TESTING CARPET FOR TOXICS

Chemicals affecting human health and hindering the circular economy

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ABOUT THIS RESEARCH

This report is based on research by the Vrije Universiteit Amsterdam (the Netherlands), the Ecology Center (United States) and the University of Notre Dame (United States). The organizations and 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, Ph.D., performs research on emerging chemicals and fast-screening methods.

— Mrs. Ike van der Veen has worked for years on the analysis of per- and polyfluorinated compounds.

Ecology Center

The Ecology Center is a Michigan-based non-profit environmental organization 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 recognized 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: Les Stone

EXECUTIVE SUMMARY

About this report

The objective of this investigation was to provide a snapshot of the toxic substances present in carpets sold by some of the largest carpet manufacturers in the United States (US). Products from each company were tested. This report summarizes the findings and of these tests and compares them to the companies' marketing claims, as well as to regulatory requirements and certification standards.

The need to design for recycling

The US is the largest market in the world for carpet and home to some of the largest carpet producers, resulting in 11 billion ft² of carpet sold per year. Approximately 3.5% of all waste disposed in US landfills is carpet discard—equivalent to 2 million US tons. Less than 5% of carpet discard is recycled, and less than 1% is recycled in a closed loop (i.e., turned back into carpet). The rest is downcycled into less valuable products.[1]

While the European Union (EU) announced ambitious circular economy goals in 2018 that will apply to all its Member States, the US does not have a federal recycling mandate, and only half of US states have any mandatory recycling laws. Most state-based programs that focus on diverting waste from landfill are increasingly looking to remove construction and demolition debris, including carpet, from landfill. In furtherance of that goal, in 2010, California became the first constituency in the world to adopt a law placing responsibility on carpet manufacturers for recycling carpets. Updated in 2017, the law requires that 24% of carpets sold in the state be recycled by 2020.

One of the main obstacles to achieving closed-loop carpet recycling is that these products were not designed with reuse and recycling in mind. Among the design flaws is the fact that carpets often contain so many toxic chemicals that the recyclate becomes too contaminated to be used in new products.

Another challenge in enabling closed-loop cycles for less toxic carpet is that it is hard to source clean recycled feedstocks. The carpet industry has contributed to this problem by operating for decades under a veil of secrecy about the chemicals and materials used in manufacturing. Regulatory programs that lack teeth, combined with certification programs that fail to consider the most typical chemicals of concern,[i] have enabled the industry to use over 40 "chemicals of concern"– chemicals known to cause or suspected of causing cancer, endocrine disruption, and a variety of other negative health effects.[2] This lack of transparency also makes it challenging for consumers to know whether manufacturers' myriad health and environmental claims are true.

Methodology

For this investigation, samples were selected from six of the largest US carpet manufacturers: Engineered Floors (including subsidiary J+J Flooring Group), Interface, Milliken, Mohawk, Shaw, and Tarkett (including subsidiary Tandus Centiva). Two samples were selected from each manufacturer (12 in total) – one representing the manufacturer's best-selling product, and the other representing its most "environmentally friendly" product (according to the manufacturer's claims). The carpets were tested for the presence of Bisphenol A; flame retardants; fluorinated stain repellents (Per- or polyfluoroalkyl substances – PFASs); isocyanates; nonylphenol; phthalates; and polycyclic aromatic hydrocarbons (PAHs).[ii] In addition, there was general testing for total fluorine and heavy metals.

Investigators at VU Amsterdam conducted a rapid screening using ambient mass spectrometry (MS) to screen for the presence or absence of these compounds above a certain level. Carpets that tested positive on certain compounds were further analyzed, via a target analysis method, to verify the identity of the compounds. The Ecology Center in Michigan used a High Definition X-Ray Fluorescence (HD XRF) spectrometer to quantify metals and non-metal elements, including bromine, chlorine, phosphorus, and sulfur, in all carpet backing samples. Dr Graham Peaslee at the University of Notre Dame used Particle Induced Gamma-ray Emission (PIGE) spectroscopy to analyze total fluorine.

i –See Appendix for an overview of common carpet-certification schemes.
ii – Previous research has found that these substances may be present in carpet.

Key findings

The investigation found of a number of chemicals, including nonylphenol, PFASs, and phthalates. At least one toxic chemical was found in most carpets tested; many products included two or more.

Hazardous compounds, including endocrine disruptors, carcinogens, and reproductive toxicants, were found or potentially identified in all of the carpets analyzed. In every instance, carpets with recycled content tested positive for one or more of the chemical contaminants. Despite this, almost all of these carpets are advertised as complying with numerous environmental certifications. These disturbing results indicate not only potential health risks but also a lack of transparency and robustness in carpet certification—and, by extension, the carpet industry itself. Moreover, the presence of problematic substances stands in the way of realizing a circular economy.

Per- or polyfluoroalkyl substances (PFASs) or the presence of total fluorine were detected in six of the 12 carpets tested. PFASs are a large class of chemicals. These substances have attracted attention in recent years due to their persistence in the environment and suspected (and, in some cases, confirmed) health impacts. Perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS) are suspected carcinogens, toxic to reproduction, and may cause developmental disorders. Perfluoro-n-hexanoic acid (PFHxA), perfluoro-n-butanoic acid (PFBA) and perfluorobutane sulfonate (PFBS) are potential endocrine disruptors. PFHxA and perfluoro-n-heptanoic acid (PFHpA) are suspected of harming developing fetuses. In a number of carpets, more than one PFAS was detected.

Phthalates—Bis(2-ethylhexyl) phthalate (DEHP), Di-n-octyl phthalate (DNOP), and Diisobutyl phthalate (DIBP)—were found in five carpets. DEHP and DIBP are banned in US children's toys and childcare articles at concentrations above 1,000 parts per million (ppm) via the Consumer Product Safety Improvement Act of 2008.[3] [i] Although this regulation does not apply to carpet, it indicates the potential level of health risk to babies and small children from exposure to this substance, to which they might be exposed by spending time on carpeting. DNOP, found in two carpets (including at a 20% level in a carpet sold by J+J Flooring), is a suspected endocrine disruptor. DIBP, found at low levels in two of the carpets tested, is a suspected endocrine disruptor and developmental toxicant.

Conclusions and recommendations

The report concludes that the carpet industry must change and become part of the solution for a healthy circular economy. Similar testing of carpet products sold by major EU manufacturers detected no toxic substances in 3 out of 15 carpets, including 2 produced with recycled content, indicating that carpets can be made in a better way.

This report concludes with the following policy recommendations:

- **Hazardous chemicals need to be regulated for use in carpets and other consumer products at a federal level. The most progressive US states can start this process by taking the lead with ambitious chemical legislation.**

- **Mandatory Extended Producer Responsibility (EPR) bills (similar to the one in California) should be put in place to realize a circular economy in the carpet sector. These should set minimum requirements for non-toxic and circular carpet design and eco-modulated fees to encourage manufacturers to go beyond these minimum requirements. California legis lators should also address toxicity in the implementation of their legislation.**

- **Federal and/or state laws should put in place a Right to Know Bill that mandates disclosure of all carpet ingredients and additives.**

Although policies would definitely help to establish a level playing field, carpet manufacturers must take the lead. We therefore conclude by recommending that manufacturers should:

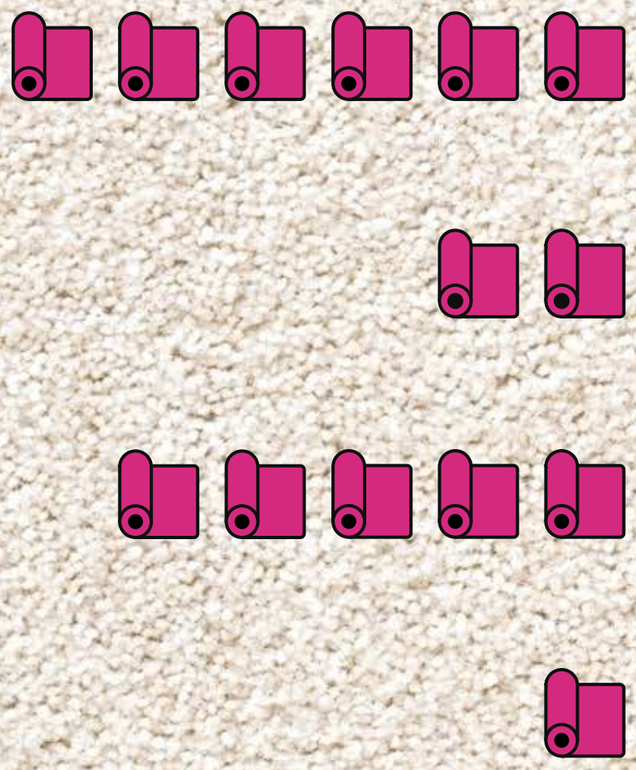
- **Phase out any substances of concern from their products; and**

- **Take immediate measures to ensure their products are designed for a healthy and circular economy (toxic-free, durable, reusable, and recyclable).**

- **Make all information on materials and chemicals in their products publicly available.**

i - Please see Appendix for an explanation of the Consumer Product Safety Improvement Act (2008).

Toxic chemical detected in carpets and their potential health impacts



Fluorinated stain repellants (PFAS)

Coal Fly Ash* (mercury, lead, arsenic)

Phthalate Plasticizers

Nonylphenol

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.

** Coal Fly Ash possibly present due to high levels of iron and lead found in these carpets*

Health hazards:

- Developmental Disorders
- Endocrine Disruptor
- Asthma / Respiratory irritant
- Reproductive Disorders
- Carcinogen
- Neurological Disorders

1. INTRODUCTION

1.1. Background to the report

This report presents the findings from an investigation into the presence of toxic chemicals in carpets sold in the United States (US).

Previous research by the Healthy Building Network (HBN) has identified 44 toxic substances frequently used in US carpets, including endocrine disruptors, carcinogens, and mutagens.[4] It has shown how these can affect consumers' and workers' health, as well as posing obstacles that prevent the industry from moving toward 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. These toxic substances are insufficiently regulated, and certification schemes fail to cover them adequately, leaving consumers and workers unknowingly exposed to toxic chemicals in carpets.

Following up on previous research, the aim of this investigation was to test for toxic substances present in specific carpets sold by the largest global carpet manufacturers on the US market. This report summarizes the findings, giving a snapshot of toxic substances found in US carpets and comparing them to companies' commitments, as well as to legislation and certification standards. It also presents a comparison between carpets sold in the US and those sold in the EU.[5]

Three independent research centers undertook the testing and analytical chemistry informing this report: the Vrije Universiteit Amsterdam (VU Amsterdam) (the Netherlands), the Ecology Center (Michigan, US), and Notre Dame University (Indiana, US).

1.2. Background to the carpet industry

As the largest market in the world for carpet, the US is home to some of the largest carpet producers, including Shaw, Mohawk, and Interface. Carpet holds a 60% share of the US flooring market, with 11 billion ft² sold per year. Approximately 3.5% of all waste disposed in US landfills is carpet discard—equivalent to 2 million US tons per year. It is estimated that 89% of all carpet waste is discarded in landfill in the US; 6% is incinerated, and less that 5% is recycled.[6] Of that 5%, only 20% is recycled in a closed loop (i.e., turned back into carpet)—the rest is downcycled into less valuable products. That means that just 1% of carpet discards are recycled back into carpet each year.[7]

In recent years, there has been growing advocacy for the use of Extended Producer Responsibility (EPR) schemes to tackle industrial waste, including carpet. Most state-based programs that focus on diverting waste from landfill are increasingly looking to remove construction and demolition debris, including carpet, from landfill. In furtherance of that goal, in 2010, California passed the world's first law that places responsibility on carpet manufacturers for recycling carpets.[8] Updated in 2017 (AB 1158), the law requires that 24% of post-consumer carpet in the state be recycled by 2020. However, under the overseeing body (the industry-led Carpet America Recovery Effort), recycling levels have stagnated in recent years. Furthermore, the California law does not address the issue of toxicity—a significant oversight, given that non-toxicity is a prerequisite for a healthy circular economy model (see Box 1).

Credit: Les Stone

2. METHODOLOGY

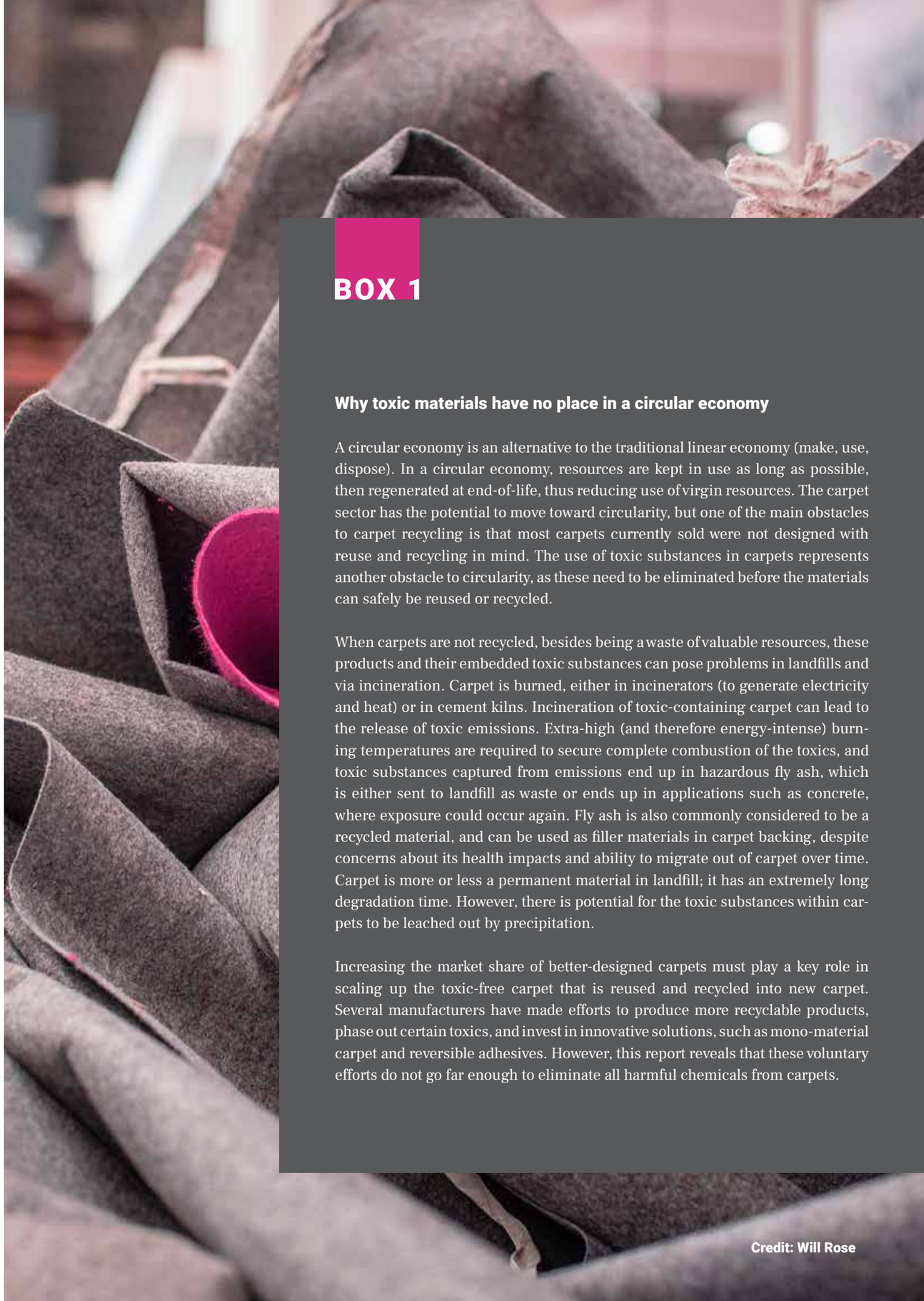
2.1. Sample collection

For this investigation, samples were selected from six of the largest US carpet manufacturers: Engineered Floors (including subsidiary J+J Flooring Group), Interface, Milliken, Mohawk, Shaw, and Tarkett (including subsidiary Tandus Centiva). For each of these manufacturers, two carpets were procured and tested. Where possible, the product marketed as the most "environmentally friendly" or "ecological" and the most popular carpet were selected.[i] This was to obtain different samples from each manufacturer and to include carpet 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 least-expensive product was chosen. The HBN supported the carpet-sample selection using their libraries of carpet information, including the Pharos building product database. In total, 12 US carpet samples were tested.

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 fiber from the backing and kept the backing for metal and non-metal element testing, while the face fiber was sent to the University of Notre Dame (US) for total fluorine testing.

i – These two criteria are not mutually exclusive; as such, some carpets selected represent both a popular and an "eco" choice.



BOX 1

Why toxic materials have no place in a circular economy

A circular economy is an alternative to the traditional linear economy (make, use, dispose). In a circular economy, resources are kept in use as long as possible, then regenerated at end-of-life, thus reducing use of virgin resources. The carpet sector has the potential to move toward 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 burned, 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. Fly ash is also commonly considered to be a recycled material, and can be used as filler materials in carpet backing, despite concerns about its health impacts and ability to migrate out of carpet over time. 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, phase out certain toxics, and invest 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 carpets.

Credit: Will Rose

Credit: Will Rose

2.2. Analysis

The Ecology Center reviewed the chemicals from previous studies by the HBN[9] and Anthesis Consulting[10] that identified toxic chemicals thought to be present in carpets. 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[i] and heavy metals.

2.2.1. VU Amsterdam: Rapid screening

Under the leadership of Professor Jacob de Boer, Head of the Environmental and Health research group, the VU Amsterdam screened the selected carpets for the presence of a range of compounds: antimicrobials; Bisphenol A; flame retardants; isocyanates; nonylphenol; PAHs; PFASs; and phthalates. This was done with a rapid screening method to screen for 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 Environmental and Health research group developed a fast-screening ambient mass spectrometry (MS) method.[ii] This method has been applied for brominated and organophosphorus flame retardants and plasticizers and related chemicals (intermediates, fillers, etc.) in electronics,[11,12] and can identify which compound is present in plastics or carpets.

The 12 carpet samples were taken apart into separate layers. For most carpets, two layers were tested (face fiber and backing); in three cases, there was a layer in between the face fiber and backing, and all three layers were tested. For the analyses of the fiber layer, fibers 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 small parts of the material entering the glass tube, which were also analyzed by Direct Probe TOF-MS.

All samples were analyzed with positive polarity as well as 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 needed further verification with a target analysis to verify the identity of the compound.

i – The total fluorine testing was undertaken in additional to the PFASs screening, which only screened for a few specific PFASs, as there are many on the market.
ii – 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).

2.2.2. 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 sulfur, in all carpet backing samples. The methods and quality assurance practices have been previously described by the Ecology Center.[13] The HD XRF analyzer 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. 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 analyzed) of approximately 1mm. Three measurements, in unique locations, were sampled on each carpet backing. These results were averaged.

Most backings were analyzed 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 minimize signal from the substrate underlying the sample.

For all metals and non-metal elements of interest (except for chlorine, phosphorus, and sulfur), 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.

2.2.3. University of Notre Dame: Total fluorine screening

Total fluorine was analyzed by Particle Induced Gamma-ray Emission (PIGE) spectroscopy. The PIGE method utilized applied a commonly used ion-beam analysis technique, which was adapted for the detection of total fluorine associated with PFASs on papers and textiles. This method identifies fluorine, which is an element. It does not identify specific chemical substances (PFASs); however, the entire class of organofluorine chemicals used as stain repellents on carpets has 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.[14] Typical PFASs found on carpets include perfluorooctanesulfonic acid (PFOS), pentafluoropropionic anhydride (PFPA), perfluorooctanoic acid (PFOA), and a variety of fluorotelomer alcohols.[15]

2.2.4. VU Amsterdam: Target analysis

VU Amsterdam then subjected the positive samples from the screening study to further testing to verify and quantify 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).[16] Quantification was performed with external calibration of PFASs, phthalates, and 4-nonylphenol.

Credit: Relevant Films

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.

3. KEY RESULTS

3.1. Overview

This chapter 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 US federal- and state-level regulations, company certifications, and companies' own commitments and policies relating to toxic substances.[i] Product-related information, such as specifications and certifications, was taken from publicly available online resources.

The investigation found a number of chemicals including nonylphenol, PFAS, and phthalates. The uses, potential health impacts, and regulations and legislation related to these chemicals are explored in Table 1.

It is important to note that people are exposed to multiple chemicals on a daily basis 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.[17] As such, the levels of chemicals of concern detected in the carpet samples contribute to overall exposures that are of concern. This study did not investigate the health risk of chemicals in the carpets, and this report refers to findings from other studies and regulations when discussing health risks.

For some chemical groups, like phthalates, regulatory limits have been established that are at least partly based on preventing potentially harmful exposure levels. For some phthalates, this level is 0.1% (1,000ppm) for toys and childcare products in the US. However, all uses of phthalates in products, including those <1,000ppm, contribute to the total exposure risk for an individual. Many phthalates are hormone-disrupting chemicals, which, contrary to common toxicology assumptions, may cause health concerns at or below existing safety thresholds.

i – See Appendix for an overview of key regulation and carpet-certification schemes.

Credit: Relevant Films

BOX 2

Restrictions on toxic substances in drinking water

In addition to direct exposure to carpets, there are other ways in which these chemicals make their way into our environments. There have been well-documented incidents in which carpet-manufacturing plants in the US have polluted downstream drinking water with chemicals such as stain repellents. In May 2017, the town of Centre, Alabama, sued many of the world's largest carpet companies for contaminating the town's water with PFAS.[18] When landfilling carpet and during certain carpet recycling processes, there are risks of chemicals leaching, causing risk to human health and contaminating the environment, notably water streams. The federal government has adopted National Primary Drinking Water Regulations and has set Maximum Contaminant Levels, which are enforceable standards, for a range of chemicals including the phthalate DEHP.[19] For other chemicals, such as PFAS, it has set Health Advisory Levels (HALs) intended to protect against non-cancer effects. HALs are informal technical guidance for unregulated drinking-water contaminants to assist federal, state, and local officials.[20]

Several states, such as Minnesota[21] and New Jersey[22], have introduced further drinking water and groundwater standards to protect the environment and health of citizens. The ground- and drinking-water limits cannot be directly compared to the findings, but they do provide a relevant framework to understand the health and environmental risks the use of these chemicals brings.

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

Chemicals	Use	Health impacts	Regulated?
Phthalates The following phthalates were detected: — DEHP — DNOP — DIBP	Commonly used to add flexibility to PVC carpet backing.	A number of phthalates are classified as reprotoxic. Many are endocrine disruptors and have been linked to developmental disorders. DEHP is listed as a carcinogen, reproductive toxicant, and developmental toxicant under California Proposition 65. DNOP is a suspected endocrine disruptor, developmental toxicant, and asthmagen. DIBP is a suspected endocrine disruptor and developmental toxicant.	DEHP is listed as a carcinogen, mutagen, or reproductive (CMR) toxicant on the International Chemical Secretariat SIN List. It is included in California Prop 65. The use of DEHP and DIBP is banned in US children's toys and childcare articles at concentrations above 1000ppm via the Consumer Product Safety Improvement Act of 2008. DNOP is on the SIN List. DEHP, DNOP, and DIBP are Environmental Protection Agency (EPA) Chemicals of Concern with published action plans. DEHP is a Hazardous Air Pollutant subject to the Clean Air Act. California, Vermont, and Washington prohibit the manufacture, sale, or distribution of children's products containing DEHP or DNOP in concentrations above 1000ppm. In Washington State, DEHP and DNOP are on the Reporting List of Chemicals of High Concern to Children (RLCHCC). The Vermont Department of Health also lists DNOP and DEHP as a Chemical of High Concern to Children.
Nonylphenol The following nonylphenol was detected: — 4-Nonylphenol (branched)	Possibly used as a carpet adhesive, or as an antioxidant in plastic and rubber materials.	4-Nonylphenol (branched) is an endocrine disruptor, developmental and reproductive toxicant, eye and skin irritant, and aquatic toxicant (acute and chronic).	4-Nonylphenol (branched) is on the SIN List. In Washington State, 4-Nonylphenol (branched) is on the RLCHCC list. 4-Nonylphenol (branched) is on the Department of Toxic Substances Control (DTSC) list in California. A Significant New Use Rule (SNUR) was established for 4-Nonylphenol (branched) in 2014. 4-Nonylphenol (branched) is subject to the Toxic Substances Control Act (TSCA) sections 8(b) and 12(b).

Chemicals	Use	Health impacts	Regulated?
Fluorine In this investigation, the following PFASs were detected: — PFOA — PFOS — PFBA — PFBS — PFHpA — PFHxA — PFPeA — 6:2FTS Total fluorine levels were also tested.	Used as a stain or water repellent.	PFASs are known to be persistent organic pollutants. PFOA and PFOS are listed as developmental toxicants under California Prop 65. Both are suspected carcinogens, toxic to reproduction, and may cause developmental disorders. PFHxA, PFBA, and PFBS are potential endocrine disruptors. PFHxA and PFHpA are suspected of harming developing fetuses. The International Agency for Research on Cancer has identified PFOA as a carcinogen.	Many PFAS are either on the SIN or SINimilary lists. The US TSCA has a SNUR proposed for PFOA and PFOS. PFOA and PFOS are listed on CA Proposition 65. PFHxA is on the California DTSC list. PFHpA and PFBA are on Minnesota's Toxic Free Kids Act "chemicals of high concern" list PFHpA, PFO, and PFOA are EPA Chemicals of Concern with an Action Plan published. 6:2FTS is on the California DTSC list. Total fluorine, as a class of organofluorine chemicals, is not currently regulated.

Notes: Unless otherwise stated, the information presented in this table is taken from HBN's Data Commons website and the International Chemical Secretariat Substitute It Now! (SIN) List website, as well as previous reports by the HBN and Anthesis Consulting Group.[23]

We also tested for the presence of metals and non-metal elements—including antimony, bromine, lead, iron, phosphorus, and chlorine. These tests analyzed 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 but not further interpreted—with the exception of iron, lead, and sulfur results in two carpets due to their potential link to fly ash (commonly used in US carpets). 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.

BOX 3

Better, healthier carpets are possible—but not in the US?

In addition to US samples, carpet products sold by the main EU manufacturers were tested. These findings were published by European NGOs in October 2018.[24]

A few striking differences came to light when comparing the EU and US findings. While most US samples had some substances of concern, no indicators of toxic chemicals were detected in three of 15 European carpets. One of the EU carpets was produced by Tarkett and one by Interface, both of which are also selling on the US market. 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), these examples hopefully indicate that carpet can be designed in a better, healthier way. It is also encouraging to see that these carpets contain recycled content, demonstrating the way forward for a toxic-free, circular economy.

Another notable difference seems to be the use of PFASs, usually as stain repellents, in US carpet. PFASs were detected in only 1 EU sample, whereas they were found in 6 of the 12 US samples. While further research is needed to test a wider range of carpets, these results seem to suggest that companies have more robust screening systems for the carpets they sell on the EU market.

Credit: Will Rose

3.2. Findings by company

3.2.1. Engineered Floors (J+J Flooring)

Engineered Floors LLC is a privately held carpet producer based in Dalton, Georgia. J+J Flooring is a commercial modular (tile) and broadloom flooring manufacturer that became a division of Engineered Floors in 2016. This investigation found no information relating to sustainability and chemical management on the Engineered Floors website. The J+J Flooring website has a section on sustainability, in which it summarizes its environmental policy: "continual improvement in its environmental objectives, reduction of pollution, abiding by all relevant environmental regulations and requirements."[25]

This investigation could not locate chemical policy information in the sustainability section of the J+J Flooring website. J+J Flooring holds a "Zero Waste to Landfill" certification by GreenCircle Certified, although this applies to direct waste only—not the eventual landfill of its products. Incineration is also included as an alternative to landfill. In its 2017 Sustainability report, J+J Flooring states that its products have the following certifications: Carpet and Rug Institute (CRI) Green Label Plus, Floor Score, and NSF Platinum Certification.[26] Some products have a Red List Free (RLF) Declare label from the International Living Future Institute and/or an NSF/ANSI-140 Sustainable Assessment for Carpet certification.

The Engineered Floors products chosen for testing were the TrafficMASTER Thoroughbred II (the largest line by Engineered Flooring found on the Home Depot website) and Curtain Call by J+J Flooring (marketed as an "eco" product).

3.2.1.1. TrafficMASTER Thoroughbred II

The TrafficMASTER Thoroughbred II is a residential tufted (broadloom) carpet with a BCF polyester face fiber and polypropylene backing. It has CRI Green Label Plus certification for indoor air quality, and is advertised as having hypoallergenic and stain-resistant features (SoilShield technology). It is not advertised as having any recycled content.[27]

Although the screening method detected indications of PFASs, these were not confirmed by the target analysis. Further research is recommended.

3.2.1.2. Curtain Call, Carrie 546

Curtain Call is a modular carpet with a Nylon 6 fiber (Encore® BCF with recycled content)[28] and Nexus® modular backing—a PVC backing which contains a fly-ash filler.[29] Curtain Call is NSF 140 Gold Certified and has a CRI Green Label Plus certification. The backing contains 43.31% pre-consumer recycled content, which presumably is fly ash.[30]

The following substances were found:

Di-n-octyl phthalate (DNOP)	350ppm (fiber) 200,000ppm (backing)
Chlorine	471,158ppm (backing)

The level of chlorine found is an indicator of the PVC used in this product. The presence of the phthalate DNOP demonstrates the importance of screening recycled materials for toxicity, particularly in relation to PVC. In addition to the carpet backing, this investigation also found DNOP in the face fiber, which may indicate that the phthalates could migrate from the carpet during the use phase. DNOP is suspected to be an endocrine disruptor, a developmental toxicant, and an asthmagen.

California, Vermont, and Washington State prohibit the manufacture, sale, or distribution of children's products containing DNOP in concentrations above 1000ppm.[31] In Washington, DNOP is on the Reporting list of chemicals of high concern to children (RLCHCC). The Vermont Department of Health also lists DNOP as a chemical of high concern to children.

The use of DNOP is not prohibited under the CRI Green Label Plus. Material health is minimally addressed in NF 140 certification; eight long-chain PFASs are banned under the certification, but phthalates do not appear to be addressed.

3.2.2. Interface

Interface is the world's largest manufacturer of commercial carpet tile. Its US headquarters are based in Georgia. In 2017, the company had net sales of US $996.5 million.[32] Interface has a sustainability program called Mission Zero,™ which it defines as its "promise to eliminate any negative impact [the] company has on the environment by 2020."[33] This program includes goals on resource efficiency, renewable energy, and reducing waste, as well as "closing the loop" on carpet design.

On its US website, Interface outlines its new mission (Climate Take Back™), which aims for zero negative impact on the environment—including redesigning its products, zero pollutants, zero waste, closing the loop, and creating a circular economy. The company states that 58% of materials in the products it sells are from recycled or biobased sources.[34] Company policies relating to individual toxic substances could not be found on the US Interface website in this investigation. A 2012 article by Interface Global stated the company's intention to phase out all virgin PVC by 2020.[35]

The Interface products chosen for testing were Super Flor (a popular residential carpet widely used in affordable housing projects[36]) and On Line (which represents both an "eco" choice and a popular Interface product).

3.2.2.1. Super Flor 41Z, Pacific Sunset

Super Flor is a tile carpet with face fiber composed of 82.5% nylon and 17.5% polyester. It has a Graphlar backing made from bitumen. It contains 42% post-industrial/pre-consumer recycled content (limestone and polyester), and the product specification includes a Declare label that states the product is compliant with the Living Building Challenge (LBC).[37]

The following substances were found:

4-nonylphenol (branched)	31,000ppm (backing)
Diisobutyl phthalate (DIBP)	230ppm (backing)
Sulfur	19,749ppm

In Washington State, 4-nonylphenol (branched) is on the RLCHCC list.

The substance is also banned under the International Living Future Institute Red List. The Red List is linked to the LBC, with which this carpet is deemed "compliant." However, somewhat confusingly, carpets listed as "Living Building Challenge compliant" can contain LBC Red List ingredients, for which the International Living Futures Institute has granted an exemption to reflect current market limitations in the industry.

The DTSC list in California includes 4-nonylphenol (branched). A SNUR was established for the substance in 2014, which obligates the EPA to consider risks associated with new uses. It is also subject to TSCA sections 8(b) and 12(b), which require reporting to the EPA on the chemical's potential human health and environmental effects, and require exporters to submit a notification to the EPA.

Low levels of DIBP were detected in the backing. DIBP is an EPA Chemical of Concern with a published Action Plan. Its use is banned in US children's toys and childcare articles at concentrations above 1000ppm via the Consumer Product Safety Improvement Act of 2008.

3.2.2.2. On Line Marigold

On Line is a commercial carpet tile with face fiber made from 100% recycled Nylon 6 and a GlasBac backing made from PVC, including recycled content. Overall, it is made from 72% recycled content. It has a CRI Green Label Plus certification, an Environmental Product Declaration (EPD), and a Sustainable Assessment for Carpet certification.[38]

The following substances were found:

Di-n-octyl phthalate (DNOP)	320ppm (fiber)
Chlorine	198,445ppm (backing)
Iron	28,140ppm (backing)
Lead	12ppm (backing)
Diisobutyl phthalate (DIBP)	210ppm (backing)

The level of chlorine found is an indicator of the PVC used in this product. This investigation found low levels of DNOP present in the face fiber. Potential sources of this phthalate include contamination of post-consumer Nylon 6 feedstock, post-production migration of phthalates from the carpet, or use of phthalates in fiber pigments or spinning oils. Low levels of DIBP were detected in the backing. DIBP is an EPA Chemical of Concern with a published Action Plan. Its use is banned in US children's toys and childcare articles at concentrations above 1,000ppm via the Consumer Product Safety Improvement Act of 2008.

California, Vermont, and Washington prohibit the manufacture, sale, or distribution of children's products containing DEHP or DNOP in concentrations above 1,000ppm.[39] In Washington State, DNOP is on the RLCHCC list. DIBP is an EPA Chemical of Concern with a published Action Plan.

The iron and lead could be indicators of fly ash as a possible ingredient in the secondary backing. Fly ash is widely used as a filler in carpet tile in the US, and is commonly considered to be a recycled material. However, there are concerns about the health impacts of fly ash and its ability to migrate out of carpet over time.[40] Toxic substances such as lead, mercury, and arsenic can be found in fly ash. Lead (detected in this sample) is on the California Proposition 65 list as a carcinogen, reproductive toxicant, and developmental toxicant. In 2016, the US FDA issued guidance that the use of lead in cosmetics be restricted to 10ppm.[41]

3.2.3. Milliken

Milliken is a US carpet manufacturer with more than 35 manufacturing sites in Australia, Belgium, China, France, India, the US, and the UK. Headquartered in South Carolina, Milliken predominately sells flooring for commercial use, although it also sells flooring in the residential sector.

On its US website, Milliken states that it uses third-party verification, including Declare®, EPDs, and ISO certificates. While the company does not disclose policies for specific toxics, its sustainability report (which covers global operations) states that it is "committed to understanding 100% of chemical ingredients used in the materials [it selects] for Milliken flooring solutions."[42] The report states that the company will "prioritise chemicals of high concern for elimination and minimize exposure and risk where hazards cannot be prevented." Milliken also claims that its modular carpet collections comply with the LBC Red List imperative.

The US Milliken products chosen for testing were New Slant and a "plush carpet" style sold under the Milliken brand at Menards (a home-improvement store). New Slant was selected as an "eco" choice because it is labeled as LBC RLF. The Menards carpet was the least-expensive Milliken range identified.

Credit: Will Rose

3.2.3.1. Menards, Bianca, Ruby

The Milliken-branded carpet from Menards is a broadloom carpet for residential and light-to-medium commercial use. It has a Premium WearOn® fiber made from Nylon 6, and Synthetic Actionbac backing (likely latex). The product specification states it has been treated with a "soil release treatment" called Milliken Milliguard® and an antimicrobial treatment called Milliguard® AM.[43] This carpet does not appear to have any certifications.

The following substances were found:

Perfluorooctanoic acid (PFOA)	38ppm (fiber)
Perfluoro-n-butanoic acid (PFBA)	110ppm (fiber)
Perfluoro-n-pentanoic acid (PFPeA)	74ppm (fiber)
Perfluoro-n-hexanoic acid (PFHxA)	460ppm (fiber)
Perfluoro-n-heptanoic acid (PFHpA)	44ppm (fiber)
6:2FTS	41ppm (fiber)
Perfluorooctanesulfonic acid (PFOS)	2ppm (fiber)
Total PFASs	**769ppm**
Total fluorine	>25ppm (303cts/uC)

Testing of this carpet revealed a number of different PFASs in its face fiber. While federal US regulations do not restrict PFASs for use in carpet, per- and polyfluoroalkyl substances have attracted attention in recent years due to their persistence in the environment and suspected (and, in some cases, confirmed) health impacts. It is estimated that 95% of people in the US have traces of PFAS in their blood.[44] The regulatory process typically does not consider simultaneous exposure to multiple chemicals, so more research is needed to assess the health impacts of this.

PFOS and PFOA are EPA Chemicals of Concern with published action plans, and a SNUR has been proposed for both substances via the TSCA. PFOS and PFOA are on California's Proposition 65 list as developmental toxicants, and a number of the fluorinated stain repellents found are on the California DTSC list (although this product is not available for sale in California.)

This product is advertised as having an antimicrobial finish. While this investigation did not detect antimicrobials, this is likely due to testing limitations; further research is therefore recommended.

3.2.3.2. New Slant, Pinnacle, 120 Adobe

New Slant is a commercial-use tile carpet composed of Nylon 6 fiber and PVC-free ComfortPlus backing (90% recycled content), and finished with a stain repellent (StainSmart). The product specification states that this carpet has EPD certification, a Declare label (which the company says shows it complies with the LBC Red List imperative), and an NSF certification.[45]

The following substances were found:

Total fluorine	>25ppm (2,202cts/uC)

The presence of total fluorine would suggest that this carpet may contain PFAS, so further research is recommended.

Credit: Will Rose

3.2.4. Mohawk

Mohawk is one of the largest carpet manufacturers in the world. It sells residential and commercial carpet, and its annual revenue is US $9.5 billion.[46] The company is headquartered in Dalton, Georgia, and sells carpet in the US under the brand names Mohawk, Karastan, IVC, PERGO, Quick-Step, Durkan, and Mohawk Group. On its website, Mohawk claims that the company "leads the pack when it comes to eco friendly flooring … [its] approach to sustainability covers every point of a product's life cycle, from raw materials, manufacturing, and distribution to installation methods and end-of-life recycling."[47] Mohawk's Sustainability report 2017 states that one of its product lines is Living Product Challenge certified.[48] There is no detailed information in Mohawk's sustainability report or on its website relating to its chemicals policies.

The Mohawk products chosen for testing were Bigelow (a low-cost and popular Mohawk carpet) and Air.o (an "eco" choice using fully recycled fiber).

3.2.4.1. Bigelow, Mindful

The Bigelow Mindful is a commercial carpet with a face fiber made from EnviroStrand™ (PET), containing "up to 100% recycled content." It has a Weldlok Unitary (SBR) backing, and is advertised as having a finish of Sentry Plus stain repellent. The carpet has CRI Green Label Plus certification and a Declare label that states it is "Red List Free."[49]

The following substances were found:

Perfluoro-n-butanoic acid (PFBA)	22ppm (fiber)
Perfluorobutane sulfonate (PFBS)	160ppm (fiber)
Total PFASs	**182ppm (fiber)**
Total fluorine	>25ppm (1,889cts/uC)

PFBA and PFBS were found in the fiber of this carpet, which could be linked to the advertised stain-repellent finish. PFBA and PFBS are on the LBC Red List.[50] The regulatory process typically does not consider simultaneous exposure to multiple chemicals, so more research is needed to assess the health impacts of this.

3.2.4.2. Air.o New Beginnings with Pad, Nouveau

Air.o is a residential carpet with 100% PET face fiber and backing. It has a CRI Green Label Plus certification.[51] The Mohawk website states that its Air.o carpets are 100% recyclable; it is not clear whether the product contains any recycled content.[52]

The following substances were found:

Perfluoro-n-butanoic acid (PFBA)	71ppm (fiber)
Perfluorobutane sulfonate (PFBS)	27ppm (fiber)
Total PFASs	**98ppm (fiber)**
Total fluorine	>25ppm (1,709cts/uC)
Bromine	135ppm (backing)
Antimony	127ppm (backing)

PFBA and PFBS were found in the fiber of this carpet, indicating a potential stain-repellent finish. PFBA is on Minnesota's Toxic Free Kids Act "chemicals of high concern" list.

The bromine found could indicate the presence of brominated flame retardants, which would need further research to be identified.

Antimony can be used as a catalyst in the production of polyesters. Antimony trioxide is also used in combination with chlorinated and brominated flame retardants to increase fire resistance. The levels detected in this product are consistent with residual antimony from the polyester production.

3.2.5. Shaw

Shaw is a flooring company based in Dalton, Georgia, with an annual revenue of almost US $ 6 billion. It sells commercial and residential carpets under a number of brands, including Anderson Tuftex, COREtec, Patcraft, Philadelphia Commercial, Shaw Contract, Shaw Floors, Shaw Hospitality, Shaw Sports Turf, Southwest Greens, and USFloors. Shaw's chemical-management policies appear to be based on the Cradle to Cradle (C2C) certification program; its website states:

Our products adhere to a rigorous methodology for assessing material health, based on understanding and evaluating the ingredients that go into our products … guided by Cradle to Cradle principles, we design with intention, and a focus on material health, water, renewable energy, and social responsibility.[53]

BOX 4

How self-regulation and voluntary certifications fall short (Green Label Plus, C2C)

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). This is in stark contrast with the CRI Green Label Plus label, which several investigated products held, and which only limits certain (but not all) volatile organic compounds (VOCs). This label does not limit the detected phthalates or PFASs, which are not volatile substances but are nonetheless released from products. Also, at the Basic, Bronze, and even Silver certification levels, the C2C program allows many toxic substances to be present, because 5% of the product (by weight) does not have to be screened. As consumers are rarely experts on what different levels of certification mean, this is potentially misleading.

Credit: Will Rose

The company states its overall sustainability goal as "safe ingredients that can be perpetually recycled."[54] Shaw's 2017 Sustainability report states that 88% of the products it manufactured in 2017 were certified by C2C.[55]

The Shaw products chosen for testing were Diverge modular carpet by Patcraft (as this carpet is approved for procurement by the city of San Francisco as an "eco" choice[i]) and a Philadelphia Commercial carpet (as this was the least-expensive line identified by New York State's real-estate purchasing program).[56]

3.2.5.1. Patcraft Diverge

The Patcraft Diverge modular is a carpet tile with a Nylon 6 face fiber (Solution Q Extreme Nylon 6)[57] and EcoWorx polyolefin backing.[58] It is claimed to have no PFASs and to be "compliant [with SF (San Francisco) Environment regulations] because it's untreated cationic yarn which is inherently stain, water, and oil resistant."[59] It has 38% pre-consumer recycled content (by weight), and claims to be "the industry's first fully recyclable, non-PVC carpet tile backing."[60] It is also claimed that "All EcoWorx® products come with a global Environmental Guarantee, which guarantees that when it reaches the end of its useful life, Shaw will collect and recycle the EcoWorx® into new EcoWorx.®"

According to the product specification, the product has C2C Silver, NSF 140 Gold, and CRI Green Label Plus certifications, and contributes to USGBC LEED.

The following substances were found:

Iron	25,223ppm (backing)
Sulfur	16,077ppm (backing)
Lead	8ppm

This product contained none of the primary chemicals of concern tested for in this project, although the backing layer contained significant levels of iron (2.5%) and sulfur (1.6%), and the carpet also contained lead.

The iron, lead, and sulfur could be indicators of fly ash as a possible ingredient in the secondary backing.[ii] Shaw has told HBN that: "Beginning in late 2016, we decided to make this the across-the-board standard and ceased using fly ash as a filler." As such, it is possible that the sample obtained was produced before 2016 (despite being sold as "new.")[61]

Fly ash is widely used as a filler in carpet tile in the US, and is commonly considered to be a recycled material. However, there are concerns about its health impacts and its ability to migrate

i – With the goals of reducing waste and increasing the adoption of safer alternatives to harmful building products, San Francisco established a new regulation for carpet installed in city-funded projects (such as public schools, libraries, and government buildings) in May 2018. For more information, see: https://www.buildinggreen.com/newsbrief/san-francisco-sets-high-bar-carpet.

ii – The EPD states that fly ash or glass cullet could be used

out of carpet over time.[62] Toxic substances such as lead, mercury, and arsenic can be found in fly ash. Lead (detected in this sample) is on the California Proposition 65 list as a carcinogen, reproductive toxicant, and developmental toxicant. In 2016, the US FDA issued guidance that the use of lead in cosmetics be restricted to 10ppm.[63]

3.2.5.2. Philadelphia Commercial, Power Up

The Philadelphia Commercial Power Up is a broadloom carpet for commercial use. It has a nylon face fiber (100% Solution Q Nylon 6)[64] and a "ClassicBac" backing with SBR latex precoat.[65] There is no extensive product specification available online. It uses Shaw's most common backing and fiber combination. According to its "Eco Scorecard," it has NSF 140 Gold and C2C Silver certifications.[66]

The following substances were found:

Perfluorooctanoic acid (PFOA)	14ppm
Perfluoro-n-butanoic acid (PFBA)	14ppm
Perfluoro-n-pentanoic acid (PFPeA)	14ppm
Perfluoro-n-hexanoic acid (PFHxA)	200ppm
Perfluoro-n-heptanoic acid (PFHpA)	93ppm
Perfluorooctanesulfonic acid (PFOS)	590ppm
Total PFASs	**1,157ppm**
Total fluorine	>25ppm (7,540cts/uC)

US regulations do not restrict these PFASs for use in carpet. However, PFOS is an EPA Chemical of Concern with a published Action Plan, and a SNUR has been proposed via the TSCA. PFOS is on the California Proposition 65 list as a development toxicant, and all the fluorinated stain repellents found are on the California DTSC list. PFOS and PFOA are on Washington State's RLCHCC.

PFOS and PFOA are on the C2C banned lists, which means they are not allowed to be present at over 1,000ppm in any C2C-certified product. In addition, PFOS and PFOA are suspected carcinogens according to EU CLP, and both are on the California Proposition 65 list. As suspected CMRs, neither should be allowed above 100ppm in C2C Silver-certified products. The caveat is that only 95% of the product needs to be assessed at Silver level.

The regulatory process typically does not consider simultaneous exposure to multiple chemicals, so more research is needed to assess the health impacts of this.

3.2.6. Tarkett (Tandus Centiva)

Tarkett is a global flooring and sports surfaces company based in France with a global revenue of €2.7 billion. The company sells carpet on the US market via its subsidiary, Tandus Centiva, which has its headquarters in Dalton, Georgia. The joint US sales of Tandus Centiva and FieldTurf (a US artificial turf-sports field brand, also owned by Tarkett) were US $550 million in 2014.[67] Tandus Centiva is the fourth-largest carpet-tile producer in the US.[68]

Tarkett and Tandus Centiva have a sustainability strategy inspired by C2C principles. Its key principles are resource stewardship, people-friendly space, reuse, and good materials. According to Tandus Centiva, "good materials" means: "Abundant, rapidly renewable, recycled, and recyclable, respecting people, health, and the environment."[69]

Tarkett claims to be committed to the transition from a linear to a circular economy model; Tandus Centiva states: "Closed Loop Circular Design is our way of best applying the Cradle to Cradle® principles to support the development of the Circular Economy."[70]

C2C has an extensive approach to deal with chemicals. It has lists of banned chemicals, which include certain phthalates, stain repellents, and flame retardants. While this list is a good start (and goes beyond other voluntary certifications), it does not take a class-based approach to chemical selection. For instance, not all phthalates are included on the banned list at Basic and Bronze levels, despite all having similar properties and health impacts. At the Silver level, CMR substances (like phthalates) are further restricted. Yet a loophole seems to exist even there, as this applies to 95% of the product materials—and therefore does not apply to 5%. Another issue is that substances on the banned list are still allowed, up to 1,000ppm, at Basic and Bronze levels —so they are not really banned from products.

Tarkett has announced that its vinyl-production sites in North America, Europe, and China use non-phthalate plasticizer technology (with the exception of recycled content in some products).[71] Tarkett states it is committed to substituting all its phthalate plasticizers in all products for alternative forms of plasticizer by 2020.[72]

Tarkett has also announced that, on a global level, carpet production in North America and Europe does not use fluorine, having replaced it with safer alternatives. In North America, the company has stated that it uses only fluorine-free soil treatment (called Eco-Ensure) for Tandus Centiva carpets, woven, and tufted rugs.[73]

Tandus Centiva states that, as well as C2C certification, it holds CRI Green Label Plus, MAS Green Certified, NSF/ANSI 140, NSF/ANSI 332, Recycled Content, Carbonfree Certification, and FloorScore certifications.[74]

Credit: Les Stone

Tarkett has a ReStart® program that offers reclamation and recycling of samples, products, and installation waste. The company has a closed-loop reclamation facility in Dalton, Georgia, and recycles an average of 5,000 US tons of flooring each year.

3.2.6.1. Tandus Centiva Construct

This is a carpet tile for commercial use with a Nylon 6 face fiber, a polyester primary backing, and ER3 secondary backing made of PVC and "pre-consumer calcium alumina glass spheres" (fly ash). The EPD of the ER3 backing states it includes 45–66% overall recycled content and a minimum of 20% post-consumer content.[75] It has a number of certifications, including CRI Green Label Plus and NSF/ANSI 140 Platinum. The backing system is claimed to be 100% closed-loop recyclable via the ReStart® program and to not antimicrobials.

The Tandus Centiva Construct was selected because it was the least-expensive Tarkett carpet identified by New York State's real-estate purchasing program.

The following substances were found:

Perfluoro-n-butanoic acid (PFBA)	49ppm
Perfluoro-n-pentanoic acid (PFPeA)	58ppm
Perfluoro-n-hexanoic acid (PFHxA)	91ppm
Perfluoro-n-heptanoic acid (PFHpA)	84ppm
6:2FTS	49ppm
Perfluorooctanesulfonic acid (PFOS)	13ppm
Total PFASs	**344ppm**
Total fluorine	>25ppm (11,642cts/uC)
Bromine	182ppm

US regulations do no restrict these PFASs for use in carpet. However, PFOS is an EPA Chemical of Concern with a published Action Plan; a SNUR has been proposed for the chemical via the TSCA; and it is on California's Proposition 65 list as a development toxicant.

The bromine found could be an indicator of brominated flame retardants, which would need further research to be identified. The low level indicates an unintentional use; for instance, as part of recycled content.

3.2.6.2. Tandus Centiva Accentuate

The Tarkett Accentuate is a carpet tile with Dynex Nylon 6 face fiber and Ethos Modular Polyvinyl butyral (PVB) backing.[76] It was selected as Tarkett's ecological product for this investigation because it uses post-consumer recycled PVB.

PVB is a plastic laminate recovered from automobile windshield glass. Tarkett obtains PVB from the Dlubak Glass recycling operation in Upper Sandusky, Ohio.[77] The US Occupational Health and Safety Administration has found that this plant has repeatedly violated safety requirements.[78]

The Dynex face fiber is claimed to have permanent stain resistance because of the cationic properties inherent to its structure.[79] The Ethos Modular backing has Omnicoat Technology, which is "a proprietary coating that creates a chemical barrier that works no matter what type of adverse flooring substrate problems rear their ugly heads."[80] The backing is made from recycled PVB, which is a waste film from post-consumer windshields and safety glass.[81] The backing has 26–51% recycled content, 26% of which is from post-consumer sources.

According to its EPD, the Ethos Modular product line has C2C Silver[i] and NSF 140 Platinum rating certifications. The Accentuate product brochure, however, does not mention these certifications, which might be confusing to the consumer.

The Ethos product brochure mentions that "all vinyl products, when recovered, are 100% recyclable in Tandus Centiva's closed-loop recycling process."

The following substances were found:

Bis(2-ethylhexyl) phthalate (DEHP)	250ppm
Bromine	223ppm
Chlorine	151ppm
Lead	12ppm (backing)
Antimony	79ppm

DEHP is banned in US children's toys and childcare articles at concentrations above 1000ppm via the Consumer Product Safety Improvement Act of 2008.[82] This regulation does not apply to carpet, but it indicates the potential level of health risk to babies and small children from DEHP. Although this chemical was detected at levels lower than 1,000ppm, it could be problematic for the realization of a circular economy and the accumulative effect of phthalates that children come into contact with via different products should be considered.

DEHP is included in the US EPA Chemicals Action Plan as a chemical of concern. It is also on the EPA Toxic Release Inventory (TRI), which means that US industry facilities must report to the EPA how much of it is released annually into the environment and/or managed through recycling, energy recovery, and treatment.[83]

DEHP is a classified CMR.[ii] This product has C2C Silver certification, which stipulates that CMRs are not allowed above 100ppm. However, only 95% of a product (by weight) needs to be assessed for the C2C Silver certification, leaving a loophole via which DEHP can remain present in the product.

The chlorine and bromine findings do not reflect any intentional content as listed in Tarkett's Declare label.[84] A possible source for these halogens, and also for antimony, is cross-contamination from the glass-recycling operation where PVB is collected.


Credit: Relevant Films

i – C2C version 3.1.
ii – According to EU regulations. It is also a carcinogen according to California's Proposition 65, and is on California's DTSC List.

3.3 Discussion of findings

Hazardous compounds, including endocrine disruptors, carcinogens, and reprotoxic substances, were detected in most of the carpets tested for this report. This indicates potential health risks and is a barrier to realizing a circular economy.

Per- or polyfluoroalkyl substances (PFASs) were found in six carpets. These substances have attracted attention in recent years due to their persistence in the environment and suspected (and, in some cases, confirmed) health impacts. PFASs found in this investigation were PFOA, PFOS, PFBA, PFPeA, PFHxA, PFHpA, PFBS and 6:2FTS. PFOA and PFOS are suspected carcinogens, toxic to reproduction, and may cause developmental disorders. PFHxA, PFBA, and PFBS are potential endocrine disruptors. PFHxA and PFHpA are suspected of harming developing fetuses. In a number of carpets, more than one PFAS was detected. The regulatory process typically does not consider simultaneous exposure to multiple chemicals, so more research is needed to assess the health impacts of this.

Phthalates were found in five carpets (DEHP, DNOP, and DIBP). All phthalates found are listed as EPA Chemicals of Concern with published action plans. DEHP and DIBP are banned from US children's toys and childcare articles at concentrations above 1,000ppm via the Consumer Product Safety Improvement Act of 2008.[85] Although this chemical was detected at levels lower than 1,000ppm, it could be problematic for the realization of a circular economy. DNOP, found in two carpets (including at a level of 20% in a J+J Flooring carpet), is a suspected endocrine disruptor, and Washington and Vermont list it as a chemical of high concern to children.

One carpet contained 4-Nonylphenol (branched). A SNUR was established for 4-nonylphenol (branched) in 2014, which obligates the EPA to consider risks associated with new uses. The substance is also subject to TSCA sections 8(b) and 12(b), which require reporting to the EPA on the chemical's potential human health and environmental effects, and require exporters to submit a notification to the EPA. Washington also lists it as a chemical of concern to children.

These substances are not banned from use in carpet, and certification schemes are full of loopholes that allow them to persist in new products. Two phthalates (DEHP and DIBP) have some restrictions in place for toys and childcare products at federal level. Some other substances are banned from use in childcare products and toys in progressive states like Washington—but not in carpet. Given the amount of time small children spend on carpets and their vulnerability to chemical exposure—via inhaling fumes, ingesting contaminated dust and carpet (micro)fibers through hand-to-mouth behaviors, and increased skin contact on carpets—it is warranted that carpet should be subject to the same level of protection as childcare products.


Credit: Will Rose

BOX 5

BOX 5: Phthalates, PVC and carpets

Polyvinyl chloride, or PVC, is used in the US as a binder in carpet tile and broadloom backing.[86] 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 the customer-use phase to end-of-life disposal.[i] The toxic nature of PVC also poses substantial problems for carpet recycling.

One major concern in relation to consumer health is the use of phthalate plasticizers within PVC. Phthalates are a class of petrochemicals used to add flexibility to the vinyl, and US federal regulators have identified many as carcinogenic, reproductive disruptors, and contributors to developmental disorders, neurological disorders, and asthma.[87]

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. The global manufacturer Tarkett (parent company of Tandus Centiva) has committed to substituting phthalate plasticizers for alternative plasticizers by 2020, and claims to have already substituted all metal-based stabilizers (such as lead and cadmium) for non-harmful alternatives (calcium-zinc and barium-zinc).[88] During this investigation, phthalates were found in a number of carpets.

Even without the presence of phthalates, PVC is an inherently problematic material. Organotins, used as stabilizers 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, mercury cells, or PFAS-coated membranes.[89] Its 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 burned, PVC again releases dioxin—a known carcinogen—into the environment. The European Commission has also acknowledged that plasticizers used in flexible PVC (such as those used in carpet backing) can be detected in landfill leachates.[90]

In light of the difficulty of safely disposing of PVC, and in line with the move toward 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, while Milliken claims that it tries to eliminate the use of virgin PVC where possible, including in its broadloom and modular carpets.[91]

HBN recommends phasing out the use of virgin PVC in all carpet manufacturing, and that carpet manufacturers using recycled PVC in their products should screen the feedstock to ensure toxic additives (such as phthalates) are not recycled back into the system.[92] A recent study by Anthesis also recommended that manufacturers completely move away from using PVC in carpet backing.[93]

Credit: Will Rose

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

4. CONCLUSIONS AND RECOMMENDATIONS

4.1. Conclusions

The objective of this report was to provide a snapshot of the toxic chemicals present in carpets sold in the US, building on earlier research that showed their potential presence. The testing—implemented by the VU Amsterdam in the Netherlands and the Ecology Center and University of Notre Dame in the US—found the presence of a number of hazardous substances in carpet sold by major US carpet producers.

The most commonly identified substances were PFASs and phthalates. This investigation contextualized the toxic substances identified against the backdrop of federal and state regulation, and found very little in the way of protection for consumers (or workers) exposed to carpet therein. At a federal level, none of the toxic substances discovered are regulated for use in carpet—despite their known or suspected hazardous health profiles. At a state level, a number of progressive states have regulated these chemicals in relation to specific consumer products (again, such as children's toys), but not carpets. Arguably, the exposure pathway for babies and young children crawling on carpets is similar to that for babies and young children playing with toys, so this loophole in the regulation is concerning. Furthermore, many phthalates are hormone-disrupting chemicals, which—contrary to common toxicology assumptions—may cause health concerns at or below existing safety thresholds.[94]

The investigation also discovered a number of carpets that had "eco" certifications which prohibit the toxic substances found in the products; yet, certification loopholes (for example, lower levels of certification providing more lenient restrictions on toxic substances) meant the product could contain the toxic substance and still be awarded a "green label." This is undoubtedly confusing, and potentially misleading, for consumers.

Eight of the 12 samples tested in this investigation contained recycled content in either the backing (such as recycled PVC or polyurethane) or the face fiber (such as recycled nylon). While it is positive that all major brands in the US are offering products containing recycled materials, this must not come at the expense of the health of US residents.

These findings come amid growing awareness of the health aspects of recycled materials, which must be addressed to realize a truly circular economy. 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. The findings 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

4.2. Recommendations

Policy makers should:

— Regulate hazardous chemicals for use in carpets at a federal level. At a minimum, substances restricted in toys should also be restricted in carpet, due to the time small children spend on carpeting. The most progressive US states can start this process by taking the lead with ambitious chemical legislation. Some states—such as Washington—already have legislation in place in relation to toys that could serve as a model for regulating the chemicals in carpets, although a review of the levels permitted is also recommended.

— Put in place mandatory EPR bills (similar to the one in California) to realize a circular economy in the carpet sector. These should set minimum requirements for non-toxic and circular carpet design, as well as eco-modulated fees to encourage manufacturers to go beyond these minimum requirements. California legislators should also address toxicity in the implementation of their legislation.

— Put in place a Right to Know Bill. Federal and state laws should mandate disclosure of all ingredients and additives in carpets.

Manufacturers should:

— Phase out toxic and non-recyclable carpets. Manufacturers can take immediate measures to ensure their products are designed for a circular economy. It is recommended that they design products for durability, reliability, and recyclability—and without the hazardous chemicals identified in this report and previous research.[95] As outlined in this report, some products sold in the EU by some of the same manufacturers indicate that such products already exist.

— Make all information on materials and chemicals in their products publicly available. Manufacturers can do this in the form of a "product passport" that lists all this information in a consistent, transparent, and accessible way.

Credit: Les Stone

APPENDIX:

Key US chemical regulations and lists

California Department of Toxic Substances Control (DTSC)

Many of the toxic substances in carpet and related adhesives are on the California DTSC's Candidate Chemicals list. These are chemicals that select authoritative bodies have determined exhibit hazard traits or environmental or toxicological endpoints.[96]

California Proposition 65

California's Proposition 65 is one of the most far-reaching chemical right-to-know statutes in the US. It lists chemicals known to the state to cause cancer or reproductive toxicity, and obliges companies to provide a "clear and reasonable warning" before "knowingly and intentionally" exposing a person to a certain list of chemicals. Proposition 65 also has "discharge prohibitions," which prohibit companies from knowingly discharging or releasing a Proposition 65-listed chemical into a drinking-water source or onto land where it can, or probably will, pass into a drinking-water source.[97]

Consumer Product Safety Improvement Act (CPSIA) of 2008

The CPSIA is an amendment to the earlier Consumer Product Safety Act, the umbrella statute for the Consumer Product Safety Commission (CPSC). This amendment provided the CPSC with new regulatory and enforcement tools, and introduced a limit on the levels of some phthalates permitted in toys and certain childcare articles (Section 108).

EPA Chemicals of Concern

The EPA Chemicals of Concern list was established in December 2009. It includes four classes of chemicals (including phthalates), each of which has an Action Plan. Inclusion of a chemical on this list indicates that it is potentially dangerous and that further regulatory action is warranted.

EPA Significant New Use Rule (SNUR)

SNUR obligates the EPA to consider the risks associated with new uses of a chemical. Persons subject to these SNURs are required to notify the EPA at least 90 days before commencing such manufacture or processing. The required notifications provide the EPA with the opportunity to evaluate the intended use and, if necessary, to protect against potential unreasonable risks from that activity before it occurs.

EPA Toxic Release Inventory (TRI)

The EPA TRI covers chemicals that are causing cancer or other chronic human health effects, significant adverse acute human health effects, and significant adverse environmental effects. US facilities in different industry sectors must report annually regarding how much of each chemical is released to the environment and/or managed through recycling, energy recovery, and treatment. These details are then disclosed via the TRI.[98]

Toxic Substances Control Act (TSCA)

The TSCA was established in 1976 and enable the EPA to require reporting, record-keeping, testing, and restrictions relating to chemical substances and/or mixtures. The sections of the TSCA mentioned in this report and their requirements are:

- Section 5: SNUR (discussed above).
- Section 8(b): Requires EPA to compile, keep current, and publish a list of each chemical substance that is manufactured or processed (including imports) in the US for uses under the TSCA.
- Section 12(b): Requires any person who exports or intends to export a chemical substance or mixture that is subject to certain rules or orders under the TSCA to submit a notification to the EPA.

Key carpet certifications

Blue Angel

Internationally used ecolabel, administered by the German federal government, covering materials used during manufacture, use, and disposal. Has an extensive scope for regulating chemicals (34 of 44 chemicals identified in the HBN report are banned under Blue Angel).

Carpet and Rug Institute (CRI) Green Label Plus

Industry label from the US CRI. Launched in 1992, the CRI Green Label focuses solely on the emission of VOCs, and is used internationally. According to Healthy Building Network (HBN) research, just one of the 44 identified chemicals is part of the testing for this certification.

Cradle-2-Cradle (C2C)

A 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 44 chemicals identified by HBN, eight are banned or limited under C2C at the Silver level.

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 an extensive list of chemicals. It also bans the use of PVC.

NSF/ANSI 140: Sustainability Assessment for Carpet

Run by NSF International, this certification is based on life-cycle assessment principles and offers three levels of achievement: Silver, Gold, and Platinum. It primarily focuses on volatile organic compounds (VOCs). It restricts the use of long-chain PFAS—but not the shorter-chain alternatives.

Red List Declare Label

The Living Building Challenge (LBC) is an initiative from the International Living Future Institute. It is a building-certification program that includes a requirement to avoid a specified "Red List" of hazardous chemicals in all products used to construct the building. The Declare label is a transparency label whereby companies disclose chemicals used in their product. The product is categorized on the Declare label as either "Declared," "Red List Compliant," or "Red List Free." According to the HBN, the Red List contains 21 of 44 chemicals identified as high risk in carpet.

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