TESTING FOR TOXICS

How chemicals in European carpets are harming health and hindering circular economy

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This report was researched and written by the Changing Markets Foundation in collaboration with independent researchers and academics. The purpose of this report is to shed light on industry-specific issues related to carpet manufacturing and recycling in Europe. The information in this document has been obtained from sources believed reliable and in good faith. The authors accept no liability whatsoever for any direct or consequential loss arising from the use of this document of its contents.

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ABOUT THE RESEARCH

This report is based on research by the Vrije Universiteit Amsterdam (Netherlands), the Ecology Center (US) and the University of Notre Dame (US). These research organisations have checked their testing results are integrated correctly into this report. The organisations and their researchers involved in this report are listed below.

Vrije Universiteit Amsterdam

The Department of Environment and Health at the Vrije Universiteit Amsterdam (VU Amsterdam) conducts academic research and training to better understand the impact of environmental contaminants on human health and the environment.

— Pim Leonards, Professor in Environmental Bioanalytical Chemistry has more than 20 years of experience in studies related to environmental chemistry, analytical method development, indoor exposure assessment and metabolomics. He has published more than 100 peer-reviewed articles on the topics of environmental chemistry, analysis, ecotoxicology and metabolomics.

— Sicco Brandsma, PhD performs research on emerging chemicals and fast-screening methods.

— Mrs Ike van der Veen has been working for years on the analysis of per-and polyfluorininated compounds.

Ecology Center

The Ecology Center is a Michigan-based non-profit environmental organisation that works at the local, state and national levels for clean production, healthy communities, environmental justice and a sustainable future.

— Jeff Gearhart, Research Director has worked for over 20 years on air quality, pollution prevention, life-cycle assessment, green chemistry and consumer product testing. He is the author or co-author of 15 studies on toxic chemicals in products. He holds a Master of Science in Environmental Science from the University of Michigan and developed the now internationally recognised HealthyStuff.org.

University of Notre Dame

The University of Notre Dame is a private research university in Indiana.

— Dr Graham Peaslee, Professor of Physics, has worked on analytical measurement techniques in nuclear science as applied to environmental problems for the past 15 years. He studies mixed media such as lake sediments, soils, house dust and consumer products for the presence of chemicals of concern, such as heavy metals, halogenated flame retardants and per- and polyfluorinated compounds. He has 188 peer-reviewed publications in basic and applied science.

Credit: Will Rose

1. EXECUTIVE SUMMARY

This report reveals the presence of toxics – including phthalates, fluorinated stain repellents and halogenated flame retardants – in carpets produced and sold by some of the largest carpet manufacturers in Europe. The findings pinpoint a lack of comprehensive chemicals regulation and show failings of self-regulation in the carpet industry. They lay bare how toxic chemicals in European carpets – including endocrine disruptors, carcinogens and reprotoxic substances – are posing a potential health risk to European Union (EU) citizens and hindering the EU's transition to a circular economy. The report also highlights the legislative opportunity to address this in upcoming EU work on the interface between toxicity and recyclability, and argues that these two issues must be tackled immediately to realise a healthy and safe circular economy.

The EU is the second-largest market in the world for carpets (after the US) and home to some of the largest carpet manufacturers. It is estimated that 65% of EU demand for carpet is fulfilled by EU-based manufacturing, with the largest companies being located in the Netherlands, Belgium and the UK. It has also been estimated that less than 3% of carpet placed on the market is recycled in the EU – a worryingly low percentage, and one that must increase in line with the EU's circular economy targets, such as the 65% municipal waste recycling target by 2030.

Previous research has highlighted that over 50 toxic substances can be present in European carpets, including endocrine disruptors, carcinogens and mutagens.[1] This research has also exposed how these toxics are insufficiently regulated, via both EU legislation and certification schemes, leaving consumers and workers exposed and without adequate information about what may be present in their carpet.

This report builds on previous research and goes a step further by testing toxics present in some of the most popular European carpet brands. For this investigation, two carpets were tested from each of the seven largest manufacturers in Europe: Associated Weavers, Balta Industries, Beaulieu International Group, Forbo, Interface, Milliken and Tarkett (Desso). Where possible, the most popular carpet for each manufacturer was selected for testing as well as the most 'ecologically friendly' option (as marketed by the companies themselves). Additionally, one carpet sold by Dutch company Donkersloot was selected for testing on the basis that it claims to represent an eco-innovation on the market. The carpets were tested for the presence of toxic chemicals by VU Amsterdam (Netherlands), the Ecology Center (US) and the University of Notre Dame (US).

The testing found a number of chemical groups in the carpet samples, including phthalates, flame retardants and per- and polyfluoroalkyl substances (PFASs), as well as indications of antimicrobials, isocyanates, nonylphenol and bisphenol A (BPA). Several of these substances have been classified as, or are suspected to be, carcinogens, endocrine disruptors and/or causes of developmental harm. These are worrying findings, as consumers – as well of people handling carpet, like installers and recyclers – are exposed to these products on a daily basis.

In particular, the investigation revealed a number of phthalates present in European carpets. The Forbo Westbond carpet was found to contain the phthalate DEHP, which the EU has classified as toxic for reproduction and endocrine disrupting for human health and the environment. DEHP has been banned in the EU since 2015; however, a worrying exemption has been granted that permits its use in recycled PVC for certain uses, including carpets.[i]

The flame retardants TCPP and TDCPP were also found to be present in carpets tested in this investigation. TDCPP (found in Milliken carpet) is a suspected carcinogen. Indications of nonylphenol, ethoxylated were detected in one carpet. Nonylphenol is toxic to aquatic organisms and categorised under the EU Classified, Labelling and Packaging (CLP) Regulation as a reproductive toxic, suspected of damaging fertility and causing harm to the unborn child.

Six of the 15 samples tested in this investigation contained recycled content, either in the backing (for example, recycled PVC or polyurethane) or the face fibre (most commonly recycled nylon). Of the six carpets with recycled content, four were found to contain tested substances, including phthalates, flame retardants and indications of isocyanates. These results indicate that recycled content can contain toxics – similar to those found in virgin content – but also that it seems possible to have recycled content without toxics.

Of the 15 European carpet samples tested, no toxics were detected in three carpets: Beaulieu Avenue,[ii] Desso (Tarkett) Airmaster and Interface Composure. Although it cannot definitively be said that these carpets do not contain any toxics (due to limitations of the testing method and scope of the investigation), it is encouraging to see that cleaner carpets already exist on the market. Additionally, as two of the three products (the Desso and Interface carpets) contain

i –DEHP is on the EU Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) Authorisation List.
ii –In the Beaulieu Avenue product, no toxics were found – but this product came without a backing layer, so the findings do not cover the entire product.

Credit: Will Rose

recycled content and are also marketed as being designed for a circular economy, this lends weight to the argument that the goals of a circular economy and non-toxicity can be realised in parallel.

This report provides a case study of how policy loopholes and inconsistencies can lead to suboptimal outcomes for both consumers and actors trying to realise circular economy.

It concludes with policy recommendations, which call on governments and the EU to:

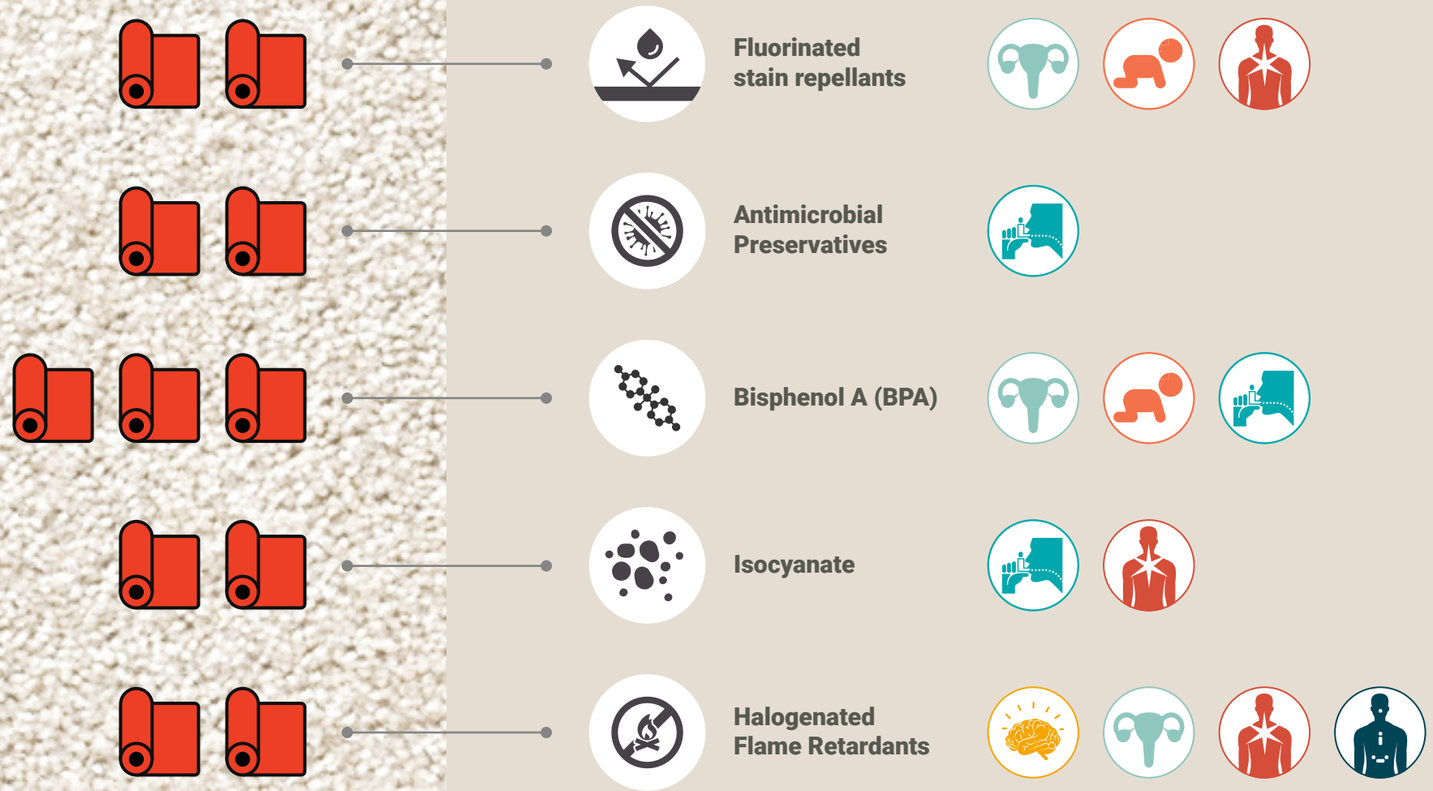
- **Expand bans on hazardous chemicals and close loopholes on how chemicals are addressed in different product groups;**

- **End exemptions for chemicals in recycled materials through the upcoming revision of the interface between chemicals, products and waste legislation, including regulating chemical groups instead of individual chemicals; and**

- **Put in place measures to realise a circular economy in the carpet sector, including Extended Producer Responsibility (EPR) schemes for the sector which set minimum requirements for non-toxic and circular carpet) and eco-modulated fees to reward manufacturers that go beyond the minimum.**

Finally, manufacturers must take immediate measures to ensure their products are designed for a healthy and circular economy (toxic-free, durable, reusable and recyclable). Although policies would definitely help to set a level playing field, this report shows that carpet manufacturers already have solutions (carpets in which no toxics were detected) on the market; they now need to bring these solutions to scale to become part of a toxic-free circular economy.

Toxic chemicals detected in carpets and their potential health impacts



number of carpets in which each substance was detected

This graphic outlines some of the most hazardous substances found or identified via testing and some of their highest possible or suspected hazards, but does not reflect all hazardous content that can be found in carpet, or all associated hazards for the chemicals and chemical groups listed. See the report text for additional information on specific chemical hazard associations.

Health hazards:

Developmental Disorders

Endocrine Disruptor

Asthma / Respiratory irritant

Reproductive Disorders

Carcinogen

Neurological Disorders

2. INTRODUCTION

2.1 Background to the report

This report presents findings from an investigation into the presence of hazardous substances in carpets sold in the European Union (EU).

Previous research[2] has revealed that over 50 toxic substances can be present in European carpets, including endocrine disruptors, carcinogens and mutagens. It has shown how these can affect consumers' and workers' health, as well as posing obstacles for the industry to move towards a circular economy. Toxic substances often persist in recycled products and can negatively influence the quality of the recyclate, making it harder to compete with virgin materials. Previous reports have also shown that these toxics are insufficiently regulated and that certification schemes fail to cover them adequately, leaving consumers and workers exposed and without proper information about the toxics in their carpet.

Following up on previous research, the aim of this investigation was to test for toxics present in specific carpets sold by the largest global carpet manufacturers on the EU market. This report summarises the findings, giving a snapshot of toxics in EU carpets and comparing them to companies' own commitments, legislation and certification standards.

The testing and analytical chemistry informing this report was undertaken by three independent research centres: the Vrije Universiteit Amsterdam (VU Amsterdam) (Netherlands), the Ecology Center (Michigan, US) and Notre Dame University (Indiana, US).

2.2. Background to the carpet industry

The EU is the second-biggest market in the world for carpet (after the US) and home to some of the largest carpet producers. Belgium, the Netherlands and the UK are the EU's leading manufacturing countries. Overall, it is estimated that 65% of EU demand for carpets is fulfilled by EU-based manufacturing. The industry has an annual revenue of 47 billion EUR.[3]

An estimated 1.6 million tonnes of carpet are disposed of in the EU annually, mostly ending up in landfills and incinerators. It is estimated that, currently, less than 3% of carpet placed on the market is recycled in the EU.[4]

BOX 1

Why toxic materials have no place in a circular economy

The carpet sector has the potential to move towards circularity, but one of the main obstacles to carpet recycling is that most carpets currently sold were not designed with reuse and recycling in mind. The use of toxic substances in carpets represents another obstacle to circularity, as these need to be eliminated before the materials can safely be reused or recycled.

When carpets are not recycled, besides being a waste of valuable resources, these products and their embedded toxic substances can pose problems in landfills and via incineration. Carpet is burnt either in incinerators to generate electricity and heat or in cement kilns. Incineration of toxic-containing carpet can lead to the release of toxic emissions. Extra-high (and therefore energy-intense) burning temperatures are required to secure complete combustion of the toxics, and toxic substances captured from emissions end up in hazardous fly ash, which is either sent to landfill as waste or ends up in applications such as concrete, where exposure could occur again. Carpet is more or less a permanent material in landfill; it has an extremely long degradation time. However, there is potential for the toxic substances within carpets to be leached out by precipitation.

Increasing the market share of better-designed carpets must play a key role in scaling up the toxic-free carpet that is reused and recycled into new carpet. Several manufacturers have made efforts to produce more recyclable products, phasing out certain toxics and investing in innovative solutions such as mono-material carpet and reversible adhesives. However, this report reveals that these voluntary efforts do not go far enough to eliminate all harmful chemicals from all carpets. Despite the fact that recyclable and toxic-free carpets already exist, they are not being rolled out fast enough, and policy measures are needed to accelerate the transition to a circular economy.

3. METHODOLOGY

3.1. Sample collection

For this investigation, samples were selected from seven of the largest European carpet manufacturers: Associated Weavers, Balta, Beaulieu International Group, Forbo, Interface, Milliken and Tarkett. For each of these manufacturers, two carpets were procured and tested. Where possible, the most 'environmentally friendly' or 'ecologically' marketed product and the most popular carpet were selected.[i] This was to obtain different samples from each manufacturer and to include carpet designs with recycled content and other 'ecodesign' features.

When it was not possible to identify an ecological product, a product with features that seemed common to the producer was chosen. When it was not possible to identify the most popular carpet, a generally popular product or the cheapest product was chosen. One additional sample from the Dutch manufacturer Donkersloot was selected on the basis that it claims to represent an eco-innovation on the market. The total number of European carpet samples was 15.

New carpet samples for each of the selected products were procured and split into two samples, which were shipped to VU Amsterdam in the Netherlands and the Ecology Center in the US. The Ecology Center separated the face fibre from the backing and kept the backing for metal and non-metal element testing, while the face fibre was sent to the University of Notre Dame for total fluorine testing.

3.2. Analysis

VU Amsterdam and the Ecology Center reviewed the chemicals from previous studies by the Healthy Building Network[5] and Anthesis Consulting.[6] On this basis, a shortlist of chemicals from the following chemical groups was selected for testing: antimicrobials; Bisphenol A; flame retardants; fluorinated stain repellents (PFASs); isocyanates; nonylphenol; phthalates; and polycyclic aromatic hydrocarbons (PAHs). In addition, there was general testing for total fluorine [ii] and heavy metals.

3.2.1. VU Amsterdam: rapid screening

Under the leadership of Professor Jacob de Boer, Head of the Environment and Health research group, the VU Amsterdam screened the selected carpets for the presence of a range of compounds: antimicrobials; Bisphenol A; flame retardants; fluorinated stain repellents (PFASs); isocyanates; nonylphenol; PAHs; and phthalates. This was done with a rapid screening method to detect the presence or absence of these compounds above a certain level. From here on, this phase will be referred to as the 'screening phase'.

The VU Environment and Health research group developed a fast-screening ambient mass spectrometry (MS) method.[iii] This method has been applied for brominated and organophosphorus flame retardants and plasticisers and related chemicals (intermediates, fillers, etc.) in electronics,[7 8] and can identify which compound is present in plastics or carpets.

The 15 carpets were taken apart into separate layers. For most carpets, two layers were tested (face fibre and backing); in three cases, there was a layer in between the face fibre and backing, and all three layers were tested. For the analyses of the fibre layer, fibres were cut off the carpet and placed in a specific glass probe (capillary), which was used for Direct Probe-Time of Flight MS (TOF-MS) analyses. For the analyses of the other layers (i.e. the backing and the layer in between), the glass probe was scratched over the material, resulting in little parts of the material entering into the glass tube, which were also analysed by Direct Probe TOF-MS. All samples were analysed with positive polarity as well as with negative polarity MS mode. Identification of compounds was based on comparison of the accurate mass detected (+/- 0.004 D) with the expected accurate mass.

The screening was qualitative and indicated whether a compound was detected above the limit of detection (LOD) of 0.05% in the product, just above the LOD or not detected. If certain compounds did not show with this method, it is possible the compound was present at lower levels (<0.05%). The screening phase helped indicate the presence of certain substances. This screening method and the presence of a compound need further verification with a target analysis to verify the identity of the compound.

3.2.2. Ecology Center: screening for metals and non-metal elements

A High Definition X-Ray Fluorescence (HD XRF) spectrometer was used to quantify metals and non-metal elements, including bromine, chlorine, phosphorus and sulphur, in all carpet backing samples. The methods used and quality assurance practices have been previously described by the Ecology Center.[9] The HD XRF analyser uses a technology known as X-ray fluorescence spectrometry to detect chemical elements, such as antimony; arsenic; cadmium; chlorine; lead; mercury; and tin. The major benefit of HD XRF is that monochromatic excitation eliminates the X-ray scattering background under the fluorescence peaks, greatly enhancing detection performance.

i – These two criteria are not, in theory, mutually exclusive; but in this investigation, there was no crossover between the two categories.
ii – The total fluorine testing was done in additional to the PFASs testing, which only tested for a few specific PFAS, as there are many on the market.
iii – The screening method used was direct probe (DIP) coupled to atmospheric pressure chemical ionization-high resolution time-of-flight mass spectrometry (DIP-APCI-HR-TOF-MS).

Credit: Relevant Films

This analytical approach results in detection limits in the low parts-per-million (ppm) range for many elements of interest in a variety of materials. The HD XRF had a spot size (the area actually analysed) of approximately 1mm. Three measurements, in unique locations, were sampled on each carpet backing. These results were averaged.

Most backings were analysed intact, while some required separation into two or more backing layers. Thin samples, such as the thin backing layer of carpet tiles, were folded multiple times to minimise signal from the substrate underlying the sample.

For all metals and non-metal elements of interest, except for chlorine, phosphorus and sulphur, quantification limits with HD XRF were in the ppm range. Different sample properties (thickness, plastic type, fillers) can cause absorption and enhancement of the X-ray and impact the actual detection limit. The limit of quantification for chlorine was generally at least several hundred ppm.

3.2.3. University of Notre Dame: total fluorine screening

Total fluorine was analysed by Particle Induced Gamma-ray Emission (PIGE) spectroscopy. The PIGE method utilised applied a commonly used ion-beam analysis technique, which was adapted for the detection of total fluorine associated with poly- and perfluoroalkyl substances (PFASs) on papers and textiles. The method identifies fluorine, which is an element. The method does not identify specific chemical substances (PFASs); however, the entire class of organofluorine chemicals used as stain repellents on carpets have similar chemical structures and health impacts. Analysis was completed by Dr Graham Peaslee at the University of Notre Dame.

This method[i] is highly sensitive to fluorine atoms, and indicates the total fluorine present above approximately 25ppm in carpets. This makes it a particularly appropriate analysis method for the surface concentrations of fluorine as a surrogate for PFASs. PFASs on consumer products are often intentionally applied after fabrication as surface treatments, because they impart water- and stain-resistant qualities and typically contain 12–18 fluorine atoms per molecule, which means PIGE is sensitive to PFAS concentrations in solids.[10] Typical PFASs found on carpets include perfluorooctanesulfonic acid (PFOS), pentafluoropropionic anhydride (PFPA), perfluorooctanoic acid (PFOA) and a variety of fluorotelomer alcohols.[11]

3.2.4. VU Amsterdam: verification

As a next step, VU Amsterdam subjected the positive samples from the screening study to further testing to verify the findings of the screening phase. This was done by solvent extraction of the samples followed by quantitative analysis with GC/MS[ii] or LC/MSMS,[iii] also referred to as the 'target phase'. This method has very low detection limits (down to sub ng/g).[12]

i – The carpet samples were exposed ex vacuo to a beam of 3.4MeV protons for 180 seconds. Typically, 50nA of beam on target was used to excite 19F nuclei, which subsequently decay with characteristic gamma-rays (110keV and 197keV) that are measured quantitatively to give the number of fluorine atoms present in a sample.
ii – Gas chromatography–mass spectrometry.
iii – Liquid chromatography–tandem mass spectrometry

4. KEY FINDINGS

4.1. Introduction

This section presents the findings from the testing carried out by VU Amsterdam, the Ecology Center and the University of Notre Dame, and places them in the context of EU regulations, company certifications and companies' own commitments and policies relating to toxics. Product-related information, such as specifications and certifications, was taken from publicly available online resources.

The screening investigation found indications of a number of chemical groups, namely antimicrobials, flame retardants, isocyanates, nonylphenol, PFASs and phthalates. The uses, potential health impacts and regulations related to these chemicals are explored in Table 1. The presence of flame retardants, PFASs and phthalates in the carpets was verified with the target analysis methods; antimicrobials, BPA and isocyanates need further verification.

It is important to note that people are exposed on a daily basis to multiple chemicals with known or suspected health effects, including the chemical groups in this study. For each chemical group, there are many other sources of exposure in indoor environments. There is also potential for cumulative impacts because many of these ubiquitous chemicals co-occur in the indoor environment and may contribute to common adverse outcomes. As such, the levels of chemicals of concern detected in the carpet samples contribute to overall exposures that are of concern.

For some chemical groups, like phthalates, regulatory limits have been established that are at least partly based on preventing potentially harmful exposure levels. For phthalates, this is level is 0.1% (1,000 ppm) for toys and childcare products in the EU. However, all uses of phthalates in products, including those <1,000 ppm, contribute to the total exposure for an individual. The Toys Safety Directive sets regulatory limits on the use of substances classified as carcinogenic, mutagenic, or toxic for reproduction (CMR) in toys. These do not apply to carpet, despite the direct contact and exposure of babies and small children to carpet. The Toy Safety Directive gives an indication of the level of protection needed across all products; in the most hazardous categories (1A and 1B), CMRs are usually limited to a concentration of 0.1% or 0.3%.[13] For certain halogenated flame retardants, the Directive sets a concrete and low content limit of 5ppm for toys in the EU.

After presenting the results of the testing, this chapter will take a more detailed look at each company, the toxic substances found in their carpets and how these compare to their own commitments or any certification schemes they are part of. Although testing implemented for this report cannot provide any concrete conclusions on the health effects of exposure to this carpet, it is an indicator of the presence of certain chemicals in carpets sold in the EU. The authors of this report recommend further research to establish these links.

Testing at the VU Amsterdam Credit: Relevant Films

Table 1: Chemicals found or possibly identified and their possible uses in carpets, general health impacts and regulations

Chemicals	Use	Health impacts	Regulated?
Phthalates In this investigation the presence of the following phthalates was indicated: — Bis(2-ethylhexyl) phthalate (DEHP) — Di-n-octyl phthalate (DNOP) — Dimethyl phthalate (DMP)	Commonly used to add flexibility to PVC carpet backing.	A number of phthalates are classified as reprotoxic.[14] Many are endocrine disruptors and have been linked to developmental disorders. DEHP has been classified by the EU as toxic for reproduction and endocrine disrupting for human health and the environment.	Under EU REACH legislation, many phthalates are listed as Substances of Very High Concern.[15] DEHP is on the REACH Authorisation list (Annex XIV) and its use has been banned in the EU since 2015. However, DEHP has been authorised in recycled PVC for certain uses, including carpet, until 2019. DNOP is on the EU Restricted List (Annex XVII), but this restriction does not apply to carpet.bDEHP and DNOP are on the International Chemical Secretariat SIN List; DMP is on the SINimilarity List.
Flame retardants In this investigation the presence of the following flame retardants was indicated: — TCPP — TDCPP	Used in carpets to prevent the spread of fire.	TCPP and TDCPP are chlorinated (halogenated) organophosphate flame retardants. Many halogenated flame retardants are linked to neurological effects, endocrine disruption and decreased fertility. TDCPP is classified in the EU as a suspected carcinogen.	The EU's Toy Substance Directive has set a flame-retardant limit for TCPP and TDCPP of 5ppm.[16] This does not apply to carpets, but the European Chemicals Agency (ECHA) has recently requested further information on these flame retardants to support a possible restriction. TDCPP is listed on the EU SIN List and TCPP is on the SINimilarity List.
Nonylphenol* In this investigation the presence of the following nonylphenol was indicated: — Nonylphenol, ethoxylated	Possibly used as carpet adhesive, or as an antioxidant in plastic and rubber materials.	Nonylphenol, ethoxylated is toxic to aquatic organisms.	Nonylphenol, ethoxylated is on the EU REACH Candidate List and also restricted for certain textiles in concentrations equal to or greater than 0.01% by weight, but it is unclear whether this applies to carpet. Nonylphenol, ethoxylated is on the SIN List.
Fluorine In this investigation, the presence of per- and polyfluorinated substances (PFASs) was indicated. We found indications of the presence of the following PFASs: — PFBA — PFPeA — PFHxA — PFHpA — HFPO-DA — PFBS — PFHxS — 6:2FTS	Used as a stain or water repellent.	PFASs are known to be persistent organic pollutants. In the EU they are regarded as suspected carcinogens, toxic to reproduction and potential causes of developmental disorders.	Despite similar hazard profiles of different PFASs, only PFOS and its derivatives are currently banned under the Stockholm Convention on Persistent Organic Pollutants (POPs), and PFOA will be restricted under REACH as of 2020. Many other PFASs have been proposed for either being added to the Stockholm Convention or for restriction under REACH. Many PFAS are either on the SIN or SINimilary lists.

Chemicals	Use	Health impacts	Regulated?
Antimicrobials* In this investigation the presence of the following antimicrobials was indicated: — 2-Methyl-4-isothiazolin-3-one (MIT) — Methylchloroisothiazolinone	Used in carpets to provide a level of protection against dust mites, moulds, bacteria and fungi.	MIT is toxic in contact with skin, fatal if inhaled and toxic if swallowed. Methylchloroisothiazolinone is fatal in contact with skin, fatal if inhaled and fatal if swallowed. It causes severe skin burns and eye damage, and may cause respiratory irritation.	Both Methylchloroisothiazolinone and MIT are restricted by the EU's Toy Substance Directive to 0.75mg/kg (content limit) in aqueous toy materials.
Bisphenol A (BPA)*	Used as a surfactant.	BPA may damage fertility or the unborn child, causes serious eye damage, may cause an allergic skin reaction and may cause respiratory irritation.	BPA is listed as a Substance of Very High Concern. BPA is on the EU Restricted List (Annex XVII), but this restriction does not apply to carpet. The EU's Toy Substance Directive has set a limit for BPA 0.1mg/l (migration limit).[17]
Isocyanates* In this investigation the presence of the following isocyanates was indicated:[i] — 4,4'-methylenebis (phenyl isocyanate) (MDI) — 2 4'-methylenebis (phenyl isocyanate) — diphenylmethane-2,2'-diisocyanate — 4,4'-methylenebis (phenyl isocyanate)	Used in the production of polyurethane, which can be used as carpet backing.	Methylene diphenyl diisocyanate is a known skin and respiratory sensitiser as well as a suspected carcinogen. Diisocyanates are also a major cause of occupational asthma.	These four isocyanates are on the EU Restricted List (Annex XVII). They are restricted in concentrations of ≥0.1% by weight, unless the packaging discloses potential health risks and protective gloves are provided. Two of the listed iscocyanates are listed on the SINimilarity list (4,4'-methylenebis (phenyl isocyanate) (MDI) and 4,4'-methylenebis (phenyl isocyanate)).

In this investigation, we also tested for the presence of metals and non-metal elements – including antimony, bromine, lead, iron and phosphorus – and chlorine. These tests analysed samples for chemical elements, not organic compounds. Some elements, like lead, have well-studied toxicity in their elemental form. Other elements, including bromine, chlorine and phosphorus, can be used as indicators of flame-retardant chemistry, which uses one or more of these elements. Further research using other analytical methods is required to identify exact chemical structures and related health impacts from these findings. Therefore, these results are listed under the results but not further interpreted. However, in some instances the presence of certain metals and/or chlorine verifies findings from the VU's testing; for example, low levels of chlorine could indicate the use of chlorinated flame retardants, and bromine levels of 5–500ppm may indicate the presence of brominated flame retardants as contaminants. In these cases, further investigation of these samples is recommended.

Notes: Unless otherwise stated, the information presented in this table is taken from the ECHA website and the International Chemical Secretariat SIN List website, as well as previous reports by the Healthy Building Network and Anthesis Consulting Group.[18] Compounds marked * were identified by the screening method but need further verification via target analysis.

i – The screening method could not distinguish between the four isocyanates.

BOX 2

How voluntary certifications fall short

Many of the hazardous substances found in this investigation are banned by the ambitious ecolabels Blue Angel and Nordic Swan. (See Appendix for an overview of certifications) However, none of the carpets tested for this report had these ecolabels. This is in stark contrast with the GUT label, which several investigated products had – but which, for instance, does not limit the use of all the detected phthalates, flame retardants or isocyanates. Also, the Cradle to Cradle certification allows some of these substances; for instance, at its basic and bronze levels, some phthalates and flame retardants are allowed. As consumers are rarely experts on what different levels of certification mean, this can be potentially misleading.

Credit: Will Rose

4.2. Findings by company

4.2.1. Associated Weavers

Associated Weavers (AW) is one of the biggest producers of tufted broadloom carpet in Europe, and is part of the Belgotex International Group. AW is headquartered in Belgium and exports to over 55 countries. Its estimated annual revenues are 170 million EUR.[19]

AW's website claims that 'the pursuit of sustainable enterprise in general and environment-friendly production in particular is deeply anchored in AW's business strategy'.[20] However, no specific toxics policies could be found. It was also unclear from its website and annual report whether all its products have GUT (Gemeinschaft Umweltfreundlicher Teppichboden) certification – an industry-led certification scheme established solely for carpets.[i] Previous studies have identified GUT as a prevalent certification of choice for most European carpet manufacturers, although research has shown the label covers only 13 of 59 potentially hazardous chemicals found in carpet.[21]

For AW, two general products were chosen. In terms of an ecological product, recytex backing was identified, but it was not possible to find and purchase a product with this backing online. Therefore, there is no 'most ecological' product among the AW selected carpets. From the product information publicly available online, it was not clear whether the chosen carpets have any certifications.[ii]

4.2.1.1. Stainaway Harvest Heathers Deluxe

Stainaway is a residential broadloom carpet with a polypropylene fibre and hessian backing. The following substance was detected:

Unidentified phthalate *	>500 ppm

* This compound was identified but need further verification via target analysis.

The Stainaway carpet testing indicated the presence of an unidentified phthalate, which needs to be verified by further research. Blue Angel and Nordic Swan certification schemes, by German and Nordic governments respectively, already take the precautionary approach of banning all phthalates from carpets.

4.2.1.2. Disney & Kids Carpet

This is a children's broadloom carpet and the cheapest AW carpet that could be identified online. It has a 100% polyamide face fibre and a felt backing. The following substances were detected:

Methylchloroisothiazolinone*	<500 ppm
2-Methyl-4-isothiazolin-3-one (MIT)*	<500 ppm

* These compounds were identified by the screening method but need further verification via target analysis.

i – Research by the Anthesis Consulting Group (See reference 1) has shown that GUT only bans or restricts 13 of 59 hazardous chemicals identified as possibly being present in carpet.
ii – ISO certification and CE marking are not included in the certifications mentioned in this section.

Methylchloroisothiazolinone and MIT are antimicrobial substances used in carpets to provide a level of protection against dust mites, moulds, bacteria and fungi. The screening method gave indications of these substance but further research is need to confirm their presence and determine their levels. It is noteworthy that these substances are banned by Blue Angel and Nordic Swan labels for textile flooring,[i] and the GUT label limits the use of the antimicrobial MIT at levels to 100 mg/kg.[22] However, these substances are not yet restricted by EU regulations.

4.2.2. Balta Industries

Balta Industries is one of the largest manufacturers of carpet in the EU. It had global sales of 725 million USD (628.5 million EUR) in 2016.[23] The company is headquartered in Belgium and offers products to several regions globally, with a focus on Western Europe.

While the Balta website claims: 'Sustainability is not just a word within the Balta Group',[24] very little information on sustainability can be found. No policies limiting hazardous substances could be identified. In general terms, their brochure refers to GUT as well as TÜV[ii] and PRODIS [25] certification, even though the latter is not a certification scheme but rather the product information system of GUT. It is neither clear nor easy to identify which products have been GUT tested and accredited. For most products, specifications are not publicly available; a customer number is needed to access them.

4.2.2.1. Gala and Stripes

This is a 'Broadloom favourite' residential carpet with a polypropylene fibre, felt backing and 'Lifetime Stain Warranty'. No product specification could be accessed online.

The following substances were detected:

2-Methyl-4-isothiazolin-3-one (MIT) (antimicrobial)*	around 500 ppm
Antimony	287 ppm
Sulphur	4,073 ppm

* This compound was identified by the screening method but needs further verification via target analysis.

In the Gala and Stripes carpet, the screening method showed indications of antimicrobial MIT around 500ppm, yet further research is need to confirm its presence and determine the levels. Although it is unclear which label this carpet has, if any, it is noteworthy that these substances are already banned by Blue Angel and Nordic Swan labels for textile flooring.[i] The GUT label limits the use of the antimicrobial MIT to levels of 100 mg/kg, which equals 100ppm.[26] The GUT label also limits the presence of antimony to 150mg/kg. The amount found in the Gala and Stripes carpet is almost double. Moreover, the EU Toy Safety Directive set limits to the presence of antimony for different material characteristics. For dry, brittle and powder-like or pliable materials, the limit is 45mg/kg (45ppm).

4.2.2.2. Amaize[iii]

The Amaize broadloom is marketed as an ecological product for the residential market. It has a face fibre made of 100% PTT 'triexta AMAIZE' (with 37% corn sugar), a woven polypropylene primary backing and a secondary 'Twinback' backing.[27] This carpet has the GUT label.
The following substances were detected:

Nonylphenol, ethoxylated*	around 500 ppm

* This compound was identified by the screening method but needs further verification via target analysis.

The screening of the Amaize carpet showed indications of nonylphenol, ethoxylated, but this needs to be verified by further research. GUT does not ban or limit the found nonylphenol; however, 'nonylphenol, ethoxylated' is on the EU REACH Candidate List, and is restricted for certain textiles in concentrations equal to or greater than 0.01% by weight. It is currently unclear whether this restriction applies to carpet.[28]

4.2.3. Beaulieu International Group

Beaulieu International Group is among the largest European carpet manufacturers, and is headquartered in Belgium. Carpet brands include Carus, Ideal and Orotex. Beaulieu International Group is a vertically integrated company that produces its own yarns, fibres and technical textiles. The company is also a major multinational producer of hard-surface flooring.

While the company has a dedicated 'Sustainability' page on its website, no specific targets or policies could be identified. The website does mention on its 'Safety' page that it is a 'daily concern that all employees return home safe and well', and on its 'Planet' page that 'Beaulieu International Group actively seeks to eliminate or minimise the impact of its processes and products on the environment'.

No specific ecological product could be identified for the Beaulieu International Group; hence, two products were selected that seemed to represent commonly sold products: one from the Avenue brand and one from the Orotex brand.

4.2.3.1. Beaulieu Avenue

This is a commercial broadloom carpet with a propylene fibre and a latex backing (carboxylated styrene butadiene latex).[29] The carpet sample was not delivered with a backing, so no testing on the backing could be done. None of the chemicals tested for were identified. However, we cannot be completely certain of the absence of substances, as the testing method and scope were limited and part of the product was missing.

i – See Appendix for an overview of certifications.
ii – A company providing inspection and product certification services.
iii – This sample was not tested for fluorine by the University of Notre Dame, nor for metals and other non-metal elements by the Ecology Center.

4.2.3.2. Beaulieu Orotex

This is a residential broadloom carpet with '100% synthetic' fibre and 'resine (624)' backing, according to the product declaration.[30] This information is too vague to identify the exact materials used, although the following substance was detected:

Chlorine	2,915 ppm

The carpet sample contained only fibre and no backing. A level of chlorine was found in the fibre material, indicating that an unknown chlorine-based chemistry is present in this carpet. Lower levels of chlorine (like the one found) could, for instance, be an indicator of the use of chlorinated flame retardants, but this requires further research. In addition, it is hard to draw conclusions about this product because the backing was missing.

4.2.4. Donkersloot

Donkersloot is a Dutch carpet manufacturer that focuses on creating '100% recyclable' carpet suitable for a circular economy. The company's website advertises its use of technology from DSM Niaga ('Niaga™ technology'), which enables complete separation of the carpet backing, glue and face fibre. The company claims this technology innovation enables it to make carpet from recycled materials that can again be fully recycled after use. The tested BT40 product is a broadloom carpet for commercial use. Its face fibre is made from polyamide 6 yarn; the backing material is not stated online but seems to be felt. The following substance was detected:

Antimony	171 ppm

The antimony level found in this carpet is above the levels set by the GUT label (150mg/kg, or 150ppm). The EU Toy Safety Directive also sets limits on the presence of antimony for different material characteristics; for dry, brittle and powder-like or pliable materials, the limit is 45mg/kg (or 45ppm) – the same limit recommendable for carpet, as chemicals can migrate with dust, exposing babies and children who spend time on the carpet to risk.

4.2.5. Forbo

Forbo is a Dutch carpet manufacturer with an estimated annual European revenue of 155 million EUR.[31] Its flooring division sells commercial and residential floor coverings, including Marmoleum, Luxury Vinyl Tile (LVT) and carpet tiles. Forbo has a publicly available brochure called Creating Better Environments (CBE) that outlines its general sustainability policies, although it does not give many details relating to company policies on specific toxics. The brochure does refer to use of phthalates, stating that 'almost all of [Forbo's] vinyl ranges are phthalate free'. However, it is not clear if this includes use of phthalates in carpet backing or solely refers to the company's LVT range.

The CBE brochure also outlines a number of certifications the company has received, including Blue Angel, BREEAM (Building Research Establishment Environmental Assessment Method), TÜV and Nordic Swan, although it does not detail which carpet/flooring product each certification is applicable for. Product specifications are available for all products on the company website.

For Forbo, the Tessera carpet tile was selected for testing because it is advertised on the Forbo website as the 'most popular' product, while the Westbond carpet was selected because the company widely advertises it as a good choice for eco-conscious consumers ('for those looking for something closer to nature').

4.2.5.1. Forbo Tessera

Tessera is a commercial-use carpet tile. Its face fibre is 100% Aquafil polyamide (nylon 6,6) with over 50% recycled content, and the backing is a mixture polymer of modified bitumen and inert inorganic fillers, with a middle layer of glass fibre.[32] Forbo Tessera does not appear to have any certification (apart from CE and ISO; see footnote[ii] on page 25).

The following substances were detected:

Dimethyl phthalate (DMP)	>500 ppm
Unknown phthalate*	>500 ppm
Bisphenol A (BPA)*	Around 500 ppm
Sulphur	30,026 ppm

*This compound was identified by the screening method but needs further verification via target analysis.

The Forbo Tessera Environmental Product Declaration (EPD) discloses the use of DOTP, a 'phthalate free' plasticiser, in the product; however, DMP andanother unknown phthalate were also found. As with the Westbond carpet (discussed next), the screening method showed indications of BPA lower than 500ppm, although further research is needed to verify this. BPA is restricted for use in the EU (although this restriction does not apply to carpets). The EU's Toy Substance Directive has set a limit for BPA of 0.1mg/l (migration limit).

4.2.5.2. Forbo Westbond

Westbond is a commercial-use carpet tile. The Westbond sample tested in this investigation had 100% polyamide face fibre (nylon 6,6), although there are also options with 80% dyed/undyed wool in this range. The backing is PVC, incorporating at least 70% recycled content. Westbond carpet has a British Standards Institute certification.[33]

The following substances were detected:

Bis(2-ethylhexyl) phthalate (DEHP)	> 500 ppm
DNOP	> 500 ppm
Bisphenol A (BPA)*	< 500 ppm
Chlorine	343,410 ppm

*This compound was identified by the screening method but need further verification via target analysis

The Forbo Westbond EPD discloses the use of DINP as a plasticiser in the product; however, we also found additional phthalates (DEHP and DNOP). DEHP has been on the EU REACH Authorisation List since 2015 but, as mentioned earlier, a worrying authorisation permits its use in recycled PVC for certain uses, including carpets, until 2019. The level of chlorine found in this product is indicative of the PVC used therein. The presence of phthalates in this carpet, made with recycled backing, demonstrates the importance of phasing out all toxics in the design stage of carpet manufacturing to ensure the industry can safely move to a circular economy model.

The screening method showed indications of BPA lower than 500ppm, although further research is needed to verify this. BPA is restricted for use in the EU, although this restriction does not apply to carpet. The EU's Toy Substance Directive has set a limit for BPA of 0.1mg/l (migration limit). Again, this limit does not apply to carpet.

Although it is not stated whether this carpet has specific certifications, Forbo advertises itself as complying with Nordic Swan and Blue Angel labels, among others. The use of phthalates DEHP and DNOP are banned under both of these schemes.

4.2.6. Interface

Interface is the world's largest manufacturer of commercial carpet tile, with European headquarters in the Netherlands and the UK. The company has an estimated annual European revenue of 198 million EUR.[34]

Interface has a sustainability programme called 'Mission Zero™', which it defines as '[its] promise to eliminate any negative impact [the] company has on the environment by 2020'.[35] This programme includes goals on resource efficiency, renewable energy and reducing waste, as well as 'closing the loop' on carpet design. The company states that 50% of materials used in its European factories are now recycled or biobased. It is not clear from the Interface EU website whether the company has policies relating to individual toxics. An article by Interface Global in 2012 stated the company's intention to phase out all virgin PVC by 2020.[36]

For Interface Europe, the Composure carpet and a carpet with Circuit Bac Green were selected for testing. The Composure carpet was listed as a popular choice for consumers on the company's British and Dutch websites, while the Circuit Bac Green backing is specifically promoted as an 'eco' choice due to its recycled and biobased content.

4.2.6.1. Interface Composure

Composure is a tufted patterned structured loop tile used for commercial purposes. It has 100% solution-dyed nylon face fibre (containing recycled content) and a Graphlex™ (bitumen-based) backing. According to the product specification, Composure appears to have a GUT and BRE Global certification.[37]

In this investigation, nothing was detected in the Composure carpet sample. While this does not guarantee that there are no toxics in this product (our screening method tested for a limited range of toxics), it is encouraging to note that carpets can be produced in a less toxic way. Please see Box 3 for more details about ecodesign.


Credit: Will Rose

4.2.6.2. Interface Conscient with CircuitBac Green

Conscient with CircuitBac Green backing is a commercial-use carpet tile, with solution-dyed nylon face fibre and backing made from recycled and biobased materials. The backing consists of wood resin, containing recycled filler, glass-fleece reinforcement and polypropylene covering fleece. The product has an EPD and has the GUT label.[38]

The following substances were detected:

Iron	2,495 ppm
Chlorine	8,089 ppm

The findings show an unknown chlorine-based chemistry is present in this carpet. Lower levels of chlorine (like the one found) could, for instance, be an indicator of the use of chlorinated flame retardants, but this requires further research.

Credit: Will Rose

4.2.7. Milliken

Milliken is a US carpet manufacturer with European manufacturing sites in Belgium, France and the UK. It predominantly sells flooring for commercial use.

Milliken has a detailed sustainability report available on its website, which includes details of its policies relating to toxic chemicals. While the company does not disclose policies for specific toxics, its sustainability report states that it is 'committed to understanding 100% of chemical ingredients used in the materials [it selects] for Milliken flooring solutions'. The report states that the company will 'prioritise chemicals of high concern for elimination and minimise exposure and risk where hazards cannot be prevented'. Milliken also claims that its modular carpet collections comply with the Red List imperative by the Living Building Challenge.[i] Product specifications are available on the Milliken website.

The European Milliken products chosen for testing were Nordic Stories (Tectonic) and Light Trails. Nordic Stories was chosen as it is promoted by Milliken as one of its most popular products; Light Trails was chosen as it is promoted as an 'eco' product due to its recycled content.

4.2.7.1. Milliken Nordic Stories (Tectonic)

Nordic Stories (Tectonic) is a tufted, textured loop pile carpet tile for commercial use. It has a dyed nylon 6,6 face fibre and a 90% recycled content polyurethane backing. The product has GUT and Carpet and Rug Institute (CRI) Green Label Plus certification for indoor air quality, and an 'A' grade BREEAM rating.[39]

The following substances were detected:

Isocyanates:* 4,4'-methylenebis (phenyl isocyanate) (MDI) and/or 2 4'-methylenebis (phenyl isocyanate) and/or diphenylmethane-2,2'-diisocyanate and/or 4,4'-methylenebis (phenyl isocyanate)	Around 500 ppm
TCPP	>500 ppm
TDCPP	>500 ppm
Chlorine	20,205 ppm

* These compounds were identified by the screening method but need further verification via target analysis

i – The Living Building Challenge (LBC) is a building certification programme that includes a requirement to avoid a specified Red List of hazardous chemicals in all products used to construct the building. According to the Healthy Building Network, the Red List contains just 21 of 44 chemicals identified as high risk in carpet.

BOX 3

Better, healthier carpets are possible

This investigation found three carpet samples that did not display indicators of the presence of toxic chemicals.[i] While it cannot definitively be said that these carpets do not contain any hazardous substances (due to the limitations of the screening method and scope of this testing), if true, these examples show that carpet can be designed in a better, healthier way. It is also encouraging to see that both of the two carpets in which no toxics were detected contained recycled content, demonstrating that tackling toxics and a circular economy can be done.

The Desso Airmaster carpet has a face fibre made of nylon 6 and ECONYL, and an EcoBase backing – a polyolefin base containing at least 75% Cradle to Cradle positively defined recycled content. ECONYL is made from regenerated nylon. In addition to being based on recycled content, the Airmaster carpet is advertised as being fully recyclable, which is a key for closed-loop recycling. The Interface Composure carpet is not advertised as an 'eco' choice, although all Interface products are promoted (to an extent) as environmentally aware choices. Its face fibre contains recycled nylon. Both Interface and Desso (part of Tarkett) offer takeback systems for carpet after use.

Both the Airmaster and Composure carpets are carpet tiles for commercial use, possibly reflecting a growing interest in the business world in creating healthier workplace environments. However, it is important to note that these products remain niche; they represent a small percentage of the commercial market and are not available to private consumers. The residential sector, which is predominately broadloom based, should learn from best practice in the commercial sector and ramp up better design.

Building healthier carpets into a circular economy model begins right at the design stage, and preventing or eliminating substances of concern in the design phase reduces the complexity of recycling the product at its end of life. Considering that the life span of a carpet can be 10–15 years, ecodesign needs to happen now to ensure circular economy in the future.

Credit: Will Rose

4.2.7.2. Milliken Light Trails

Light Trails is a tufted, textured loop pile carpet tile for commercial use. Its face fibre is made of 100% regenerated nylon (ECONYL™) and it has a 90% recycled content polyurethane backing. Light Trails has antimicrobial and anti-soil properties.[40] The product has GUT and CRI Green Label Plus certification for indoor air quality and an 'A' grade BREEAM rating.

The following substances were detected:

Isocyanates:* 4,4'-methylenebis (phenyl isocyanate) (MDI) 2 4'-methylenebis (phenyl isocyanate), diphenylmethane-2,2'-diisocyanate 4,4'-Methylenebis (phenyl isocyanate)	Around 500 ppm
TCPP	> 500 ppm
TDCPP	> 500 ppm
PFASs: PFBA (Perfluoro-n-butanoic acid) PFPeA (Perfluoro-n-pentanoic acid) PFHxA (Perfluoro-n-hexanoic acid) PFHpA (Perfluoro-n-heptanoic acid) HFPO-DA PFBS (Perfluorobutane sulfonate) PFHxS (Perlfuorohexane sulfonate) 6:2FTS	around 30 ppm^
Iron	1,272 ppm
Sulphur	14,464 ppm

* These compounds were identified by the screening method but need further verification via target analysis.
^ This level concerns the sum of the found PFAS.

The isocyanates identified with the screening method in the two Milliken carpets are on the EU Restricted List (Annex XVII) and not allowed to be present in concentrations of or above 0.1% (1,000ppm). The test results indicate that the isocyanates are present at around 500ppm, although their presence needs to be confirmed and levels quantified by further research. Both Milliken carpets also tested positive for the chlorinated flame retardants TDCPP and TCPP. These were found in the (recycled) polyurethane foam layers in both carpets. TDCPP is on the SIN List of chemicals, and is classified by the EU as a suspected carcinogen.

i – In total, no toxics were detected in three samples; but the Beaulieu carpet did not have a backing, so it is not further elaborated on as an example of healthier design.

The EU's Toy Safety Directive has set a limit for the flame retardants TCPP and TDCPP of 5mg/kg (5ppm), indicating the level of risk from exposure for children. This does not apply to carpets, but ECHA has recently requested further information on these flame retardants to support a possible restriction.[41]

A number of per- and polyfluorinated substances (PFASs) were found in the Light Trails carpet. These are often used as stain or water repellents. One of these, PFHxA, has been nominated for classification as a substance of very high concern because it is a suspected carcinogen. Another, PFHpA, is suspected to be a reprotoxic substance and endocrine disruptor.[42] That these PFASs are not yet regulated demonstrates the need for a class-based systems approach to chemicals regulation, for their chemical structure is similar to toxics that have already been regulated for their negative health impacts.

4.2.8. Tarkett

Tarkett is a global flooring and sports surfaces company based in France, with a global revenue of 2.7 billion EUR. The company sells carpet on the European market via its subsidiary, Desso, which has its headquarters in the Netherlands. Desso had sales of 202 million EUR in 2013.

Tarkett and Desso have a sustainability strategy inspired by Cradle to Cradle principles. Its key principles are: resource stewardship, people-friendly space, reuse and good materials. Tarkett is committed to the transition from a linear to a circular economy model, which consists of recycling resources in a loop from the design and production phases to later use and recovery stages.

Tarkett's subsidiary Desso has set the following goals:
By 2020 all our materials will have to be free of toxins that could cause harm (though allowed by all regulations certain chemical components are not healthy enough to be passed as Cradle to Cradle®), energy used will be renewable and the specially designed goods will be capable of being taken back and the materials used to make new high grade products, ending the need to continually draw on the earth's resources to meet growing consumer demand across the world.[i][43]

Cradle to Cradle has an extensive approach to dealing with chemicals. It has lists of banned chemicals,[44] which include certain phthalates, stain repellents and flame retardants. While this is a good start (and goes beyond other voluntary certifications), it does not include all chemicals in a certain class; for instance, not all phthalates are included on the banned list at basic and bronze levels, whereas they all have similar properties and health impacts. As for silver level, CMR substances (like phthalates) get restricted further. Yet even there a loophole seems to exist, as this applies to 95% of the product – and thus not to the remaining 5%. Another issue is that substances on the banned list are still allowed at up to 1,000ppm at basic and bronze levels. This means they are not really banned from products. In addition, Tarkett has announced that 100% of its vinyl production sites in Europe, North America and China use non-phthalate plasticiser technology,[45] and is committed to substituting all its phthalate plasticisers in all products for alternative forms of plasticiser by 2020.[46]

Tarkett has also announced that, on a global level, its carpet production in Europe and North America does not use fluorine as it has been replaced by safer alternatives.

4.2.8.1. Desso Essence

This is carpet tile for the commercial market, with a nylon 6 face fibre, a polyester fleece primary backing and Desso Probase Polyver secondary backing. It is not clear from the Essence product specification which materials the Probase Polyver is made of; however, a separate EPD[47] mentions that Probase contains calcium carbonate, bitumen, latex and glass fibre.

This product has GUT, BREEAM, CRI Green Label Plus and Cradle to Cradle[i] Bronze certification. The following substance was detected:

Sulphur	24,636 ppm

This sulphur is likely an indicator of the bitumen used in the backing.

4.2.8.2. Desso AirMaster

The Airmaster is a carpet tile for the commercial market with nylon 6 and ECONYL[ii] face fibre and Desso EcoBase backing (a polyolefin-based backing). It is marketed as one of Desso's most environmentally friendly products. The product declaration states this backing contains at least 75% C2C positively defined recycled content.[iii]

This product has GUT, BREEAM, CRI Green Label Plus and Cradle to Cradle Silver certification. No hazardous substances were found in the scope of this testing. Although we cannot be completely certain of the absence of substances, as the testing method and scope were limited, this is an encouraging result – especially since this product has a high level of recycled content and comes with the assurance that it can be fully disassembled and the individual materials recycled.[48] This finding seems to support the case that a circular economy and non-toxicity can go hand in hand, if safe and recyclable materials are used (see Box 3).

4.3. Discussion of findings

Hazardous compounds, including endocrine disruptors, carcinogens and reprotoxics, were found or potentially identified in all but three carpets in this investigation. These are troubling results and indicate potential health risks. Moreover, the substances found stand in the way of realising a circular economy.

Phthalates, which are usually used to add flexibility to PVC, were found in three carpets. This is particularly alarming, as a number of phthalates are classed as reprotoxic endocrine disruptors and have been linked to developmental disorders. DEHP, one of the phthalates found, was banned

i – See Appendix for an overview of certifications.
ii– ECONYL® is a nylon 6 yarn made from 100% regenerated content.
iii – 'Positively defined' 'all ingredients have been assessed as either Green (optimal) or Yellow (tolerable) according to the Cradle to Cradle® assessment criteria, as described in Cradle to Cradle® Certified CM Product Standard Version 3.0.'

Credit: Will Rose

in 2015 but an exemption for the use in recycled PVC in certain uses, such as carpet, was granted. DNOP, another phthalate found, is on the EU REACH restricted list. However, this restriction only applies to children's toys and childcare products that can be put in children's mouths – not to carpet.

In addition, chlorinated flame retardants were found in two European samples and, in the same samples, the presence of isocyanates was detected. One of the flame retardants found is classified in the EU as a suspected carcinogen. Both flame retardants found (TCPP and TDCPP) are restricted by the EU Toy Safety Directive to 5ppm in the content of toys. This limit does not apply to carpet, but it indicates the potential level of health risk to babies and small children from direct exposure.

Indications of nonylphenol, ethoxylated were detected in one of the carpets. Nonylphenol is toxic to aquatic organisms and categorised under the EU CLP Regulation as a reproductive toxic, suspected of damaging fertility and causing harm to the unborn child. Nonylphenol, ethoxylated is on the EU REACH Candidate List and restricted in certain textiles articles, but it is unclear whether this applies to carpet.

In one European carpet, a range of PFASs were found, which are known to be POPs. In the EU, they are regarded as suspected carcinogens, toxic to reproduction and potential causes of developmental disorders.

These findings are especially worrying as – besides one flame retardant (as of 2020) and one phthalate (after 2019) – these substances are not banned from use in carpet – even though, for some of them, restrictions already exist for toys and childcare products or certain textiles. Given the amount of time small children spend on carpets and their vulnerability to chemical exposure – through the inhalation of fumes, ingestion of carpet (micro)fibres through hand-to-mouth behaviours, and increased skin contact on carpets – it is warranted that carpet should be subject to the same level of protection as the Toys Safety Directive, and restrictions applicable to toys and childcare products under REACH.

BOX 4

Phthalates, PVC and carpets

Polyvinyl chloride, or PVC, is used as a binder in carpet tile and broadloom backing (more commonly in the US than the EU).[49] In recent years, a number of high-profile campaigns have drawn attention to the negative health and environmental impacts of PVC – from its supply chain to customer-use phase to end-of-life disposal.[i] The toxic nature of PVC also poses substantial issues when it comes to carpet recycling.

One major concern in relation to consumer health is the use of phthalate plasticisers within PVC. Phthalates are a class of petrochemicals used to add flexibility to the vinyl, and EU and US federal regulators have identified many as carcinogenic, reproductive disruptors and contributors to developmental disorders, neurological disorders and asthma.[50]

Phthalates can migrate out of carpet during its use phase, which poses a serious health risk to consumers – particularly young children and babies, who spend a lot of time close to the floor and are at higher risk of hand-to-mouth exposure.

A number of leading carpet manufacturers have publicly committed to phasing out certain phthalates. EU manufacturer Forbo claims that almost all of its vinyl ranges are phthalate free (although it is unclear whether this extends to its carpet products).[51] The global manufacturer Tarkett (parent company of Tandus Centiva and Desso) has committed to substituting phthalate plasticisers for alternative plasticisers by 2020, and claims to have already substituted all metal-based stabilisers (such as lead and cadmium) for non-harmful alternatives (calcium-zinc and barium-zinc).[52] During this investigation, a number of carpets were found to have phthalates present (see Chapter 4 for a detailed analysis of the results).

Even without the presence of phthalates, PVC is an inherently problematic material. Organotins, used as stabilisers in PVC, are reproductive toxicants. Antimony trioxide, used in PVC carpet backing, is considered to be carcinogenic. PVC is produced using chlorine chemistry, and its manufacturing is based on asbestos diaphragms or mercury cells.[53] PVC production emits carcinogenic dioxins and ozone-depleting chemicals, such as carbon tetrachloride. The asbestos used during production also needs to be disposed of.[ii] When burnt, PVC again releases dioxin, a known carcinogen, into the environment. With regard to landfill, the European Commission has acknowledged that plasticisers used in flexible PVC (such as those used in carpet backing) can be detected in landfill leachates.[54]

In light of the difficulty of safely disposing of PVC, and in line with the move towards a circular economy, a number of manufacturers use recycled PVC in their carpet backings. Interface has pledged to phase out virgin PVC in all carpets by 2020; EU company Milliken claims it tries to eliminate the use of virgin PVC where possible, including in its broadloom and modular carpet.[55]

The US NGO Healthy Building Network recommends that the use of virgin PVC is phased out in all carpet manufacturing, and that carpet manufacturers using recycled PVC in their products screen the feedstock to ensure toxic additives, such as phthalates, are not recycled back into the system.[56] Furthermore, a recent study by Anthesis recommended that manufacturers move away from using PVC in carpet backing entirely.[57]

Credit: Will Rose

i – See previous campaigns by Greenpeace and Healthy Building Network.
ii – Health Building Network has recently launched a project looking at this in more detail.

5. CONCLUSIONS AND RECOMMENDATIONS

The objective of this report was to provide a snapshot of the toxic substances present in European carpet, building on earlier research that showed their potential presence.

The testing – implemented by VU Amsterdam in the Netherlands and the Ecology Center and University of Notre Dame in the US – found the presence of a range of hazardous substances in carpet sold by major European carpet producers.

Among the substances detected were phthalates, flame retardants and fluorinated stain repellents, as well as indications of nonylphenol ethoxylates, nonylphenol, BPA and antimicrobials. Several of these have been classified as (or are suspected to be) carcinogens, endocrine disruptors, causes of developmental disorders and harmful to the unborn child. These are worrying findings, as consumers – as well of people handling carpet, like installers and recyclers – are exposed to these substances on a daily basis. The results also lay bare several incoherencies in the EU's regulations, namely:

— **Chemicals that are banned in some products, like children's toys and childcare products, are allowed in other products without proper assessments of exposure and health risk – especially for more vulnerable groups. Babies and young children could often come in close contact with carpets; such legislative loopholes must therefore be closed.**

— **In some cases, products containing recycled materials are subject to less stringent regulation due to exemptions. One example of this is allowing the use of a certain phthalate (DEHP) in recycled PVC, despite it being banned in 2015. From a health perspective, this does not make sense.**

— **Legislation regulates individual chemicals instead of the whole class of chemicals, for which proof of hazardous health impacts already exists. Phthalates and fluorinated stain repellents are notable examples: only a few phthalates and one of the tested fluorinated stain repellents are banned from the EU market, but other phthalates and fluorinated stain repellents with similar chemical made-up (and very probably the same hazardous health impacts) are allowed. A chemicals class approach should be adopted – an approach that is already taken by the SIN List.**

Six of the 15 samples tested in this investigation contained recycled content, either in the backing (for example, recycled PVC or polyurethane) or the face fibre (most commonly ECONYL – recycled nylon.) Of six carpets with recycled content, four were found to contain toxics, including phthalates, flame retardants and indications for isocyanates. These results indicate that recycled content can contain toxics similar to those found in virgin content – but also, that it is possible to have recycled products without detecting toxics.

These findings come amid growing awareness of the health aspects of recycled materials, which must be addressed to realise a truly circular economy.[58] In addition to health concerns, the presence of hazardous substances in recycled materials decreases the recyclate's quality, and thus its value and potential to be recycled indefinitely. They show that manufacturers and policy makers should ensure the highest priority is given to better-designed products – without hazardous substances – to enable safe use, reuse and closed-loop recycling.


Credit: Relevant Films

Recommendations

1. Expand restrictions on hazardous chemicals, and close loopholes on how chemicals are addressed in different product groups

The EU's chemical policy should be strengthened to regulate all hazardous substances across all products, including carpets. The European Commission (EC) should ensure coherent implementation of the precautionary principle to make sure people in the EU – especially vulnerable groups, such as babies and pregnant women – are not exposed to chemicals regulated in one product via another product that is not regulated, or has been exempted.

The EC must deliver on its commitment, under the Seventh Environment Action Programme, to publish a strategy towards a non-toxic environment by 2018, and come forward with sets of clear proposals for implementation as soon as possible.

Greater policy coherence can be achieved in the circular economy, as well as other areas, with the implementation of a detailed health impact assessment (HIA) when preparing policy initiatives. HIA will improve the effectiveness of policy responses and guard against unforeseen consequences, ensuring more future-proof and credible policymaking. At member-state level, the ambition of chemical legislation needs to be increased across the EU. At the moment, differences in legislation create uneven health protection across Europe; for instance, volatile organic compounds (VOCs) flooring legislation is more ambitious in some member states than others.

2. Recycled materials should be subject to the same chemical regulation as virgin materials to protect human health

The EC must come up with measures that properly address the current inconsistencies on how chemicals are regulated in new and recycled products. The current consultation on the interface between chemical, product and waste legislation is an opportunity to address the level of ambition and inconsistencies between policies that affect health and the circular economy.

The EC should ensure the adoption of a chemicals class approach, which the SIN List already uses. To ensure safety and scalability of circularity, systemic changes need to be implemented across REACH, product policy and the waste regulatory framework.

3. Realise non-toxic circular economy in the carpets sector

This and previous reports have shown that carpet manufacturers can ramp up their efforts to move towards a circular economy with the support of progressive policies, such as Extended Producer Responsibility (EPR) systems with ambitious recycling targets and eco-modulated fees to promote the market uptake of circular carpets.

Member states should take the opportunity to realise their circular economy targets by putting in place national EPR schemes for the carpet sector. These policies should set recycling and reuse targets and minimum requirements for non-toxic and circular carpet, and adopt eco-modulated fees to reward manufacturers that go beyond minimum requirements. Such policies will reward healthy ecodesign, while at the same time covering the costs of collection, reuse and recycling. A mandatory information exchange system – including information on toxicity and circular economy aspects, such as a product passport system – is essential for the shift to a circular economy.

4. Manufacturers must immediately phase out toxic and non-recyclable carpets

Manufacturers can take immediate measures to ensure their products are designed for a healthy and circular economy. It is recommended that they design products for durability, reliability and recyclability – and without the chemicals identified in this and the Anthesis reports.[59] Some of the carpets tested for this report (see Box 3) seem to confirm that such products are already on the market.

In addition, it is recommended that manufacturers make all information on materials and chemicals publicly available in the form of a product passport that covers all this information in a consistent, transparent and accessible way.

APPENDIX:

Common carpet certifications

GUT (Gemeinschaft Umweltfreundlicher Teppichboden)

Founded by leading European carpet manufacturers in 1990, GUT is the only certification meant solely for carpets. A large proportion of carpets sold in the EU are certified under GUT. It has a fairly limited scope for regulating chemicals; just 13 of 59 identified in the Anthesis report are banned or limited by GUT.[60]

Blue Angel

Internationally used ecolabel, administered by the German federal government, covering materials used during manufacture as well as use and disposal. Has an extensive scope for regulating chemicals (51 of 59 chemicals identified in the Anthesis report are banned or limited under Blue Angel).

Nordic Swan

Voluntary ecolabelling system that covers manufacture, use and disposal of floor coverings, including carpet. Applies to Scandinavian countries: Denmark, Finland, Iceland, Norway and Sweden. Nordic Swan bans or limits 49 of 59 chemicals identified in the Anthesis report. It also bans the use of PVC.

Cradle-2-Cradle (C2C)

Multi-attribute, continuous improvement methodology that evaluates a company's products, systems and operations. Acknowledged internationally, the certification is awarded at five levels (Basic, Bronze, Silver, Gold and Platinum) and is administered by the NGO Cradle to Cradle Products Innovation Institute. Of the 59 chemicals identified in Anthesis report, 26 are banned or limited under Cradle to Cradle.

CRI Green Label Plus

Industry label from the US Carpet and Rug Institute (CRI). Launched in 1992, the CRI Green Label focuses on the emission of VOCs, and is used internationally.

BREEAM (Building Research Establishment Environmental Assessment Method)

International scheme that provides certification relating to the sustainability performance of individual buildings, communities and infrastructure projects. Assessment/certification can take place at a number of stages, from design and construction to operation and refurbishment.

Credit: Will Rose

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