5	5	5	1	0	1
2,4,7,9-Tetramethyl-5-decyne-4,7-diol (Tol eq)	126-86-3		50	48	49	36	35	36
Pentadecane	629-62-9		5	5	5	3	3	3
Diethyl Phthalate (Tol eq)	84-66-2		1	2	2			
Hexadecane	544-76-3		4	4	4	2	2	2
Sum of other aliphatic hydrocarbons			12	19	15			
Sum of other aromatic hydrocarbons			13	19	16			
Sum of unidentified VVOC			4	0	0			
Sum of unidentified VOC			0	10	7			
Sum of unidentified SVOC			0	0	0			
Sum of all measured VVOC			9	6	5	0	0	0
Sum of all measured VOC			326	369	349	52	80	66
Sum of all measured SVOC			0	0	0	0	0	0
Sum of all measured compounds			335	375	354	52	80	66
TVOC (Tol eq)	-		512			79		
TSVOC (Tol eq)	-		<1			<1		
Sum of all aldehydes (VOC)	-		3	4	4	0	0	0
Sum of all carboxylic acids (VOC)	-		22	15	19	0	28	14
Sum of all hydrocarbons (VOC)	-		194	233	214	6	5	5
Sum of all aromatic hydrocarbons (VOC)	-		54	66	60	0	0	0

Table B3.8: VOC emissions from rug T08

Sample Name :2003998-2 MST T08			5,02 L	2,99 L	T08 1d Average	5,9 L	3,9 L	T08 28d Average
Name	CAS	CMR	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3
Acetonitrile (Tol eq)	75-05-8		2	4	3			
Acetone	67-64-1		3	5	4	0	2	1
Acetic acid	64-19-7		14	15	15	0	21	10
1-Butanol	71-36-3		1	1	1			
Propanoic acid	79-09-4		2	2	2	0	5	2
Butanoic acid	107-92-6		1	0	1			
alpha-Pinene	80-56-8		1	1	1			
Phenol	108-95-2	Muta.2	2	3	2			
Decane	124-18-5		5	5	5			
3-Carene	498-15-7		11	11	11			
o-Cymene	527-84-4		2	2	2			
1-Hexanol, 2-ethyl-	104-76-7		2	2	2			
Limonene	5989-27-5		2	2	2			
Benzyl alcohol	100-51-6		2	2	2			
Ethanone, 1-phenyl-	98-86-2		2	4	3			
Undecane	1120-21-4		50	55	53			
Nonanal	124-19-6		7	6	7	0	6	3
Naphthalene (Tol eq)	91-20-3	Carc.2	70	71	71	2	2	2
Dodecane	112-40-3		69	73	71			
Decanal	112-31-2		0	1	1	0	4	2
Caprolactame	105-60-2					1	6	4
Tridecane	629-50-5		40	40	40	3	3	3
Formamide, N,N-dibutyl- (Tol eq)	761-65-9		3	2	2			
4-Phenylcyclohexene (4-PCH) (Tol eq)	4994-16-5		1	0	1			
Biphenyl	92-52-4		6	5	5			
Tetradecane	629-59-4		3	3	3	1	2	1
Pentadecane	629-62-9		1	2	1	1	1	1
1,2-Benzenedicarboxylic acid, diethyl ester (Tol eq)	84-66-2		1	2	2			
Sum of other aliphatic hydrocarbons			57	52	54	11	7	9
Sum of other aromatic hydrocarbons			66	59	63	4	3	3
Sum of unidentified VVOC			0	0	2	0	0	0
Sum of unidentified VOC			34	23	28	5	3	4
Sum of unidentified SVOC			0	0	0	3	0	1
Sum of all measured VVOC			5	9	7	0	2	1
Sum of all measured VOC			456	447	451	28	62	45
Sum of all measured SVOC						3	0	1
Sum of all measured compounds			467	462	465	31	65	48
TVOC (Tol eq)	-		727			63		
TSVOC (Tol eq)	-		<1			<1		
Sum of all aldehydes (VOC)	-		7	8	7	0	10	5
Sum of all carboxylic acids (VOC)	-		14	15	15	0	21	10
Sum of all hydrocarbons (VOC)	-		373	370	372	22	18	20
Sum of all aromatic hydrocarbons (VOC)	-		147	139	143	6	5	5

Table B3.09: VOC emissions from rug T09

Sample Name:2003998-2 MST T09			5,02 L	2,99 L	T09 1d Average	5,9 L	3,9 L	T09 28d Average
Name	CAS	CMR	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3
Acetonitrile (Tol eq)	75-05-8		5	4	4			
Acetone	67-64-1		3	5	4			
Benzene	71-43-2	Muta.1B, Carc. 1A	2	2	2			
Acetic acid	64-19-7		510	487	498	34	86	60
1-Butanol	71-36-3		5	5	5			
Propanoic acid	79-09-4		3	3	3	0	3	1
Alpha-Pinene	80-56-8		2	2	2			
Decane	124-18-5		11	13	12			
3-Carene	498-15-7		7	7	7			
1-Hexanol, 2-ethyl-	104-76-7		2	3	2			
Acetophenone	98-86-2		3	3	3			
Undecane	1120-21-4		57	68	63			
Nonanal	124-19-6		5	5	5			
Naphthalene	91-20-3	Carc.2	42	46	44			
Dodecane	112-40-3		66	78	72			
Decanal	112-31-2		1	2	2			
Tridecane	629-50-5		43	49	46	8	7	8
4-Phenylcyclohexene (4-PCH) (Tol eq)	4994-16-5		3	3	3			
Biphenyl (Tol eq)	92-52-4		3	3	3			
Tetradecane	629-59-4		13	14	14	9	8	9
Pentadecane	629-62-9		34	31	32	21	22	21
Butylated Hydroxytoluene (Tol eq)	128-37-0					1,6	< 2	1
1,2-Benzenedicarboxylic acid, diethyl ester (Tol eq)	84-66-2		0	2	1			
Hexadecane	544-76-3		21	22	21	21	20	21
Sum of other aliphatic hydrocarbons VOC			122	110	116	43	40	42
Sum of other aliphatic hydrocarbons SVOC						72	85	78
Sum of other aromatic hydrocarbons VOC			54	53	54	5	5	5
Sum of other aromatic hydrocarbons SVOC						12	0	6
Sum of unidentified VOC			23	33	28	0	2	1
Sum of unidentified SVOC			57	53	55	11	6	9
Sum of all measured VVOC			8	9	8	0	0	0
Sum of all measured VOC			1034	1043	1038	142	194	168
Sum of all measured SVOC			57	53	55	94	91	93
Sum of all measured compounds			1098	1105	1102	236	285	261
TVOC (Tol eq)	-		1221			353		
TSVOC (Tol eq)	-		411			388		
Sum of all aldehydes (VOC)	-		6	7	7	0	0	0
Sum of all carboxylic acids (VOC)	-		513	490	502	34	89	61
Sum of all hydrocarbons (VOC)	-		472	491	482	106	103	105
Sum of all aromatic hydrocarbons (VOC)	-		105	107	106	5	5	5

Table B3.10: VOC emissions from rug T10

Sample Name:2003998-2 MST T10			4,55 L	3,1 L	T10 1d Average	5,9 L	3,9 L	T10 28d Average
Name	CAS	CMR	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3
Ethanol			2	3	2			
Acetonitrile (Tol eq)	75-05-8		2	5	4			
Acetone	67-64-1		6	8	7	0	5	3
Hexane	110-54-3		0	2	1			
2-Butanol	78-92-2		15	19	17	1	0	1
Ethyl Acetate	141-78-6		1	1	1			
Acetic acid	64-19-7		31	81	52	16	34	25
1-Butanol	71-36-3		51	52	51	5	5	5
1-Methoxy-2-propanol	107-98-2					1	0	1
1,2-Propanediol	57-55-6		9	10	9	7	9	8
Toluene	108-88-3	Repr.2	1	1	1			
Hexanal	66-25-1		0	1	1			
Butyl cellosolve (Tol eq)	111-76-2					2	2	2
1-Hexanol, 2-ethyl-	104-76-7		3	4	3			
Undecane	1120-21-4		4	5	5			
Nonanal	124-19-6		4	4	4			
Naphthalene (Tol eq)	91-20-3	Carc.2	1	1	1			
Dodecane	112-40-3		16	19	18			
Decanal	112-31-2		1	1	1			
Tridecane	629-50-5		23	25	24			
4-Phenylcyclohexene (4-PCH) (Tol eq)	4994-16-5		2	2	2			
Tetradecane	629-59-4		2	2	2			
1,2-Benzenedicarboxylic acid, diethyl ester	84-66-2		2	2	2			
Sum of other aliphatic hydrocarbons			1	0	1			
Sum of other aromatic hydrocarbons			4	11	7			
Sum of unidentified VVOC			0	0	0			
Sum of unidentified VOC			86	78	82	11	11	11
Sum of unidentified SVOC								
Sum of all measured VVOC			10	16	13	0	5	3
Sum of all measured VOC			257	319	284	43	61	52
Sum of all measured SVOC			0	0	0	0	0	0
Sum of all measured compounds			266	332	295	43	67	55
TVOC (Tol eq)	-		307			31		
TSVOC (Tol eq)	-		<1			<1		
Sum of all aldehydes (VOC)	-		5	7	6	0	0	0
Sum of all carboxylic acids (VOC)	-		31	81	52	16	34	25
Sum of all hydrocarbons (VOC)	-		54	66	60	0	0	0
Sum of all aromatic hydrocarbons (VOC)	-		8	15	11	0	0	0

Table B3.11: VOC emissions from rug T11

Sample Name :2003998-2 MS T11			5,93 L	3,2 L	T11 1d Average	5,9 L	4,0 L	T11 28d Average
Name	CAS	CMR	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3
Acetonitrile (Tol eq)	75-05-8		2	1	1			
Acetone	67-64-1		2	5	4	0	3	2
Acetic acid	64-19-7		276	326	301	71	97	84
1-Butanol	71-36-3		3	4	3			
Heptane	142-82-5		0	2	1			
Propanoic acid	79-09-4		1	0	1			
Decane	124-18-5		2	2	2			
3-Carene	498-15-7		1	2	2			
1-Hexanol, 2-ethyl-	104-76-7		1	1	1			
Undecane	1120-21-4		24	31	28			
Nonanal	124-19-6		4	5	5			
Naphthalene (Tol eq)	91-20-3	Carc.2	2	2	2			
Dodecane	112-40-3		51	65	58			
Decanal	112-31-2		1	2	2			
2-Propenoic acid, 2-ethylhexyl ester	103-11-7		4	5	4			
Caprolactam	105-60-2		4	4	4	1	6	4
Tridecane	629-50-5		41	51	46	1	2	2
Tetradecane	629-59-4		2	2	2			
Sum of other aliphatic hydrocarbons			10	8	9			
Sum of other aromatic hydrocarbons			12	14	13			
Sum of unidentified VVOC			2	1	1			
Sum of unidentified VOC			3	2	2			
Sum of unidentified SVOC			3	4	3			
Sum of all measured VVOC			4	6	5	0	3	2
Sum of all measured VOC			443	526	484	73	106	89
Sum of all measured SVOC			3	4	3	0	0	0
Sum of all measured compounds			450	536	493	73	109	91
TVOC (Tol eq)	-		431			36		
TSVOC (Tol eq)	-		<1			<1		
Sum of all aldehydes (VOC)	-		6	6	6	0	0	0
Sum of all carboxylic acids (VOC)	-		277	326	302	71	97	84
Sum of all hydrocarbons (VOC)	-		144	177	161	1	2	2
Sum of all aromatic hydrocarbons (VOC)	-		14	16	15	0	0	0

Table B3.12: VOC emissions from rug T12

Sample Name :2003998-2 MST T12			5,93 L	3,34 L	T12 1d Average	5,9 L	4,0 L	T12 28d Average
Name	CAS	CMR	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3
Ethanol	64-17-5		26	51	38			
Acetone	67-64-1		111	42	77	2	4	3
Butanal	123-72-8		3	3	3			
Ethyl Acetate	141-78-6		2	2	2			
Acetic acid	64-19-7		9	8	8	0	10	5
1-Butanol	71-36-3		190	224	207	37	34	35
Methyl Isobutyl Ketone	108-10-1		2	1	1			
Toluene	108-88-3	Repr.2	3	3	3			
Hexanal	66-25-1		0	1	1			
Butylacetat	123-86-4		2	2	2			
Heptanal	111-71-7		1	2	1			
Benzaldehyde	100-52-7		5	5	5			
Octanal	124-13-0		1	0	1			
3-Carene	498-15-7		0	1	1			
Benzene, 1,3,5-trimethyl-	108-67-8		4	0	2			
1-Hexanol, 2-ethyl-	104-76-7		14	11	13			
Ethanone, 1-phenyl-	98-86-2		2	1	2			
Nonanal	124-19-6		6	5	6			
Naphthalene (Tol eq)	91-20-3	Carc.2	3	2	3			
Dodecane	112-40-3		28	30	29			
Decanal	112-31-2		1	2	2			
2-Ethylhexyl acrylate	103-11-7		17	19	18			
Tridecane	629-50-5		29	34	32			
4-Phenylcyclohexene (4-PCH) (Tol eq)	4994-16-5		4	3	4			
Tetradecane	629-59-4		2	2	2			
Diethyl Phthalate (Tol eq)	84-66-2		0,9	2,7	1			
Sum of other aliphatic hydrocarbons			17	12	14			
Sum of other aromatic hydrocarbons			9	11	10			
Sum of unidentified VVOC				0	0			
Sum of unidentified VOC			52	56	54			
Sum of unidentified SVOC			0	0	0			
Sum of all measured VVOC			139	97	118	2	4	3
Sum of all measured VOC			404	442	423	37	44	40
Sum of all measured SVOC			0	0	0	0	0	0
Sum of all measured compounds			544	538	541	39	48	43
TVOC (Tol eq)	-		509			44		
TSVOC (Tol eq)	-		<1			<1		
Sum of all aldehydes (VOC)	-		13	12	13	0	0	0
Sum of all carboxylic acids (VOC)	-		9	8	8	0	10	5
Sum of all hydrocarbons (VOC)	-		98	98	98	0	0	0
Sum of all aromatic hydrocarbons (VOC)	-		23	20	21	0	0	0

Table B3.13: VOC emissions from rug T13

Sample Name :2003998-2 MST T13			5,35	3,18	T13 1d Average	5,90	4,00	T13 28d Average
Name	CAS	CMR	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3
Acetonitrile (Tol eq)	75-05-8		2	1	1			
Acetone	67-64-1		3	7	5	1	5	3
Acetic acid	64-19-7		31	49	40	0	10	5
1-Butanol	71-36-3		4	7	6			
Heptane	142-82-5		0	2	1			
Propanoic acid	79-09-4		4	9	6			
Toluene	108-88-3	Repr.2	0	1	1			
Hexanal	66-25-1		0	1	1			
Heptanal	111-71-7		0	1	1			
Benzaldehyde	100-52-7		3	3	3			
Phenol	108-95-2	Muta.2	2	2	2			
3-Carene	498-15-7		0	1	1			
1-Hexanol, 2-ethyl-	104-76-7		24	21	23	3	4	3
Undecane	1120-21-4		7	9	8			
Nonanal	124-19-6		0	4	2			
Dodecane	112-40-3		15	17	16	1	0	1
Decanal	112-31-2		0	1	1			
2-Ethylhexyl acrylate	103-11-7		4	5	5			
Tridecane	629-50-5		16	19	17	2	2	2
4-Phenylcyclohexene (4-PCH) (Tol eq)	4994-16-5		19	15	17	6	4	5
Tetradecane	629-59-4		2	2	2			
Diethyl Phthalate (Tol eq)	84-66-2		1	1	1			
Sum of other aliphatic hydrocarbons VOC			15	7	11			
Sum of other aromatic hydrocarbons VOC			8	11	10			
Sum of other aliphatic hydrocarbons SVOC			0	0	0			
Sum of other aromatic hydrocarbons SVOC			4	1	2			
Sum of unidentified VVOC			0	4	2			
Sum of unidentified VOC			13	13	13			
Sum of unidentified SVOC			0	1	1			
Sum of all measured VVOC			5	12	9	1	5	3
Sum of all measured VOC			168	202	185	12	21	16
Sum of all measured SVOC			4	2	3	0	0	0
Sum of all measured compounds			176	216	196	13	26	20
TVOC (Tol eq)	-		397			29		
TSVOC (Tol eq)	-		<1			<1		
Sum of all aldehydes (VOC)	-		3	10	7	0	0	0
Sum of all carboxylic acids (VOC)	-		34	58	46	0	10	5
Sum of all hydrocarbons (VOC)	-		73	73	73	9	7	8
Sum of all aromatic hydrocarbons (VOC)	-		26	27	27	6	4	5

Table B3.14: VOC emissions from rug T14

Sample Name :2003998-2 MST T14			5,93 L	3,1 L	T14 1d Average	5,9 L	4,0 L	T14 28d Average
Name	CAS	Label	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3
Acetonitrile (Tol eq)	75-05-8		1	0	2			
Acetone	67-64-1		3	12	8	0	1	1
2-propanol	67-63-0		0	1	1			
Methylene chloride	75-09-2	Carc.2	0	2	1			
1-Propanol	71-23-8		0	3	2			
2-Butanol	78-92-2		2	0	1			
Acetic acid	64-19-7		66	51	59	0	1	1
1-Butanol	71-36-3		3	5	4	0	1	1
Heptane	142-82-5		0	2	1			
Propanoic acid	79-09-4		3	3	3			
Toluene	108-88-3	Repr.2	2	3	2			
Hexanal	66-25-1		0	1	1			
Butylacetat	123-86-4		0	1	1			
Cyclohexanone	108-94-1		2	2	2			
Heptanal	111-71-7		0	1	1			
Butyl cellosolve (Tol eq)	111-76-2					6	5	5
alpha-Pinene	80-56-8		5	7	6			
beta-Pinene	18172-67-3		0	1	1			
Decane	124-18-5		17	19	18			
Octanal	124-13-0		0	2	1			
3-Carene	498-15-7		18	20	19			
1-Hexanol, 2-ethyl-	104-76-7		6	5	6	0	2	1
Limonene	5989-27-5		2	3	2			
Undecane	1120-21-4		66	76	71			
Naphthalene (Tol eq)	91-20-3	Carc.2	9	8	8			
Dodecane	112-40-3		62	71	66	4	6	5
Decanal	112-31-2		1	2	2			
Caprolactame	105-60-2		13	14	13			
Tridecane	629-50-5		34	38	36	12	17	15
4-Phenylcyclohexene (4-PCH) (Tol eq)	4994-16-5		10	8	9	1	0	1
Tetradecane	629-59-4		12	13	12	8	10	9
Pentadecane	629-62-9		15	17	16	13	16	15
1,2-Benzenedicarboxylic acid, diethyl ester (Tol eq)	84-66-2		0,9	1,8	1			
Hexadecane	544-76-3		10	11	11	7	6	6
Sum of other aliphatic hydrocarbons VOC			479	438	458	70	11	41
Sum of other aromatic hydrocarbons VOC			66	51	58	12	16	14
Sum of other aliphatic hydrocarbons SVOC			23	11	17	7	4	6
Sum of other aromatic hydrocarbons SVOC			12	5	9	2	2	2
Sum of unidentified VVOC			0	0	0	0	1	1
Sum of unidentified VOC			88	81	85	9	1	5
Sum of unidentified SVOC			20	7	14	0	0	0
Sum of all measured VVOC			4	19	12	0	2	1
Sum of all measured VOC			993	956	974	142	147	145
Sum of all measured SVOC			56	23	39	9	6	8
Sum of all measured compounds			1053	998	1026	150	156	153
TVOC (Tol eq)	-		1502			355		
TSVOC (Tol eq)	-		216			89		
Sum of all aldehydes (VOC)	-		1	7	4	0	0	0
Sum of all carboxylic acids (VOC)	-		69	54	62	0	1	1
Sum of all hydrocarbons (VOC)	-		783	754	768	127	136	132
Sum of all aromatic hydrocarbons (VOC)	-		86	70	78	13	16	15
Sum of hydrocarbons (C7-C12)	-		210	207	209	4	6	5
Sum of aromatic hydrocarbons (C7-C12)	-		17	17	17	0	0	0
Sum of aliphatic hydrocarbons (C7-C12)	-		192	190	191	4	6	5

Table B3.15: VOC emissions from rug T15

Sample Name :2003998-2 MST T15			5,91 L	3,19 L	Average	5,9 L	4,0 L	Average
Name	CAS	Label	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³
Acetonitrile (Tol eq)	75-05-8		1	0	1			
Acetone	67-64-1		2	4	3	0	2	1
Acetic acid	64-19-7		4	3	4			
1-Butanol	71-36-3		2	2	2			
Heptane	142-82-5		0	1	1			
Propanoic acid	79-09-4		2	1	1			
Decane	124-18-5		1	1	1			
3-Carene	498-15-7		1	1	1			
1-Hexanol, 2-ethyl-	104-76-7		8	5	7	0	2	1
Ethanone, 1-phenyl-	98-86-2		2	2	2			
Undecane	1120-21-4		10	10	10			
Dodecane	112-40-3		19	19	19			
Decanal	112-31-2		0	1	1			
Caprolactam	105-60-2		3	3	3	2	3	3
Tridecane	629-50-5		20	21	21	3	2	2
4-Phenylcyclohexene (4-PCH) (Tol eq)	4994-16-5		10	9	9	2	2	2
Tetradecane	629-59-4		2	2	2			
Diethyl Phthalate (Tol eq)	84-66-2		0	1	1			
Sum of other aliphatic hydrocarbons			31	24	27	2	2	2
Sum of other aromatic hydrocarbons			1	4	3			
Sum of other aliphatic hydrocarbons SVOC			0	0	0			
Sum of other aromatic hydrocarbons SVOC			0	0	0			
Sum of unidentified VVOC			0	0	0			
Sum of unidentified VOC			1	1	1			
Sum of unidentified SVOC			6	5	6			
Sum of all measured VVOC			3	4	4	0	2	1
Sum of all measured VOC			116	113	114	10	10	10
Sum of all measured SVOC			6	5	6	0	0	0
Sum of all measured compounds			126	122	125	10	12	11
TVOC (Tol eq)	-		330			46		
TSVOC (Tol eq)	-		<1			<1		
Sum of all aldehydes (VOC)	-		0	1	1	0	0	0
Sum of all carboxylic acids (VOC)	-		5	5	5	0	0	0
Sum of all hydrocarbons (VOC)	-		94	91	93	7	5	6
Sum of all aromatic hydrocarbons (VOC)	-		11	13	12	2	2	2

Table B3.16: VOC emissions from rug T17

Sample Name :2003998-2 MST T17			5,93 L	3,79 L	Average	5,9 L	4,0 L	Average
Name	CAS	CMR	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3
Acetonitrile (Tol eq)	75-05-8		2	3	3			
Acetone	67-64-1		3	4	4	1	2	2
Acetic acid	64-19-7		351	378	364	266	72	169
2-Propanone, 1-hydroxy-	116-09-6		1	0	1			
Heptane	142-82-5		1	1	1			
Propanoic acid	79-09-4		2	0	1			
alpha-Pinene	7785-26-4		2	2	2			
Decane	124-18-5		2	2	2			
3-Carene	498-15-7		14	15	14			
2-Propanol, 1,1'-oxybis- (Tol eq)	110-98-5		1	0	1			
1-Hexanol, 2-ethyl-	104-76-7		1	1	1	0	1	1
dl-Limonene	138-86-3		2	2	2			
Undecane	1120-21-4		25	27	26			
Nonanal	124-19-6		4	5	4			
Benzoic acid	65-85-0		2	1	2			
Dodecane	112-40-3		44	45	44			
Decanal	112-31-2		1	1	1			
Caprolactame	105-60-2		11	11	5	8	7	7
Tridecane	629-50-5					3	2	2
Tetradecane	629-59-4		2	2	2			
4-Phenylcyclohexene (4-PCH) (Tol eq)	4994-16-5		1	1	1			
Tetradecane	629-59-4		2	2	2			
1,2-Benzenedicarboxylic acid, diethyl ester (Tol eq)	84-66-2		1	0	1			
Sum of other aliphatic hydrocarbons			22	15	18			
Sum of other aromatic hydrocarbons			10	12	11			
Sum of other aliphatic hydrocarbons SVOC			0	0	0			
Sum of other aromatic hydrocarbons SVOC			0	0	0			
Sum of unidentified VVOC			0	0	0			
Sum of unidentified VOC			21	10	15	1	0	1
Sum of unidentified SVOC			1	3	2			
Sum of all measured VVOC			5	8	6	1	2	2
Sum of all measured VOC			523	532	522	277	82	179
Sum of all measured SVOC			1	3	2	0	0	0
Sum of all measured compounds			529	542	530	278	84	181
TVOC (Tol eq)	-		412			80		
TSVOC (Tol eq)	-		<1			<1		
Sum of all aldehydes (VOC)	-		5	6	6	0	0	0
Sum of all carboxylic acids (VOC)	-		354	379	367	266	72	169
Sum of all hydrocarbons (VOC)	-		109	106	108	3	2	2
Sum of all aromatic hydrocarbons (VOC)	-		11	14	12	0	0	0

Table B3.17: VOC emissions from rug T18

Sample Name :2003998-2 MST T18			5,93 L	3,72 L	Average	5,9 L	3,9 L	Average
Name	CAS	CMR	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3
Acetonitrile (Tol eq)	75-05-8		5	9	7	2	0	1
Acetone	67-64-1		3	4	4	0	2	1
Acetic acid	64-19-7		50	32	41	2	0	1
Propanoic acid	79-09-4		2	0	1			
2-pentanone-4-methyl	108-10-1					2	8	5
1,2-Propandiol	57-55-6		5	4	4			
2,4-Pentanediol, 2-methyl-	107-41-5		36	29	32			
Decane	124-18-5		2	2	2			
3-Carene	13466-78-9		2	2	2			
1-Hexanol, 2-ethyl-	104-76-7		2	1	2	0	3	1
Undecane	1120-21-4		24	26	25			
Nonanal	124-19-6		3	4	3			
Naphthalene (Tol eq)	91-20-3	Carc.2	1	1	1			
Dodecane	112-40-3		53	56	54			
Decanal	112-31-2		1	2	2			
Caprolactame	105-60-2		3	3	3	2	2	2
Tridecane	629-50-5		44	46	45			
Tetradecane	629-59-4		2	2	2			
2,4,7,9-Tetramethyl-5-decyne-4,7-diol (Tol eq)	126-86-3		38	29	33	17	7	12
Diethyl Phthalate (Tol eq)	84-66-2		1	1	1			
Sum of other aliphatic hydrocarbons			11	8	10			
Sum of other aromatic hydrocarbons			7	11	9			
Sum of other aliphatic hydrocarbons SVOC			0	0	0			
Sum of other aromatic hydrocarbons SVOC			0	0	0			
Sum of unidentified VVOC			0	0	0			
Sum of unidentified VOC			6	1	3			
Sum of unidentified SVOC			0	0	0			
Sum of all measured VVOC			8	13	11	2	2	2
Sum of all measured VOC			293	260	276	24	20	22
Sum of all measured SVOC			0	0	0	0	0	0
Sum of all measured compounds			301	273	287	25	21	23
TVOC (Tol eq)	-		392			43		
TSVOC (Tol eq)	-		<1			<1		
Sum of all aldehydes (VOC)	-		4	6	5	0	0	0
Sum of all carboxylic acids (VOC)	-		52	32	42	2	0	1
Sum of all hydrocarbons (VOC)	-		144	152	148	0	0	0
Sum of all aromatic hydrocarbons (VOC)	-		8	12	10	0	0	0

Table B3.18: VOC emissions from rug T19

Sample Name :2003998-2 MST T19			5,93 L	3,65 L	Average	5,9 L	3,9 L	Average
Name	CAS	CMR	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³
Acetonitrile (Tol eq)	75-05-8		3	6	5			
Acetone	67-64-1		3	4	4			
Methane, dichloro-	75-09-2	Carc.2	0	3	2			
Acetic acid	64-19-7		263	264	264	48	29	38
1-Butanol	71-36-3		2	1	2			
Heptane	142-82-5		1	1	1			
Propanoic acid	79-09-4		2	1	1			
1,2-Propandiol	57-55-6		1	0	0			
Hexanal	66-25-1		1	0	1			
Heptanal	111-71-7		1	0	0			
Phenol	108-95-2	Muta.2	1	1	1			
Decane	124-18-5		2	2	2			
Octanal	124-13-0		1	0	0			
3-Carene	498-15-7		2	2	2			
2-Ethyl-1-hexanol	104-76-7		1	1	1			
Ethanone, 1-phenyl-	98-86-2		1	2	2			
Undecane	1120-21-4		23	26	24			
Nonanal	124-19-6		5	5	5			
Dodecane	112-40-3		38	43	40			
Decanal	112-31-2		1	2	2			
Caprolactame	105-60-2		48	47	48	21	20	20
Tridecane	629-50-5		28	31	29	3	2	3
4-Phenylcyclohexene (4-PCH) (Tol eq)	4994-16-5		7	6	6			
Tetradecane	629-59-4		2	2	2			
Pentadecane	629-62-9		1	0	0			
Diethyl Phthalate (Tol eq)	84-66-2		1	1	1			
Sum of other aliphatic hydrocarbons			29	12	20	3	2	3
Sum of other aromatic hydrocarbons			3	4	3			
Sum of unidentified VVOC			0	0	0			
Sum of unidentified VOC			13	1	7			
Sum of unidentified SVOC			0	0	0			
Sum of all measured VVOC			6	14	10	0	0	0
Sum of all measured VOC			477	457	467	75	53	64
Sum of all measured SVOC			0	0	0	0	0	0
Sum of all measured compounds			482	470	476	75	53	64
TVOC (Tol eq)	-		397			34		
TSVOC (Tol eq)	-		<1			<1		
Sum of all aldehydes (VOC)	-		8	6	7	0	0	0
Sum of all carboxylic acids (VOC)	-		263	264	264	48	29	38
Sum of all hydrocarbons (VOC)	-		132	127	129	6	5	5
Sum of all aromatic hydrocarbons (VOC)	-		9	10	10	0	0	0

Table B3.19: VOC emissions from rug T20

Sample Name :2003998-2 MST T20			5,93 L	3,58 L	Average	5,9 L	4,0 L	Average
Name	CAS	CMR	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3
Acetonitrile (Tol eq)	75-05-8		2	5	4	0	2	1
Acetone	67-64-1		2	4	3	0	2	1
Methane, dichloro-	75-09-2	Carc.2	1	0	1			
Acetic acid	64-19-7		60	55	57			
Propanoic acid	79-09-4		1	1	1			
2-pentanone-4-methyl	108-10-1					5	6	5
1,2-Propandiol	57-55-6		2	3	3			
Hexylene glycol (Tol eq)	107-41-5		39	31	35	4	1	2
Phenol	108-95-2	Muta.2	0	1	1			
Decane	124-18-5		1	1	1			
2-Ethyl-hexanol	104-76-7		2	1	2	0	1	1
Undecane	1120-21-4		16	17	17			
Nonanal	124-19-6		4	3	4			
Dodecane	112-40-3		40	41	41			
Decanal	112-31-2		1	2	1			
Caprolactam	105-60-2		3	3	3	2	2	2
Tridecane	629-50-5		37	39	38			
4-Phenylcyclohexene (4-PCH) (Tol eq)	4994-16-5		2	2	2			
2,4,7,9-Tetramethyl-5-decyne-4,7-diol (Tol eq)	126-86-3		75	60	67	35	25	30
Diethyl Phthalate (Tol eq)	84-66-2		1	0	1			
Sum of other aliphatic hydrocarbons			4	3	4			
Sum of other aromatic hydrocarbons			1	0	1			
Sum of unidentified VVOC			0	0	0			
Sum of unidentified VOC			3	2	2			
Sum of unidentified SVOC			0	0	0			
Sum of all measured VVOC			6	9	8	0	4	2
Sum of all measured VOC			295	265	280	46	36	41
Sum of all measured SVOC			0	0	0	0	0	0
Sum of all measured compounds			301	274	288	46	39	42
TVOC (Tol eq)	-		378			43		
TSVOC (Tol eq)	-		<1			<1		
Sum of all aldehydes (VOC)	-		5	5	5	0	0	0
Sum of all carboxylic acids (VOC)	-		61	56	58	0	0	0
Sum of all hydrocarbons (VOC)	-		102	104	103	0	0	0
Sum of all aromatic hydrocarbons (VOC)	-		3	2	3	0	0	0

Table B3.20: VOC emissions from rug T21

Sample Name :2003998-2 MST T21			5,88 L	3,52 L	Average	5,9 L	4,0 L	Average
Name	CAS	CMR	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3
Acetonitrile (Tol eq)	75-05-8		3	6	4			
Acetone	67-64-1		3	5	4	0	2	1
Acetic acid	64-19-7		19	31	25			
Heptane	142-82-5		0	1	1			
Propanoic acid	79-09-4		1	0	1			
2-Pentanone, 4-methyl-	108-10-1		1	1	1	3	3	3
1,2-Propanediol	57-55-6		10	9	9			
2,4-Pentanediol, 2-methyl- (Tol eq)	107-41-5		34	29	31	3	0	1
Decane	124-18-5		2	2	2			
(+)-3-Carene	498-15-7		1	1	1			
1-Hexanol, 2-ethyl-	104-76-7		2	2	2	0	2	1
Undecane	1120-21-4		19	22	21			
Nonanal	124-19-6		3	4	4			
Dodecane	112-40-3		43	48	46			
Decanal	112-31-2		1	2	1			
Caprolactam	105-60-2		3	3	3	1	2	1
Tridecane	629-50-5		39	42	40	2	2	2
4-Phenylcyclohexene (4-PCH) (Tol eq)	4994-16-5		2	2	2			
Tetradecane	629-59-4		2	2	2			
2,4,7,9-Tetramethyl-5-decyne-4,7-diol (Tol eq)	126-86-3		49	39	44	13	7	10
1,2-Benzenedicarboxylic acid, diethyl ester (Tol eq)	84-66-2		0	2	1			
Sum of other aliphatic hydrocarbons			4	5	4			
Sum of other aromatic hydrocarbons			0	4	2			
Sum of unidentified VVOC					0			
Sum of unidentified VOC			5	4	4			
Sum of unidentified SVOC								
Sum of all measured VVOC			5	10	8	0	2	1
Sum of all measured VOC			238	254	246	21	16	19
Sum of all measured SVOC			0	0	0	0	0	0
Sum of all measured compounds			244	264	254	21	18	20
TVOC (Tol eq)	-		368			17		
TSVOC (Tol eq)	-		<1			<1		
Sum of all aldehydes (VOC)	-		4	6	5	0	0	0
Sum of all carboxylic acids (VOC)	-		20	31	26	0	0	0
Sum of all hydrocarbons (VOC)	-		110	128	119	2	2	2
Sum of all aromatic hydrocarbons (VOC)	-		2	6	4	0	0	0

Appendix 4 Fluorinated substances (PFAS) results

B4.1 Per- and polyfluorinated substances (PFAS) measured as concentration per area (µg/m²) of the textile surface of the rugs

	CAS-no.	T05extra	T05	T06	T18	T20	T21
Total fluorines	-	-	*5000*	*11000*	*15000*	*16500*	*19000*
Fluortelomers (FT-OH)							
4:2 FT-OH	2043-47-2	<18	<30	<18	<18	<18	<18
6:2 FT-OH	647-42-7	<9	<15	<9	<9	<9	<9
8:2 FT-OH	678-39-7	<18	<30	<18	<18	<18	<18
10:2 FT-OH	865-86-1	<9	<15	<9	<9	<9	<9
Total VFOC[1]	na	<200	<200	<200	<200	<200	<200
Fluoro sulfonamides							
N-MeFOSA	31506-32-8	<20	<40	<20	<20	<20	<20
N-EtFOSA	4151-50-2	<18	<30	<18	<18	<18	<18
N-MeFOSE	2448-09-7	<40	<80	<40	<40	<40	<40
N-EtFOSE	1691-99-2	<40	<80	<40	<40	<40	<40
PFOSA (FOSA) [p]	754-91-6	<0.007	<0.007	<0.004	<0.004	<0.004	<0.004
Perfluoroalkyl carboxylic acids (PFCA)							
PFBA	375-22-4	0.49	**0.51**	<0.06	<0.06	<0.06	<0.06
PFPeA	2706-90-3	0.44	**0.60**	<0.07	<0.07	<0.07	<0.07
PFHxA	307-24-4	0.53	**0.96**	<0.1	<0.1	<0.1	<0.1
PFHpA	375-85-9	0.67	**1.1**	<0.1	<0.1	<0.1	<0.1
PFOA	335-67-1	4.4	**8.4**	**0.18**	**0.20**	**0.18**	**0.18**
PFNA	375-95-1	<0.09	<0.12	<0.07	<0.07	<0.07	<0.07
PFDA	335-76-2	<0.10	<0.06	<0.07	<0.07	<0.07	<0.07
PFDoDA	307-55-1	<0.15	<0.16	<0.05	<0.05	<0.05	<0.05
PFUnDA	2058-94-8	<0.15	<0.04	<0.03	<0.03	<0.03	<0.03
PFTrDA	72629-94-8	<0.2	<0.3	<0.06	<0.06	<0.06	<0.06
PFBS	375-73-5	<0.25	<0.1	<0.1	<0.1	<0.1	<0.1
PFHxS	355-46-4	0.31	**0.31**	<0.1	<0.1	<0.1	<0.1
PFHpS	375-92-8	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1
Perfluoralkan sulfonic acids (PFSA)							
PFOS	1763-23-1	<0.48	**0.54**	<0.06	<0.06	<0.06	<0.06
iso-PFOS	na	<0.49	**0.73**	<0.06	<0.06	<0.06	<0.06
PFDS	335-77-3	<0.1	<0.03	<0.04	<0.04	<0.04	<0.04
Fluortelomer sulfonic acids (FTSA)							
7H-DODFHpA[p]	1546-95-8	<5.0	<2.6	<2.5	<2.5	<2.5	<2.5
PFDMOA[p]	172155-07-6	<0.6	<0.1	<0.03	<0.03	<0.03	<0.03
H.H-PFDA[p]	na	<7.1	<6.9	<2.7	<2.7	<2.7	<2.7
6:2 FTSA[p] (4H-PFOS)	27619-97-2	<0.05	<0.04	**1.3**	**0.7**	**0.7**	<0.03
9:2 FTSA[p] (4H-PFUDA)	na	<0.4	<0.4	<0.2	<0.2	<0.2	<0.2
Total PFAS	**-**	***6.53***	***13.15***	***1.48***	***0.90***	***0.88***	***0.18***
Ratio [PFAS/Fluorine]	*(%)*	-	*0,26%*	*0,013%*	*0,006%*	*0,005%*	*0,001%*

[1]Total volatile fluorinated organic compounds (VFOC) were analyzed with GC-EPED.

[p] Partly fluorinated, analyzed with LC-MS/MS.

Values stated in **bold** are measured concentrations above the limit of quantification (LOQ).

Survey and risk assessment of chemical substances in rugs for children

The purpose of the project is to map, which chemicals within the categories, VOC, phthalates and PFAS are emitted from rugs to the indoor air in children's rooms, and whether a health risk is connected thereby. The purpose of the project is also by means of sensory evaluation to assess, whether there is a connection between odours and content of chemical substances including VOC.

The chemical analyses of 21 rugs showed that all rugs emitted VOC at different levels. Even though the identified VOCs are not found to be hazardous to health at the measured concentrations, they can still cause bad odour and a decreased indoor air quality in the children's room.

All 21 rugs were screened for total-fluorine in the textile surface, out of which 5 rugs with the textile materials polyamide and polypropylene contained fluorine. These 5 rugs were analysed closer for content of specific PFAS.

A low content of PFAS was demonstrated in 5 rugs and as well as the presence of phthalate in one rug, but the substances are considered not to cause any health hazard for children.

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