THE FUTURE OF FABRIC
HEALTH CARE

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hbn HEALTHY BUILDING NETWORK

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Tom Lent is Policy Director for the Healthy Building Network (HBN), with over 25 years of experience with energy and environmental issues primarily focused on healthy and resource efficient building technologies. Tom helped develop the Green Guidelines for Healthcare Construction (GGHC) as one of the coordinators on the GGHC Steering Committee and serves on the LEED for Healthcare Committee. Tom has worked closely with health care systems and other large volume commercial consumers and product manufacturers to develop green procurement guidelines and evaluation criteria to spur the development of new environmentally sound products. Tom was honored in 2004 with Environmental Award for Outstanding Achievement by Region 9 of the US Environmental Protection Agency for his work to bring health concerns into green buildings.

ABOUT THE ORGANIZATIONS

The Healthy Building Network (HBN) is a national network of green building professionals, environmental and health activists, socially responsible investment advocates, and others who are interested in promoting healthier building materials as a means of improving public health and preserving the global environment. The Healthy Building Network prioritizes green building strategies that are closely linked to the goals of the environmental health movement. We bring the perspectives of people directly impacted by the source, production, use and disposal of building materials to green building professionals: architects, planners, designers, specifiers, builders and manufacturers. HBN identifies common interests, advocates for careful materials selection as a mutually beneficial means of improving the quality of life all along the material lifecycle, and coordinates coalitions and campaigns to accelerate the transition to healthier building materials.

Health Care Without Harm (HCWH) is a campaign for environmentally responsible health care. Made up of 500 organizations in 52 countries, HCWH's mission is to transform the health care industry worldwide, without compromising patient safety or care, so that it is ecologically sustainable and no longer a source of harm to public health or the environment. The campaign's goal is to transform the design, construction and operations of health care facilities to minimize environmental impacts and foster healthy, healing environments. In collaboration with its members, it advocates for policies and practices that eliminate the incineration of medical waste, minimize the amount and toxicity of all waste generated, and promotes the use of safer materials and treatment practices.

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PREFACE

Contemporary health care settings overflow with chemicals. They exist in medical devices and equipment, computers and copiers, building materials and the finishes that cover floors, walls, ceilings and the furniture upon which we are examined, sit and sleep. Emerging science links many of these chemicals to environmental contamination and negative human health effects. Concerned that health care settings may be inadvertent sources of exposure to many of these chemicals, the Healthy Building Network (HBN) and Health Care Without Harm (HCWH) work with health care institutions to move the market to develop and produce greener and healthier building materials. Many sectors of the market, including the fabric industry, have responded by removing or substituting some of the worst-in-class chemicals from their products and investing research dollars into bio-based materials and safer alternatives.

HBN and HCWH have prepared this report to focus on the fabric industry's efforts to improve the components of fabric for the health of our communities. With more than a million yards of fabric sourced annually by hospitals and other health care institutions, significant opportunities exist to reduce the risk of environmental exposures for hospital staff, patients, and the larger global community, to improve indoor air quality, and to increase the use of recycled fabric rather than create virgin products from our dwindling natural resources.

The purpose of the report is to alert health care practitioners, architects, designers and the fabric industry itself to the potential hazards associated with fabric and to spur the development and use of safer alternatives. It provides a brief history of fabrics; a summary of some of the key chemicals of concern found in fabrics that have been developed and marketed to meet the high performance demands of key contract markets, including health care; an overview of standards and certification programs governing fabric; and examples of some of the innovative efforts coming to market from fabric manufacturers, nonprofit organizations and trade associations as they seek to bring healthier materials into our hospitals and other health care institutions. The report is based upon scientific studies, government documents and industry information obtained through the authors' work with manufacturers, health care organizations, and via internet-based research.

We hope this paper will assist the efforts of health care institutions, architects and designers and fabric manufacturers to point the way for a dramatic transformation of the fabric industry to a place of leadership in healthy and sustainable materials for the next generation.

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INTRODUCTION

Textiles are woven into the fabric of the health care built environment; draperies, privacy curtains, blankets, bedding, furniture and medical furnishings, floor and wall coverings are examples of the many fabric products used in hospitals. The demands of the contract marketplace, including health care, for durability and safety has fostered a fabric industry that puts chemicals and materials into the environment that may hurt, rather than protect, human health and the environment. The intense and unique needs of the 24/7 health care organization for cleanability, infection control, and fire safety combine to challenge the 21st century fabric industry as it moves to safer, less toxic chemicals and designs that both safeguard building occupants and promote environmental and community health.

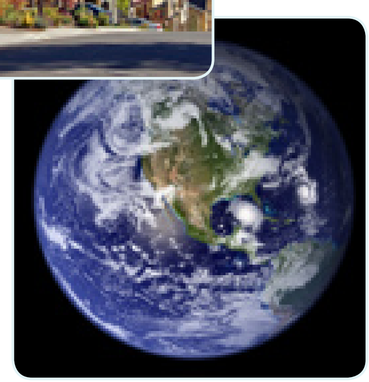
The fabric industry, like many other building product industries in recent decades, has responded to the stringent requirements of health care facilities through an increasing reliance on petrochemical-based materials. The previous generation of bio-based fabrics—wool and cotton—has been superseded by nylons, polyesters and other synthetic fibers. Performance attributes such as flame retardance for safety, durability for longevity, and cleanliness for patient well-being have been engineered into man-made fabrics through the increasing use of chemical flame retardants and protective coatings. Unaccounted for, until recently, is the cumulative effects these products and the associated chemicals used in their production might have on the long-term health and well-being of patients, staff and the broader communities with which they come in contact. Scientific studies of the chemicals used to bring these performance gains to health care fabrics are showing alarming links with a wide range of health effects from asthma to cancer.

People do not experience fabrics in health care settings alone—fabrics are prevalent in automobiles, offices and homes. Because people in the United States now spend almost 90 percent of their time indoors, and another six percent in their automobiles, the health implications of the diverse chemical components in the many materials that populate our indoor environments are being more seriously studied. The U.S. Environmental Protection Agency (EPA) estimates that 20 percent of the population exhibits health issues associated with Sick Building Syndrome and Building Related Illness.

Today, architects and designers, facilities staff and fabric companies are grappling with the emerging need to balance short-term performance gains with long-term health effects. This “life cycle” lens is a defining characteristic of a new wave of socially responsible business models. Increasingly, major fabric manufacturers, as well as purchasers, are evaluating product offerings through triple-bottom-line methodologies that seek to balance environmental, social and economic criteria, from manufacture through end-of-life disposal. Adding a chemical to the finish of a chair that makes it easier to clean may have significant short-term practical advantages for a hospital. When emitted by the 1,000+ chairs throughout the facility, however, those same chemicals in the fabric’s finishes that make it so easy to clean may also have serious long-term negative health effects. Likewise, the cubicle curtains that provide privacy to patients are treated with toxic flame retardants and other chemicals to reduce the hazards of accidental fire. In the long-term, however, they may be continually exposing those same patients to different and dangerous long-term health effects.

Within the health care sector, the commitment to sustainable building goals is inextricably linked to environmental and human health. The health care industry addresses sustainability through the framework of its historic mission, "first do no harm." In 2002, the American Society for Healthcare Engineering's (ASHE) Green Healthcare Construction Guidance Statement defined the broad goal for green construction as protecting health at three levels: building occupants, the local community and global. Insofar as the products in buildings, including fabrics and their constituent chemicals, contribute to long-term negative health impacts, the health care industry has a tremendous opportunity to use its scale and purchasing power to promote the development of safer alternatives to protect health at all three levels. The fabric and furniture industries have a complex supply chain network to bring along with them on the road to sustainability and health. In doing so, they join with the broader building industry in seeking safer, healthier, more sustainably sourced and recycled building materials.

As the dialogue begins, health care organizations are bringing clarity and inquisitiveness to these topics. With a greater awareness of green chemistry, sustainability and the connections to health, leading fabric manufacturers and health care organizations are critically examining the current state of fabric and developing more sustainable products. It is against this backdrop that this paper examines the problematic materials and chemicals of concern in fabric, the challenges in becoming more environmentally responsible throughout the material's life cycle, and the potential opportunities for innovation that can help lead toward a healthy and sustainable fabric industry. It postulates the "future of fabric."



II HISTORY OF FABRIC

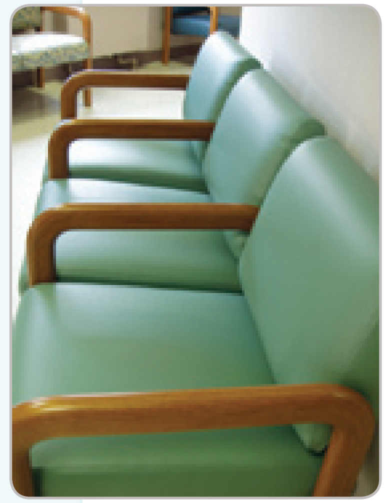
Fabric is woven into humanity and has touched so many lives—beginning in ancient times when primitive peoples used flax fibers, separated into strands and plaited or woven into simple fabrics colored with dyes extracted from plants. Given the intimate history of people and fabric, it is hard to imagine that the industry or "art" of making fabric has evolved into one that adversely affects the environment. The fabric business is often used to symbolize the transformation of manufacturing brought about by the industrial revolution, as it was one of the first industries to benefit from the energy produced by the steam engine powered by fossil fuel.[1] With industrialization, the fabric industry transformed from one grounded in nature to one that relies heavily on synthetic materials and chemicals.

For thousands of years before the introduction of synthetic fibers, the four great fibers in the fabric industry were flax, wool, cotton and silk, all products created from natural, rapidly renewable and abundant sources. Innovators developed synthetic fabrics to overcome some of the inherent limitations of natural fibers: cotton and linens wrinkle; silk requires delicate handling; and wool shrinks and can be irritating to the touch. Rayon, the first man-made fiber produced to emulate silk, became commercially available in 1910. Nylon, "the Miracle Fiber," came to market in 1939 as one of the first synthetic fibers created from petrochemicals. It established an entire new world for synthetic fibers—including thread and women's hosiery—and quickly replaced silk in a range of applications. Nylon became the dominant fiber for tents and parachutes in World War II. Nylon's successful adaptation opened the door for other synthetic fibers.

At the time nylon was introduced, cotton was the king of fibers, making up 80 percent of all fiber production. By 1945, cotton production had decreased to 75 percent and its use in the home furnishings market continued to decline.[2] Synthetic fibers made up 15 percent of the balance of the market, with wool and other fibers making up the remaining 10 percent. As more synthetics were developed, however, the man-

Discovering Vinyl Film

The development of vinyl films as a substitute for woven fabric first began during the search for a less expensive, synthetic adhesive to bond metal and rubber together. During the research and development period, Waldo Semon created a rubbery, gel-like substance using chloride (rather than bromine), ethylene (found in crude oil), and other chemicals that, when cooled, became the first polyvinyl chloride (also known as PVC or its common name, *vinyl*) material in 1926.[4] It has since evolved to be used in many ways: as a surface material that was durable, easy to maintain and clean; to be soft and flexible (by adding plasticizers); and less expensive than many of the alternatives. In the mid-1990s, the industry added protective coatings to vinyl "fabrics" for improved stain resistance and to create resistance to bleach cleaning solutions, as well as antimicrobials and germicides for cleaning. As they did with other fabrics, foam and furniture components, the industry also added flame retardant additives to some high performance vinyls to meet challenging fire safety standards.[5]



made cellulose-based fibers like rayon, and the new fossil fuel fibers and films—acrylic, nylon, polyester, and polyvinyl chloride (See sidebar "Discovering Vinyl Film")—continued to replace natural fibers. Synthetics delivered greater comfort, soil release, broader aesthetic range (for example, special dullness or luster could be achieved), dyeing capabilities, improved fiber cross section and longitudinal shape, tensile strength, abrasion resistance, colorfastness and better blending qualities, as well as lower costs.

The man-made fibers and films, and a steadily growing palette of synthetic additives, made it possible to add flame-retardancy, wrinkle and stain resistance, antimicrobial properties and a host of other performance improvements. By the mid-1960s, synthetics increased in market share to over forty percent. In the 1970s, a wave of greater consumer awareness and recognition of increasing product liability stimulated market demand for flame resistance in children's sleepwear, carpet and other products, including upholstery fabrics. For some, manufactured fibers meant "life made better."[3]

III FABRICS TODAY: CONCERNS AND ALTERNATIVES

The health care fabric industry faces significant challenges today. The past 50 years of synthetic material development have brought significant performance improvements in fabric. These improvements, however, are now beginning to be haunted by growing concerns about the health and environmental impacts of those materials and the finishes and treatments added to them. Only a small fraction of the over 80,000 chemicals registered for use have undergone even the most basic human health screening.[6] An increasing body of science, however, has identified a wide range of deleterious health impacts from the chemicals now widely used throughout the building material industry, ranging from bronchial irritants to endocrine disruption and cancer. This section will outline specific health concerns associated with the chemicals used in different aspects of fabric manufacture and finishing and describe the approaches available to reduce or eliminate the hazards.

Responding to the scientific evidence, the health care industry has begun developing criteria to identify chemicals of concern and to prioritize sustainability efforts. The Center for Health Design (CHD) and Health Care Without Harm (HCWH) recently published a priority list of criteria emphasizing avoidance of the international Stockholm Convention's list of persistent organic pollutants (POPs), other persistent bioaccumulative toxic chemicals (see sidebar on PBTs), carcinogens, mutagens, reproductive or developmental toxicants, neurotoxicants, endocrine disruptors, and volatile organic compounds (VOCs). The list encourages the use of sustainably sourced bio-based materials, or recycled/recyclable materials. (See sidebar, "Green Materials Hierarchy for Health Care")

Green Materials Hierarchy for Health Care[7]

Criterion 1: Do not use materials that contribute to the formation of persistent organic pollutants (POPs) as defined by the Stockholm Convention.

Criterion 2: Do not use materials that contain or emit highly hazardous chemicals, including:

a. Do not use materials that contain:
   - Persistent, bioaccumulative, toxics (PBTs) or
   - Very persistent, very bioaccumulative (vPvB) chemicals

b. Avoid materials that contain:
   - Carcinogens
   - Mutagens
   - Reproductive or developmental toxicants
   - Neurotoxicants
   - Endocrine disruptors

c. Avoid materials that emit criteria levels of VOCs.

Criterion 3: Use sustainably sourced bio-based or recycled and recyclable materials

a. Prefer sustainably produced bio-based materials that are:
   - Grown without the use of genetically modified organisms (GMOs).
   - Grown without the use of pesticides containing carcinogens, mutagens, reproductive toxicants, or endocrine disruptors.
   - Certified as sustainable for the soil and ecosystems.
   - Compostable into healthy and safe nutrients for food crops.

b. Prefer materials with the highest post-consumer recycled content.

c. Prefer materials that can be readily reused or recycled into a similar or higher value products and where an infrastructure exists to take the materials back.

Criterion 4: Do not use materials manufactured with highly hazardous chemicals, including those described in Criterion 2.

Today, the primary fibers that meet the performance needs of health care institutions are mostly synthetic materials—nylon, polyester, and vinyl—some of which release or are made from toxic chemicals. They may contain dyes made with heavy metals and toxic chemical additives to meet stringent fire safety codes and can be treated with finishes and antimicrobials that are not necessarily efficacious and may negatively affect human health and the environment.

Aesthetic demands of health care have changed as well. Fabrics like vinyl, which used to be acceptable in a health care environment, are now associated with an "institutional" aesthetic. Designers today want cost competitive, high performance fabric choices that connote healing, reflect advances in health care and technology, yet evoke a calming environment.

The fabric industry in the United States and Europe face additional challenges today in that they must operate under increasingly stringent and expensive environmental regulations for emissions to air, noise, and water pollution than in other parts of the world. Simultaneously, here in the United States, fabric manufacturers face severe competition from companies overseas that are able to produce fabrics less expensively and according to environmental regulations that are either lax or disregarded.

In order to move to more sustainable fabric choices, manufacturers and consumers must address the health and environmental issues in each of the major aspects of production for the contract market:

- Fibers;
- Finishes or treatments; and
- Coloring and/or dyes.

For each of these aspects, innovative companies are developing creative alternatives that are beginning to reshape the market.

Fibers and Films

Today, the natural fibers such as flax, wool, cotton, and silk that were so readily used for thousands of years, are rarely used, if at all, in the health care market in the United States. Wool retains significant market share in countries such as Australia, New Zealand, and the European Union, but has been replaced in the U.S. market by less expensive, more easily cleanable man-made fibers such as rayon, and synthetic fibers or films such as nylon, polyester, polyethylene, acrylic, polyurethane, polyvinyl chloride, and olefins. Manufacturers also create fabric blends to combine positive attributes and overcome inherent deficiencies of different fibers. These blends can also enhance the aesthetic, hand, endurance, and cost of the product. The synthetic fibers and films, however, present health problems through their use of toxic chemicals in manufacture and sustainability challenges inherent in material production based on non-renewable fossil fuel feedstock.

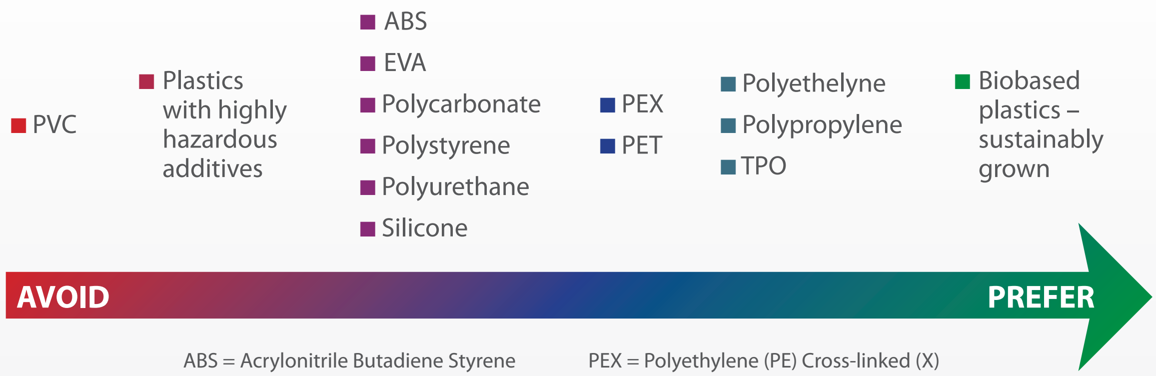
Fibers and Toxic Chemicals[8]

All of the petrochemical-based fibers in use today share a common legacy of emitting toxic chemicals in the process of refining the oil or gas from which these plastics are made. Vinyl, however, has come under more intense scrutiny due to the extreme toxicity of additional chemicals involved in its production. A recent analysis of plastics commonly used in health care placed PVC as the least preferable plastic of all those studied.[9] (See Figure 1)

PVC

Polyvinyl chloride (PVC) —commonly referred to as *vinyl*[10]— is a chlorinated plastic polymer used widely in the United States. In health care settings, it is used for wall covering, flooring, ceilings and upholstery fabric. Vinyl fabrics are also commonly used for seating, tackboard cover-

Figure 1: Plastics: Environmental Preference Spectrum



ABS = Acrylonitrile Butadiene Styrene
EVA = Ethylene Vinyl Acetate
PET = Polyethylene Terephthalate
PEX = Polyethylene (PE) Cross-linked (X)
PVC = Polyvinyl Chloride
TPO = Thermoplastic Polyolefin

Rossi, Mark & Tom Lent, "Creating Safe and Healthy Spaces: Selecting Materials that Support Healing" in *Designing the 21st Century Hospital*, Center for Health Design & Health Care Without Harm, 2006, page 66 (http://www.healthybuilding.net/healthcare/HCWH-CHD-Designing_the_21st_Century_Hospital.pdf)

ings, furniture panel coverings and trim, privacy curtains, drapery (linings), and shower curtains. Long recognized as inexpensive, durable, easy to maintain and clean, vinyl upholstery fabric is widely found on medical furnishings such as examination tables, gurneys and stools. Health care institutions source hundreds of thousands of yards of vinyl fabrics annually. The health care industry has targeted vinyl for elimination due primarily to two groups of chemicals of concern uniquely associated with it: dioxins and phthalates.

Dioxins - PVC is likely a leading source of dioxins to the environment; created due to its chlorine content, both when PVC is manufactured and when it burns in structural fires or at the end of its useful life in incinerators or landfill fires.[11] Chlorine reacts with "organic" compounds to form dioxins.[12] Dioxins include some of the most potent carcinogens known to mankind.[13] One of the most toxic dioxin compounds is not only a carcinogen, but also a reproductive and developmental toxicant and alters the immune and endocrine systems.[14] Dioxins are a family of compounds widely recognized as persistent bioaccumulative toxicants (PBTs), which has led to them becoming a global problem (see sidebar on PBTs). Dioxins are one of only 12 chemicals targeted for elimination by the international treaty entitled "The Stockholm Convention on Persistent Organic Pollutants (POPs)."[15] The U.S. Green Building Council's (USGBC) Technical Science Advisory Committee (TSAC) report on PVC in building products confirmed that "dioxin emissions puts PVC consistently among the worst materials for human health impacts."[16]

Phthalates - Vinyl also is a source of phthalate exposure in health care settings. Inherently rigid, vinyl requires additives including phthalates (or softeners) to make it flexible enough for use in IV bags, shower curtains, wall covering, flooring and upholstery. The phthalates used to soften vinyl are reproductive and developmental toxicants.[22] Because they do not permanently bind to the vinyl, phthalates can leach from fabrics into the air, soil and water. Emerging evidence links phthalates in vinyl interior materials to respiratory problems such as rhinitis and asthma in adults and chil-

Persistent Bioaccumulative Toxicants (PBTs)—a Global Problem

Many of the chemicals of concern in fabric are known as persistent bioaccumulative toxicants or PBTs. PBTs include some of the chemicals that researchers have been studying for years (e.g., dioxins), as well as chemicals that science has only recently turned its attention to (e.g., perfluorochemicals). PBTs are of concern to human health and the environment because they are "persistent," which means that they do not break down rapidly in the environment and can last for months, even years, and sometimes decades. Once emitted, PBTs can travel long distances through the atmosphere, the air and water, finally depositing sometimes far from where they originally were manufactured.[17, 18]

In addition to being persistent, PBTs bioaccumulate; they build up in living organisms via air, soil, water and food. Many PBTs are stored in fatty tissue, increasing their concentrations by orders of magnitude as they move up the food chain to humans at the top, becoming most concentrated in mothers' milk, where they are readily available to breastfeeding infants. Lastly, but clearly of great concern to humans, is the fact that PBTs are toxic. They include some of the most potent carcinogens, mutagens and reproductive toxicants known to science.

Because PBTs are released into the environment and take so long to break down and disappear, dramatically high levels of these toxicants are found in wildlife and humans long after their exposure. For example, PCBs have been banned in the United States since the 1970s, yet their persistence has been so great that detectable levels of PCBs still remain in humans more than 30 years later.[19] Twelve PBTs have been targeted for elimination by International Treaty[20] and more are subject to action by national and international bodies.[21]

A number of PBTs and other toxicants commonly added to and/or released from health care fabrics include: halogenated flame retardants (in fibers and finishes), volatile organic chemicals (in fibers and finishes), perfluorochemicals (in finishes), heavy metals (in colors and dyes), phthalates and dioxins (in fibers and film), antimicrobials (in finishes), and nanomaterials (in fibers/finishes). They are used to aid in manufacturing, to add color, to inhibit ignition, to repel stains or liquids, to aid in cleanability, to add antimicrobial properties, to prevent shrinkage, and to ensure stability and durability. The precautionary principle indicates that health care should seek safer alternatives to these toxicants in fabrics.

dren,[23, 24] and both obesity and insulin resistance in adults.[25] Vinyl production uses the vast majority of phthalates in the United States.[26]

Health care organizations throughout the country have been making strides to replace vinyl flooring, vinyl composition tile (VCT), carpet backing, wall coverings, and other interior finishes and furniture with non-PVC alternatives. Many of the leading fabric manufacturers have introduced film-based, non-woven fabric product lines to replace vinyl, including those made with polyurethane, polyethylene, nylon or thermoplastic polyolefins (TPOs).

This first step in moving away from PVC products is seen as advantageous to the environment but, like many other alternatives in the marketplace, can pose unique additional questions with regard to health impacts.[27]

Polyurethane

Polyurethane is generally considered the least preferable of the primary alternatives currently in use to replace vinyl applications. Thermoplastic polyurethane (TPU) is made up of polyols and diisocyanates. Diisocyanates are severe bronchial irritants and asthmagens associated with chronic exposures that can be fatal at high exposures for sensitive individuals.[28] TPU is made from a variety of highly hazardous intermediary chemicals, including formaldehyde (a known carcinogen)[29] and phosgene (a highly lethal gas used as a poison gas in World War I that, in turn, uses chlorine gas as an intermediary).[30] In combustion, polyurethanes emit hydrogen cyanide and carbon monoxide.[31]

In the analysis of plastics used in health care (see Figure 1), polyurethane is more preferable than PVC on the plastics spectrum, but still more problematic than other plastics, including polyethylene, polypropylene and thermoplastic polyolefins. Sustainably grown bioplastics are most highly rated. Nylon is not rated in the analysis.[32] It is important to note, however, that the addition of chemicals in the fiber, films or finishes—common in the fabric industry—can flip the orders of preferability. The industry needs more in-depth analysis of the environmental and health impacts of the chemical feedstocks and contents of different fibers that are now coming to market, as well as testing of the completed products.

Recycled Content and Recyclability of Fibers: Issues

Concerns about global warming, waste reduction, depletion, rising prices, and politically unstable access to foreign petrochemicals that are associated with man-made fibers have led to an increased usage of recycled fibers to replace virgin ones. The fabric industry today makes use of both pre-consumer (otherwise known as post-industrial) and post-consumer material for fiber, though neither can be claimed as a huge success. Pre-consumer material refers to scrap that comes from industrial waste whereas post-consumer material is recycled from products that have been used by consumers and recaptured at the end of life.

Pre-consumer recycled content

The USGBC's LEED credits for "recycled content" have raised the incentive for many fabric companies to show that they are "environmentally responsible" by incorporating a percentage of pre-consumer "recycled content" material into their fabric. Some manufacturers are utilizing the production waste that other manufacturing processes cannot use. In some cases, however, the recycled content is just fabric cuttings from the manufacturer's own factory floor that are returned and reused in the product manufacturing cycle. In reality this material has always been put back into production, yet now companies are marketing their fabrics as "recycled" or "green," when the practice of reusing material scraps has always made good business sense. This marketing tactic is a common form of "greenwashing" in the fabric industry.

Post-consumer recycled content

Utilization of post-consumer recycled content is challenging for several reasons, the primary one being the lack of availability of reliable quantities of plastic feedstocks. The recycling industry for many products, including plastics, is in its infancy with limited infrastructure in place to capture products at the end of their life and return them for reuse. The recycling industry for fabrics is virtually non-existent.

One notable exception is the recycling of plastic drink bottles. An increasing number of fabric manufacturers are using post-consumer polyester, made primarily from recycled PET plastic bottles. PET bottles are currently one of the most recycled plastic commodities in the United States.[33] Antimony trioxide, a heavy metal, is used as a catalyst

in the manufacture of PET plastic bottles. Antimony trioxide is recognized or suspected to be a human carcinogen,[34] although there is significant debate about how much of a risk antimony poses when it enters contract fabrics through recycled PET. Proponents of post-consumer recycled polyester believe that the magnitude of water bottles being diverted from landfills far outweighs the concerns surrounding antimony. Currently about 38 billion water bottles per year end up in landfill, representing over $1 billion worth of plastic.[35] If the bottle industry converted to antimony-free polyester, the contract fabric industry would be able to use the recycled bottles to make antimony-free recycled polyester fabric.

The adhesives and bonded sub-layers that manufacturers frequently use to bond fabrics to furniture and surfaces create an additional hurdle to reclaiming or recycling those fabrics. Adhesives gum up the recycling process system (literally and figuratively) and contaminate the fabric materials. The challenge for the industry is to develop technologies or designs that do not require adhesives, or create adhesives that are designed to release or be recycled with the fabric materials.

The use of post-consumer fabric as a component of new products faces significant distribution challenges. Closing the loop and recycling fabrics from upholstery back into a product of equal or greater value is the ideal, but will continue to be a challenge until an infrastructure exists to recycle fabrics that are technical nutrients and/or compost fabrics considered biological nutrients. Only then can we discontinue use of virgin or pre-consumer materials in production and eliminate landfill waste, even considering the frequent turnover of textiles in health care.

Eco-Intelligent® Polyester (EIP): Technical Nutrient, Heavy Metal-Free

Victor Innovatex and Designtex, working with MBDC, have developed Eco-Intelligent® Polyester or EIP, which also carries the MBDC's Cradle to Cradle (C2C) gold certification. It is considered a technical nutrient, which is described as "a material that remains in a closed loop system of manufacture, reuse and recovery, maintaining its value through many product life cycles." Polyester EIP technology replaces the antimony catalyst usually used in PET manufacturer with titanium. The EIP fabric is not made from recycled content, but is the first polyester that is antimony-free and uses only fully optimized dyes and chemicals without chlorine and PBTs. Hence, EIP is ready for recycling without bringing unwanted toxic chemicals back into the product.

Definition: Biological Nutrient

A biological nutrient is described as a material that is rapidly renewable, biodegradable and all inputs are deemed to be ecologically safe. This material can be successfully recycled until no further value is available to industrial systems, at which time these nutrients can be incorporated into biological metabolism through composting.[36]

Bioplastic fabrics

Bioplastic fabrics—utilizing plastic resins made from plants instead of oil—offer an exciting opportunity to reduce oil depletion and the global warming associated with the use of petrochemical plastics. They offer the potential to develop bionutrients, with the possibility of composting at the end of their useful life, as an alternative to either recycling or landfill. Bioplastics are just beginning to enter the marketplace. (See sidebar discussion on Ingeo.)

Bioplastics, however, must be approached with care in order not to repeat many of the problems associated with petroplastics, thus creating new problems of their own. Competition for food source plants (like corn), as well as concerns regarding soil erosion, energy use, pesticides and genetically modified organisms (GMOs) are just some of the challenges associated with modern agriculture. In order to reduce life cycle impacts well below their petrochemical counterparts, bioplastics must be derived from sustainable agriculture processes. The continuing development of markets for bio-based materials risks exacerbating modern agricultural problems already in existence. The challenge with bioplastics—as with petroplastics—is to design fabrics with their full life cycle in mind, from extraction to manufacture to use and end of life consequences. The Sustainable Biomaterials Collaborative has developed the Sustainable Bioplastic Guidelines as a road map to meet this challenge.[37]

Fabric manufacturers are beginning to respond to these issues. While Ingeo is currently produced with corn from standard agricultural practices, NatureWorks offers an offset program at an extra price to encourage farmers to raise GMO-free corn. The Working Landscape Certificate program,[38] offered by the Institute for Agriculture and Trade Policy, is a more comprehensive offset program covering a wider range of sustainable agriculture practices for corn-based products like Ingeo. The Working Landscape program certifies farmers' use of sustainable practices on agricultural acreage, such as eliminating hazardous chemicals, avoiding GMO crops, and improving soil conservation without requiring the direct sourcing of the actual crop and the additional costs required for bioplastic production.

Ingeo™

Ingeo™ is a trademark for a viable man-made fiber made from 100% annually renewable resources (corn at this time). The biopolymer makes use of carbon from plant starches, broken down into natural sugars through a process of simple fermentation and separation. The resulting resin, called NatureWorks® PLA, can be spun or extruded for use in fabrics. Ingeo has a number of advantages, including high strength, dimensional stability, resilience and resistance to ultraviolet light, more than most other synthetics. It also has relatively low flammability and smoke generation. To date, however, it is not as durable as most synthetics and has a low tolerance for high temperatures.

Finishing

"Finishing" is one of the broadest and most general of all terms in the fabric industry. It includes hundreds of post-product processes and treatments to meet certain aesthetic standards and performance measures. Finishing can be physical, chemical, temporary or permanent. Finishes can be added to fabric to resist spills, enhance stain repellency, provide antimicrobial properties, protect the primary material, and increase resistance to wear and tear. Some fabrics are treated with more than one finish, each applied at different stages of post production. In addition some small producers focus on using "clean" yarns—yarns that are already "finished" or, in the case of flame-retardancy, are inherently flame retardant.

Finishing is broadly categorized into three major areas, each with unique chemical components and related health issues:

- Stain repellents
- Flame retardants
- Antimicrobials

Stain repellents and perfluorochemicals (PFCs)

As the fabric industry continues to rely on finishes and treatments to achieve certain performance characteristics, scientists and researchers have begun to find some of the chemicals used to create them accumulating in both the environment and in human bodies.

Perfluorooctane sulfate (PFOS), is part of a family of perfluorinated compounds (PFCs) that are primary toxic compounds used in stain repellent finishes such as Crypton®, Teflon®, Gore™, and Scotchguard,™ PFC finishes are popular for their performance in the high traffic environment associated with hospitals and other busy medical facilities. PFCs are fluorocarbons, related to the chlorofluorocarbons (CFCs) that have been banned because of their ozone-depleting effects.[39] While science has only focused its attention on the public health concerns of PFCs for the past five to 10 years, their findings are alarming: researchers are finding PFCs throughout the world in humans,[40] including recent studies by NHANES in the United States,[41] as well as new studies finding some PFCs ubiquitous in the womb.[42] This is causing increased focus on reducing the sources and transmission of PFC chemicals linked to both cancer and developmenal damage.

Polytetrafluorethylene (PTFE) is a PFC polymer used as a repellent or non-stick component, often under the brand name Teflon. Not only is PTFE a PBT, but evidence has shown that it begins to break down at high heat levels, killing birds in confined spaces and resulting in flu-like symptoms in humans.[47] The U.S. EPA conducted a risk assessment of another PFC, perfluorooctanoic acid (PFOA), a chemical created as PTFE breaks down in the environment. In 2005, the EPA's draft risk assessment found "suggestive evidence" that PFOA could cause cancer in humans.[48] The EPA's Science Advisory Board (SAB), in turn, recommended that the agency should classify PFOA as a "likely" carcinogen in humans.[49]

Still, little is understood about the pathways of exposure to PFCs. What we do know is that humans are being exposed, even in the womb. In a study from Johns Hopkins Bloomberg School of Public Health, researchers analyzed cord blood samples from 300 newborns in Baltimore and found PFOS and PFOA in 99% and 100% of umbilical cord blood, respectively.[50]

While some companies are standing by, awaiting more science and regulation before they end their use of PTFE and other members of the PFC family of compounds, other companies are acting now precautionarily on the warning signs from the science now and removing or reducing PFCs from/in their products. Crypton®, one of the most popular fabric finishes/treatments in health care, released a new product "Crypton® Green," in 2007 that reduced its use of formaldehyde and PFCs.[51]

PFOS concerns force 3M Scotchguard™ reformulation

In 2000, 3M voluntarily ceased production of perfluorooctane sulfate (PFOS), used to make its Scotchguard™ product, after research raised issues with the build-up of PFOS in wildlife[43] and evidence of reproductive damage in animal studies.[44] Public attention focused on 3M after it was discovered that 3M was aware of the toxic effects of PFOS long before ceasing production.[45] Recent research found extremely high levels of PFOS polluting waterways in Minnesota where 3M is located.[46]

Flame retardants

The widespread use of petrochemical plastics and other synthetic materials in fabric and upholstery (as well as other building materials) has increased the flammability of these products, making it necessary to add chemical treatments to meet fire safety standards, either through application of the finished product or as a component of the fiber production process. The most common approach has been to add halogenated flame retardants (HFRs) (See sidebar on "HFRs"), such as PBDEs, to many products to meet these standards. (See sidebar on "PBDEs")

In the past, the contract market used natural fabrics such as cotton, linen and wool, which were treated with spray-on flame retardants to inhibit flame spread or ignition. For other upholstery fabrics, including synthetic fabrics such as vinyl, nylon and polyurethanes, manufacturers add flame retardants or barrier cloths below the fabric in order to meet fire safety codes. The U.S. interest in exporting fabrics to other countries with more stringent fire safety standards also has led to the "upgrading" of fabrics to meet higher standards by adding additional flame retardants. Studies suggest that flame retardants increase stain resistance and cleanability. Recent research, however, has raised concerns about the persistence and toxicity of many flame retardant chemicals.[52, 53, 54]

Some flame retardants are now ubiquitous in the environment, including in remote areas such as the Arctic[58] and deep in the oceans.[59] Rapidly increasing levels have been measured in sediments, marine animals and humans, indicating a significant potential for damage to ecological and human health. Halogenated flame retardants have been linked to thyroid disruption, reproductive and neurodevelopmental problems, immune suppression, and in some cases, cancer in animal studies.[60]

Scientists continue to research how humans are exposed to HFRs. What is known is that HFRs are released inadvertently during manufacture, emitted during use into household dust,[61] released in burning, or released in landfill at end of life, making their way into our air, soil, waterways, wildlife and humans. Biomonitoring shows that high levels of some HFRs are in breast milk and other fluids.[62] Unusual levels of some HFRs have been found in our waterways, including one halogenated flame retardant used in fabric treatments, Dechlorane Plus, which has been found in the Great Lakes.[63]

Definition: Halogenated flame retardants (HFRs)

Halogenated flame retardants are flame retarding compounds made with a chemical halogen attached to the carbon backbone, generally the halogens chlorine and bromine. Most common are brominated flame retardants (BFRs), widely used in plastics for electronics, foams, and fabrics.

Definition: Polybrominated diphenyl ethers (PBDEs)

Polybrominated diphenyl ethers (PBDEs) are halogenated flame retardants (see sidebar definition of HFRs) made from the chemical bromine, used in plastics, foam, fabrics and finishes, and electronic equipment. PBDEs are some of the most widely used and researched HFRs. They are showing up in alarmingly high levels in wild life and humans, including in breast milk.[55] Evidence from animal studies shows that PBDEs are toxic in ways very similar to other chemicals,[56] particularly polychlorinated biphenyls (PCBs), which were banned in the 1970s due to their persistence in the environment and links to cancer and effects on the immune system, reproductive system, nervous system, endocrine system.[57] Based on the science and research currently available, the primary manufacturer responsible for making two of the three most widely used PBDEs voluntarily ceased production in 2005. States are also legislating or regulating the reduction and/or elimination of PBDEs.

A number of fabrics currently marketed for health care use fibers that are inherently flame retardant to meet fire safety standards. Some petroleum-based synthetic fibers—such as Avora® FR Polyester® or Trevira CS and Lenzing FR viscose—use a flame-retardant additive, but are referred to as "inherently flame retardant" because the chemical treatment is added to the polymer solution before fiber extrusion. The process builds the chemical treatment into the backbone of the polyester rather than adding it later to the finished product. Because flame resistance is built into the core of the fiber or filament, the fibers can maintain their fire resistance through repeated laundering and are presumed to be less likely to expose the occupants to chemicals.[64] Ingeo PLA (see sidebar above)—as well as wool to some extent—is inherently flame retardant (wool is inherently flame resistant for cigarette ignition tests but not to open ignition tests). Limited applications for furniture upholstery also include fibers for fabrics that are considered inherently flame resistant such as Trace® FR, Kevlar®, and Nomex®Ny.

Antimicrobials

Antimicrobials are ubiquitous in all kinds of products on the market today, from hand soaps to building materials. Aggressively marketed to health care providers for enhanced infection control, antimicrobials are used in paint to inhibit mold and in numerous interior flooring and finish products, including carpet, privacy curtains and upholstery fabric. In some products, metals, such as silver or copper, are impregnated into fabric to provide the antimicrobial properties. Research indicates that environmental concerns exist from the manufacturing processes associated with antimicrobials because metals may be released into our water, soil, and air—the same metals that ironically may contribute to antibiotic resistance. Silver, in particular, has been linked with antibacterial resistance.[65] Antimicrobials can also lead to what is known as "cross-resistance," whereby through an intricate process, bacteria become resistant to the antimicrobial itself, as well as to a whole host of other antibiotics.

Plucked from the Sea: Maharam Explores Shell Waste

Maharam is addressing concerns with heavy metals by spending research and development dollars to explore using unusual materials such as Chitosan, shrimp and crab shell waste, to create bio-based antimicrobials.

Serious questions are being raised, however in the industry as to whether antimicrobials serve a measurably useful functional in health care fabrics at all. The efficacy of antimicrobials in fabrics in health care has been called into question by several independent studies. The Centers for Disease Control and Prevention (CDC) concluded a 2003 comprehensive study of infection control practice with the statement that "No evidence is available to suggest that use of these [antimicrobial] products will make consumers and patients healthier or prevent disease. No data support the use of these items as part of a sound infection-control strategy."[66] Kaiser Permanente similarly concluded in a December 2006 position statement that "[w]e do not recommend environmental surface finishes or fabrics that contain antimicrobials for the purpose of greater infection control and the subsequent prevention of hospital acquired infections." KP states that "No evidence that environmental surface finishes or fabrics containing antimicrobials assist in preventing infections." Rather, the organization recommends strict hand hygiene and environmental surface cleaning and disinfection.[67]

Volatile Organic Compounds (VOCs)

Volatile organic compounds (VOCs) are compounds including formaldehyde, acetaldehyde, toluene, and benzene that are readily released from building materials, including fabrics, into the air.[68] Volatile organic compounds are added to fabric to enhance performance and lifespan. Some VOCs have been associated with short-term acute sick building syndrome symptoms, as well as other longer-term chronic health effects, such as damage to the liver, kidney and nervous systems, and increased cancer risk.[69] VOCs are often emitted at high levels when a product is first installed and taper off to lower levels over time—related to cure time, or drying time, of components that are initially wet and ultimately dry. VOC emissions from solid materials, such as flooring and fabric in furniture and furnishings emit more slowly initially and maintain a low level of emissions over a longer period of time. Furniture wrapped in plastic at point of manufacture and unwrapped at the project site can emit concentrated VOCs when uncovered.

International and national agencies regulate releases of VOCs into the indoor and outdoor environments, as well as in occupational settings, including the U.S. EPA and the Occupational Health and Safety Administration (OSHA). Other research bodies, such as the International Agency for Research on Cancer (IARC), identify and rank VOCs by levels of concern.[70] Often, the regulatory limits do not regulate against all endpoints and mixtures of VOCs that contribute to sick building syndrome and other health concerns when emitted at low levels.

One of the VOCs of greatest concern is formaldehyde, a known human carcinogen.[71] Formaldehyde is used in the fabric manufacturing process to prevent fabric from shrinking, for improved crease resistance, dimensional stability and color fastness. It is also found in finish treatments to enhance stain resistance. The potential environmental and health effects of formaldehyde have raised such high levels of concern that international and national bodies have begun to set strict limitations on formaldehyde emissions from some product classes where formaldehyde can typically be found.[72] Several countries have taken steps to regulate formaldehyde emissions in fabrics including Japan, The Netherlands,[73] Germany,[74] Finland[75] and Norway.[76]

In addition to formaldehyde, other VOCs are incorporated into fabric through treatments and finishes. The United States has a number of programs/standards that certify and measure for VOC emissions, including those emitted from fabrics.[77] Few fabric products currently on the market, however, have been tested against and are known to meet low VOC requirements.[78] Because fabrics make up only a small element of the actual furniture component, most fabric manufacturers have not invested the time or resources to undertake emissions testing for their stand-alone fabrics.[79] Some, however, have recently obtained certification for some of their fabric styles under CA Section 01350 standards.[80, 81] However, testing of the fabric prior to finish treatments is likely to yield only part of the emissions profile. Once treated with stain repellency and other health care-targeted or high performance attributes, emissions testing is even more important to inform both the industry and end-users of emissions implications.

Nanotechnology

A new technology to resist spills and stains in fabric employs "nanotechnology," which is the infusion of microscopic nano-materials—and in the case of fabrics, nano-fibers—directly into the product so that it becomes inherently spill and/or stain resistant. Much excitement exists about the potential performance improvements that nano-materials may provide and this new industry is being enthusiastically promoted. Emerging science on the use of nanotechnology, however, has raised concerns about the lack of regulatory oversight of the industry, the absence of safety testing, and scant health data about potential environmental and human health effects.

Early science about nanotechnology provides sufficient evidence to indicate that nanoparticles may have toxic properties that are unique and deserve a closer look.[82] A recent issue paper reviewing the current science and knowledge publicly available on nanotechnology states, "The very qualities that make nano-materials commercially desirable can also make them more toxic than their normal-size counterparts."[83] Nano-fibers, also known as "whiskers," may contain problematic chemicals such as fluorotelemers (perfluorinated chemical compounds).[84] International organizations are calling for adequate and effective oversight, safety testing and assessment of the emerging field of nanotechnology, including those nano-materials that are already in widespread commercial use.[85]

Colors and Dyes

Coloring is the most complex aspect in the fabric production continuum. The fabric color may be introduced first, as in the case of solution-dyed fibers, or last, as in piece dyeing just before the goods are shipped. The development of both processes were driven by the economics of production—to eliminate coloring as a separate process or to keep inventories undifferentiated until ordered. For the health care (contract) market, dye methods are typically one of the following (see sidebar for a description of each): yarn dyeing; piece dyeing; union dyeing; crossed dyeing or solution-dyeing.

Historically, most dye stuff was derived from natural ingredients such as vegetables, animals or minerals. Today, however, most dyestuffs and binders are manufactured using synthetic chemical additives and there is much more use of heavy metals such as cadmium, a known carcinogen, and cobalt and antimony trioxide, both possible carcinogens.[87] (Cobalt is also harmful to aquatic life.[88]) Some metals used in colors and dyes are released into the environment from manufacturing and production, they do not break down readily and remain in air

Contract Textile Dye Methods

Three methods of dyeing for contract textiles:

Photo: Sharon Refvem

1. Dyeing the Yarn after Spinning:
Yarn Dyeing: Pertaining to a fabric made of yarns dyed before weaving or knitting.

2. Dyeing the fabric after construction:
Piece dyed: Fabric dyed after being woven in piece, or bolt, usually in a solid color.

Union dyed: Used when diverse fibers make up the cloth, they are usually dyed to the same color, although each fiber may require a different type or class of dye.

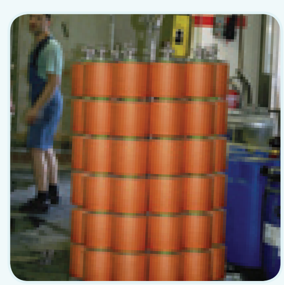


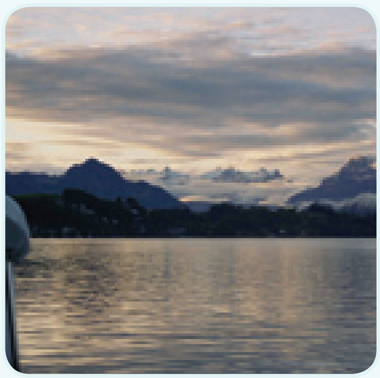
Photo: Jean Hansen

Crossed dyed: Used when diverse fibers make up the cloth and will only accept different classes of dyes. May be piece dyed by only one class of dye so that one fiber remains un-dyed or each fiber within one cloth may be dyed to a different color.

3. Dyeing the fibers before or during preparation for spinning:
Solution-Dyed: Adding dye to the chemical compound or polymer in the spinneret before extrusion into the man-made fiber. Also known as dope dyeing.[86]

Removing Toxics, Transforming Fabric: Rohner Textile Company[91]

When Rohner Textile Company, a small company in Switzerland, realized that the selvage trimmings of its finished fabrics were considered toxic waste and would not be accepted for landfill at "home," but instead had to be shipped out of the country, the executives decided to do business differently.[92] The reality that the chemicals used for dyes, finishes and fibers had potentially negative impacts on human health, the environment and the economy hit home. Rather than be reactive, the company chose to be proactive and to develop a strategy to balance the values in both economy and ecology in order to survive.



Working with McDonough Braungart Design Chemistry's (MBDC) Cradle to Cradle (C2C) program, Designtex and other partners, Rohner devised a plan to improve the quality of its products by removing some of the toxicants associated with the dyes and colors. It began with a quantitative assessment of each product's overall environmental impact and worked together with companies that were willing to partner on a long-term ecological product development process.[93] MBDC and Rohner worked with CIBA Specialty Chemicals to develop a list of 16 dye chemicals that met its environmental specification while maintaining unlimited choices of colors and designs, except for pure black. Ultimately, Rohner succeeded in eliminating all heavy metals (as well as many other harmful substances such as carcinogens and formaldehyde) from the dyestuffs and fiber from its Climatex® product line. One result of these improvements was that they found that the water going out of the Rohner mill to be cleaner than the water entering the facility.

and water for long periods of time. Some are found in or attach to particles in the air and do not break down in water, but instead bind with soil.[89, 90] Many metals find their way through the food chain into the foods we eat, including leafy vegetables, fish, dairy and meats and poultry. Once metals enter the human body, they can remain for years.

Dye stuffs in the past also required an extreme amount of water in order to be effective. While recent economic and environmental restrictions mandated that the industry replace many of the most toxic materials in the dyes, as well as minimize water use, more improvements are still needed. Because each fiber type has its own requirements for dye stuffs and no one dye can work for each fiber, the fabric industry faces immense challenges to find substitutes for the problematic chemicals (particularly heavy metals) used for coloring fabrics. But, leading firms have already demonstrated that we can move to an industry where the water coming out of a plant is as clean, if not cleaner, than the water going in (See sidebar: Rohner).

IV MARKET TRANSFORMATION

As the health care and fabric industries awaken to the health and environmental impacts of fabrics and the chemicals used in producing them, a variety of nonprofit and standards setting organizations have initiated efforts to help guide the industry toward a healthier, more sustainable future. Assistance is now available in the form of standards, certifications, guidance documents and materials assessment tools. Large volume purchasers are also starting to directly engage with manufacturers to encourage and support the move toward healthier alternatives.

Some of the chemicals of concern found in fabric have adverse effects on indoor air quality because of chemical emissions, hazardous content, or both. When choosing a fabric for use in a hospital, designers must consider a myriad of performance characteristics in addition to whether the product contains chemicals or materials of concern. Historically, most standards and/or certifications focused on performance characteristics. (See appendix A.) More recently, however, the industry has introduced sustainability standards and testing for indoor environmental quality that can be considered along with performance.

Indoor air quality standards

For indoor air quality, many certification programs measure formaldehyde and other VOC emissions and/or certify low VOC content for building materials and products, using many different standards. Most certification programs test only for VOCs and do not test for other chemicals, including semi-volatile organic compounds (SVOCs) such as perfluorinated chemicals, halogenated flame retardants or phthalates.

Currently the best programs for evaluating long-term VOC exposure hazards are generally based, at least in part, upon the California **Special Environmental Requirements Specification Section 01350 Standard for Emissions Testing** and modeled air concentrations.[94] This standard, often referred to as "Section 01350," sets emissions testing protocol and exposure concentration standards for formaldehyde and 80 other individual VOCs. The California Section 01350 test involves a 14-day process that only addresses long-term chronic exposure, not the short-term acute exposure risks during the first hours and days after installation.[95]

Scientific Certification Systems' (SCS) **Indoor Advantage Gold** Environmental Certification Program[96] and Greenguard's **Product Emission Standard for Children & Schools**[97] are two programs that utilize California Section 01350 for testing fabrics and the furniture on which these fabrics are applied. However, most fabrics on the market today have not been tested or certified for low VOC concentrations independent of furniture under either of these programs.

Building design assessments

The **Green Guide for Health Care** (GGHC)[98] is a guidance document that integrates enhanced environmental and health principles and practices into the planning, design, construction, operations and maintenance for health care facilities, from acute care to medical office buildings. GGHC provides the health care sector with a voluntary, self-certifying metric toolkit of best practices that designers, owners and operators can use to guide and evaluate their progress toward high performance healing environments.

The Green Guide recognizes the increased demand for healthier alternatives for furniture and fabric in the health care sector and provides credits to facilities that undertake efforts to source green furniture and furnishing products. To earn credits, facilities purchase furniture products that use fabrics that reduce or eliminate PBTs (with specific recognition of dioxins and heavy metals), contain low-emitting materials (fabrics made without phthalates, PFCs, formaldehyde, or HFRs), are made with sustainably sourced materials (rapidly renewable materials), and utilize recycled content. Health care facilities can use the Green Guide credits to signal to the fabric manufacturing market a desire for greener fabric options.[99]

Multi-attribute product assessments

The Healthy Building Network's **Pharos Project**[100] is establishing a comprehensive framework for defining "green" building materials, including fabric, by providing a web-based, open source materials evaluation tool that will be available to health care institutions, architects, designers, specifiers, non-governmental organizations (NGOs) and others working to provide health care organizations with quality information about the fabrics they source.

The Pharos database tool will offer consumers such as hospital and health care owners and the design and construction community a 360-degree view of a fabric's material attributes, putting industry claims in context, and testing these claims against verifiable data and user community consensus of ideal goals. Sixteen impact areas will be evaluated under the Pharos system including: health issues, both indoor and environmental; resource usage; climate change; and social justice issues such as the labor, workplace and community issues that surround the manufacture of products. The Pharos online product database will be the materials rating system that explicitly accounts for the most comprehensive range of environmental, health and social justice concerns.

The Association for Contract Textiles (ACT) is developing a voluntary **Sustainable Textile Standard** under the guidance of NSF/ANSI to provide measurable market-based definitions of progressively more sustainable commercial furnishings fabric for suppliers, manufacturers, purchasers, fabricators, specifiers and end-users. It establishes

Screening Chemicals at Interface Fabric[101]

Interface Fabric introduced the first commercial interior fabric made from renewable bioplastics, Terratex PLA, for window treatments and office cubicle paneling. Terratex PLA is created from NatureWorks LLC. (See sidebar on Ingeo.) In order to ensure that Terratex PLA did not inadvertently utilize chemicals found in many synthetic fibers, Interface established a proprietary chemical screening protocol to ensure their product did not contain chemicals of concern. The development process resulted in a comprehensive approach to material evaluation. The proprietary protocol asks questions such as:

- Is there sufficient carcinogenicity, skin sensitivity, aquatic toxicity, mutagenicity, bioaccumulation and persistence information available on the chemical to make a decision?
- Is the chemical free of hazards?
- Is the chemical structure similar to other chemicals of concern?
- Are other chemical hazards generated during the chemical synthesis or during use, recycling or disposal?

Interface Fabric is one company that has committed to evaluating the materials it uses in its fabric products and finding safer alternatives to chemicals known to harm human health and the environment.

performance criteria that address environmental, health and social and economic justice aspects throughout the supply chain. Some examples include the following:

- Fiber sourcing to include not only credit for rapidly renewable resources (fibers that are replaced by natural ecological processes within a short period of time or 10 years per the USGBC LEED Credit on Rapidly Renewable Materials), but also organic, transitional/in-conversion organic, and integrated pest management;
- Bio-based polymers and heavy metal-free fibers in addition to the more commonly addressed recycled content (pre- and post-consumer);
- Safety of materials to include avoidance of metals in dyes and pigments, carcinogens, mutagens, reproductive toxicants, PBTs, mammalian acute toxicity, and aquatic toxicity
- Water conservation, water quality, energy use reduction;
- Reduction, reuse and recycling practices, forward recycling of used fabrics; and
- Social accountability with the use of the Maplecroft Map of Human Rights Risk.[102]

The ACT standard is evaluating whether to award certification levels similar to those used in the USGBC's LEED family of products (i.e., Certified, Silver, Gold and Platinum levels, and may provide for Innovation opportunities as well). While the ANSI process ensures that the standard can be used for third party certification, it also provides for the standard to be used as a guidance document for best practices. Moreover, the standard can be used by component suppliers (manufacturers of fibers and finishes) as well as by manufacturers of textiles.[103]

McDonough Braungart Design Chemistry (MBDC) has developed the **Cradle to Cradle** (C2C)[104] certification program, referenced earlier. C2C is a proprietary protocol in which manufacturers enter in a consulting relationship with MBDC to improve the environmental profile of their products. C2C criteria focus on chemical hazard, recyclability and recycled content, energy and water use, and some social responsibility issues. MBDC does not disclose some parts of the C2C protocol.

Products that meet MBDC criteria may be certified as Silver, Gold or Platinum products or as Technical or Biological Nutrients (available for homogeneous materials or less complex products), and can be labeled as "C2C." Silver certification is awarded based on a manufacturer's completion of the process to inventory and document existing material and chemical flows and a corresponding commitment to improve the environmental profile of its products. The manufacturer does not have to undertake any changes to achieve Silver certification. Gold and Platinum certifications, however, require increasing amounts of actual changes in products and a move to safer chemistry.

Direct engagement of large purchasers

Over the past five years, health care institutions large and small have undertaken major efforts to source green building materials, assessing products throughout their life cycle. Health care leaders are stepping up to take the lead in initiating efforts to reduce and/or eliminate many of the hazardous chemicals found in fabric and to signal to the market that change is necessary. Hospitals and health care systems such as Hackensack Medical Center, the University of Texas's Houston Medical Center and Kaiser Permanente have committed research and resources to understanding the chemicals in the products they purchase and pushing the fabric industry to bring safer alternatives to market.

Over the past several years, **Kaiser Permanente** (KP) has called on the building materials market to design carpet and wall protection that consider the products' impacts on human health and the environment. KP researched a range of additional products with these impacts in mind, including casework, furniture, HVAC equipment and concrete. They became the first health care system to change its standards to require PVC-free upholstery for equipment such as examination tables and chairs in oncology units. Like every other hospital system in the United States today, KP still must purchase products that meet strict performance and economic criteria. Yet, it has enjoyed success by partnering with innovative manufacturers to leverage its considerable purchasing power to urge (and sometimes require) that manufacturers remove harmful toxicants from their products, utilize more recycled content, and include materials that are compostable or otherwise recyclable.

Following the ground-breaking work in market transformation for flooring (both carpet and hard surface flooring), wall protection and furniture, KP embarked on the evaluation of fabrics, recognizing that fabric abounds in the typical hospital environment. Fabric is part of what KP patients, staff and visitors sit on, touch, sleep, smell and as such, inadvertently "absorb" the chemistry related to all these fabrics. Through the initiation of KP's High Performance Building Committee, KP staff, consultants and a Content Expert Panel (CEP) set out to evaluate and identify chemicals of concern in the products the health system purchases to determine what fabric products the market could offer that would meet health cares' requirements while still being more environmentally responsible. Through several surveys to some of the leading fabric distributors and in-person interviews, KP was able to evaluate the current offerings on the market and determine best practices for requiring less toxic fabrics for sourcing into the future.

The information shared openly by the fabric distributors with the consultants, KP staff and the CEP demonstrated a willingness to initiate a dialogue about creating more sustainable fabrics for health care settings. The process highlighted both successes and challenges. Ultimately the road map for more sustainable and safe fabrics became better understood by a broader audience. Kaiser Permanente is interested in sharing the knowledge gained with other health care organizations and the greater design community.

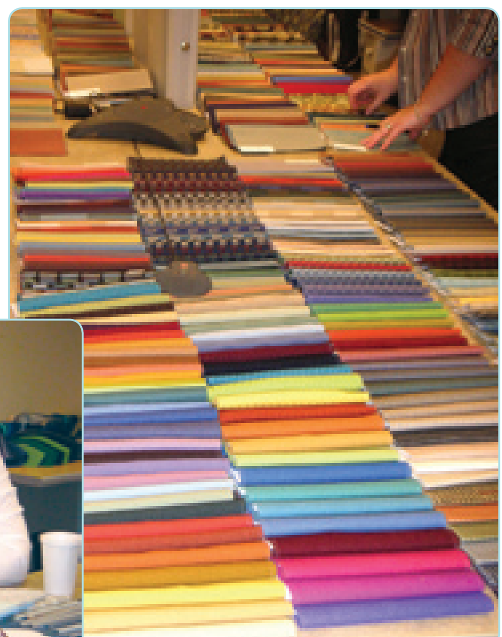


Photo: Jean Hansen, courtesy of Designtex


Photo: Jean Hansen

V CONCLUSION: THE FUTURE OF FABRIC

The challenge for the 21st century fabric industry is to enhance functionality and performance in fabrics without compromising environmental safety or human health costs. Fabric manufacturers have engineered impressive performance characteristics into modern fabrics to meet the demands of an intense 24/7 health care environment, making them more durable, cleanable, and infection and fire resistant, while still aesthetically pleasing. These improvements have come, however, at a price to health and the environment. Some of the chemicals we use for these performance gains in fabric are known to cause cancer, may inhibit a child's ability to learn, can trigger asthma or are linked to a whole host of other potential risks to human health and our environment. They are used in the chairs in our waiting rooms, the tables in our examination rooms, and the seating in our patient rooms, as well as to cover walls or create privacy on windows or within rooms.

Fabric manufacturers are beginning to understand and address how the advances of modern chemistry and fabrics can affect the environment, our communities, and the patients and staff that occupy health care facilities. A major shift is underway in innovative sectors of the industry to reduce or eliminate toxicants from fibers, finishes, and dyes and create fabric technologies that are more protective of human health and the environment.

Increasingly, health care specifiers and purchasers are concerned that the PVC in vinyl products has particularly problematic emissions in its life cycle, as does polyurethane. These emissions include persistent bioaccumulative toxic (PBT) chemicals of highest concern such as dioxin from vinyl and carcinogens such as formaldehyde from polyurethane. Fiber manufacturers are responding to these concerns by bringing to market vinyl-like fabrics with greener chemistry. These include:

- Petrochemical plastics with less toxic problems in their life cycle, such as polyethylene, polypropylene, antimony-free PET and thermoplastic polyolefins;
- Recycled plastics; and
- Bio-based products.

Given the environmental impacts and other problems with extracting more petrochemicals from the ground, the future clearly lies in technologies that close the material loop either through recycling petroleum plastics or through growing bio-plastics and composting or recycling them at the end of their life. Challenges lie ahead with each of these paths - particularly concerns with sustainably growing bioplastic feedstocks and the need for infrastructure for end of life recycling and composting.

Just like their fellow fabric manufacturers, treatment and finish manufacturers are finding that the chemicals they have relied upon are now being identified as toxicants of concern by the toxicologists; specifiers and purchasers are responding with requests for greener alternatives. Some of the most important actions that the more innovative finish manufacturers are taking to avoid key chemical groups of concern are:

- Replacing perfluorochemicals (PFCs) used for stain resistance with non-halogenated compounds;
- Replacing halogenated flame retardants (HFRs) such as PBDEs, with non halogenated retardants, or redesigning the fiber for inherent flame resistance or redesign of the products so they do not need a flame resistant fabric;
- Reducing or eliminating volatile organic compounds (VOCs);
- Reformulating dyes to avoid heavy metals; and
- Eliminating antimicrobials.

Nanotechnology appears to offer great promise for solving many performance challenges without chemicals, but may do it at a cost of yet new hazards. The technology is still in its infancy with major questions outstanding about how these microscopic scale materials may interact with and affect our bodies. Responsible health care systems are urging a "go slow" approach until better oversight and safety testing protocols are in place to help us better understand this technology.

Several efforts are emerging to help guide health care specifiers and purchasers and the fabric industry work together to develop healthier, more sustainable fabrics:

- Increasingly rigorous standards for limiting VOC emissions, based on the California section 01350 standard, such as Greenguard's Children & Schools and Scientific Certification Systems Indoor Advantage Gold;
- Green building design assessments that reward use of healthier fabrics, such as the Green Guide for Health Care; and
- Product assessment frameworks and standards that help define green fabrics across a range of attributes, including the Healthy Building Network's Pharos Project, the Association for Contract Textiles (ACT) Sustainable Textile Standard and the McDonough Braungart Design Chemistry (MBDC) Cradle to Cradle (C2C) certification.

All of these directions, guidelines and standards are only as good as the market signals that support them. Fabric and finish manufacturers rely on their customers for direction and support in improving their products. The key to market transformation to healthier products that are better for the planet lies in the concerted actions of purchasers large and small. Several major players have shown responsibility and commitment through their actions to research the issues, and engage with manufacturers to guide them to better product designs.

While we cannot expect the fabric industry to change overnight, there are alternatives already on the market that illustrate the potential for greater sustainability and healthier products. In some cases, research and development dollars will have to be devoted to examining the safety and performance characteristics of new technologies and that will take time. In other situations, however, fabric manufacturers can reduce or remove problem chemicals quickly without compromising the performance and aesthetics of the material. Perhaps innovative efforts can bring more sustainable products with even greater performance and aesthetic characteristics than the fabric industry is accustomed to.

With greater awareness of the health issues in relation to fabric, end users and designers can make more informed decisions and collectively help move the market by their specifications and purchasing power. Fabrics can then continue to be a versatile and economical design element, as they assist in differentiating interior spaces and creating an identity as well as supporting wayfinding and healing.

APPENDIX: THE ASSOCIATION FOR CONTRACT TEXTILES (ACT)[105]

The heavy use (and sometimes 24/7 operation) of furniture and fabric in medical facilities requires resilient materials that can withstand wear and tear, fading, spills, abrasion and flame spread. Specific certifications and standards for the fabric industry have evolved to evaluate product performance. While not focused on sustainability, these current standards guide health care designers and hospitals in selecting textiles to meet regulatory and performance criteria.

The Association for Contract Textiles (ACT) is a non-profit organization made up primarily of companies (fabric wholesalers) that supply fabric to the contract community. ACT member companies have adopted tests that measure performance criteria for contract interiors. Standards organizations that periodically review the tests that are selected and established for contract use include: ASTM (American Society for Testing and Materials)[106] and AATCC (American Association of Textile Chemists and Colorists).[107] While designers might choose fabrics first for aesthetics, a fabric's performance is critical to the success of its long-term installation. These standards establish the measures for fabric durability and contain useful information on fabric components: dyes, colorants and finishes.

Flammability

The measurement of a fabric's performance when it is exposed to specific sources of ignition.

Upholstery

- CA TB (technical bulletin) # 117, Section E–Class 1 (pass)

Drapery

- NFPA 701-89 (Small Scale)* - Pass (*NFPA 701-99 Test #1 is being phased in at this time, but is not yet cited in all relevant codes. Therefore, the small-scale test remains the ACT Standard until further notice.)

Wet & Dry Crocking

Transfer of dye from the surface of a dyed or printed fabric onto another surface by rubbing.

Upholstery

- AATCC 8-2001, Dry Crocking, Grade 4 minimum and Wet Crocking, Grade 3 minimum

Drapery

- AATCC 8-2001 (Solids), Dry Crocking, Grade 3 minimum and Wet Crocking, Grade 3 minimum
- AATCC 116-2001 (Prints), Dry Crocking, Grade 3 minimum and Wet Crocking, Grade 3 minimum

Colorfastness to Light

A material's degree of resistance to the fading effect of light.

Upholstery

- AATCC 16 Option 1 or 3-2003, Grade 4 minimum at 40 hours

Drapery

- AATCC 16 Option 1 or 3-2003, Grade 4 minimum at 60 hours

Physical Properties

Pilling is the formation of fuzzy balls of fiber on the surface of a fabric that remain attached to the fabric. Breaking strength is the measurement of stress exerted to pull a fabric apart under tension. Seam slippage is the movement of yarns in a fabric that occurs when it is pulled apart at a seam.

Upholstery

- Brush pill test ASTM D3511-02, Class 3 minimum
- Breaking Strength ASTM D5034-95 (2001) (Grab Test) 50 lbs. minimum in warp and weft
- Seam slippage ASTM D4034 25 lbs. minimum in warp and weft

Drapery

- Seam slippage ASTM D3597-02-D434-95 for fabrics over 6 oz./sq. yard, 25 lbs. minimum in warp and weft

Abrasion

The surface wear of a fabric caused by rubbing and contact with another fabric.

Upholstery

- Heavy Contract upholstery
  - ASTM D4157-02 (ACT approved #10 Cotton Duck), 30,000 double rubs Wyzenbeek method
  - ASTM D4966-98 (12 KPa pressure), 40,000 cycles Martindale method
- Extreme wear areas
  - These areas may require higher levels of abrasion resistance and end use can include 24 healthcare emergency rooms (and other non-healthcare areas noted). No number of double rubs or cycles recommended.

Flammability Test Procedure for Seating Furniture for Use in Public Occupancies

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