Toxic Chemicals in Building Materials

An Overview for Health Care Organizations[1]

Chemicals of concern emitted by building materials in facilities affect:

- The health and productivity of staff;
- The healing environments for patients and visitors; and
- Our communities and planet.

Lifecycle emissions from the extraction, production, use, and disposal of the materials, up and down stream, affect health care system members/patients, visitors, staff, and the larger community's health in their homes, offices, and at play.

Government bodies continue to study many of the chemicals added to or used to make building products. Many have declared some of these chemicals to be among the most hazardous known to human kind. Some of the commonly used building materials in health care may:

- Contain formaldehyde, a known human carcinogen;
- Be made from PVC, implicated in dioxin formation during production, manufacture, and disposal; and
- Include toxic chemicals found increasingly in our breast milk, urine, and blood.

While the U.S. Environmental Protection Agency (EPA) has registered more than 80,000 chemicals for use, and identified 16,000 of them as chemicals of concern, they have only subjected 250 to mandatory hazard testing and only restricted five chemicals or chemical classes.[2] With a regulatory system offering little oversight into what goes into the products used in health care, institutions must look to the market to eliminate the "worst in class" chemicals and to evaluate and encourage safer, healthier, and less toxic products.

The health care industry is uniquely positioned to move away from toxic products. With significant market power and the Hippocratic oath of "first do no harm," hospitals and other health systems are leading efforts from within the sector to source safer building materials; to avoid products containing chemicals linked to cancer, respiratory problems, hormone interference, and reproductive or developmental harm; and to undertake innovative strategies to move the market to research, develop, and produce healthier products.

Plastics

All of the petrochemical-based materials 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. Chlorinated plastics, including polyvinyl chloride, however, have come under more intense scrutiny due to the extreme toxicity of chemicals involved in their production and disposal.

PVC and Other Chlorinated Plastics

What Is PVC?

Polyvinyl chloride (PVC) —commonly referred to as *vinyl*[3]— is the most widely used chlorinated plastic polymer in the United States, with 14 billion pounds per year produced in the U.S. alone.[4] The building industry is responsible for more than 75% of that PVC use.[5] To make PVC flexible and versatile, the plastics industry can add a soup of chemicals to PVC, many of which raise concerns for human health and the environment. The health care industry has targeted PVC and other chlorinated plastics for elimination due primarily to a family of chemicals of concern uniquely associated with chlorinated plastics: dioxins. Dioxins are created during the production/manufacturing process and when chlorinated plastics are burned accidentally or intentionally during disposal.

Why Are Chlorinated Plastics a Problem?

Throughout the lifecycle of PVC and other chlorinated plastics, through manufacture and disposal, the chlorine content has the potential to produce dioxins. Dioxins are an unavoidable by-product of the manufacture, combustion, and disposal of materials containing chlorine, which can create dioxins both when the products are manufactured and when they burn in structural fires or at the end of their useful life in incinerators or landfill fires.[6] Dioxins include some of the most potent carcinogens known to humankind.[7] 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.[8] 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

CHLORINATED PLASTICS

In addition to polyvinyl chloride (PVC), the building industry uses a handful of other chlorinated plastics. Chlorinated polyvinyl chloride (CPVC) is a form of PVC with extra chlorine, often used for pipes. Polychloroprene (otherwise known as chloroprene rubber or neoprene) is found in geomembranes, weather stripping, expansion joint filler, water sealers, and other gaskets and adhesives. While most polyethylenes do not contain chlorine, two that do contain chlorine are chlorinated polyethylene and chlorosulfinated polyethylene. These two chlorinated polyethylenes are used to make geomembranes, wire and cable jacketing, roof membranes, and electrical connectors.

PERSISTENT BIOACCUMULATIVE TOXICANTS

A GLOBAL PROBLEM

Persistent Bioaccumulative Toxicants (PBTs) include some of the chemicals that researchers have been studying for years (e.g., dioxins and heavy metals), 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.[11 12]

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.[13] Twelve PBTs have been targeted for elimination by International Treaty[14] and more are subject to action by national and international bodies.[15]

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chemicals or families of chemicals targeted for elimination by the international treaty entitled "The Stockholm Convention on Persistent Organic Pollutants (POPs)."[9] The US Green Building Council has acknowledged that the chlorine content of PVC building materials and the resultant dioxin emissions "puts PVC consistently among the worst materials for human health impacts...."[10]

Are There Other Concerns with PVC?

Because PVC is inherently rigid, it requires the addition of plasticizers or softeners, known as phthalates, to provide it with some flexibility. Phthalates are semi-volatile organic compounds that have come under increased scrutiny because of their potential effects on the reproductive, respiratory, and endocrine systems. (See, "Why Are SVOCs a Problem?" below.) Moreover, PVC often requires added stabilizers, including the heavy metal lead, which is also a human health concern. (See, "Why Are Heavy Metals a Problem" below.)

Where Is PVC used in Health Care Buildings?

In health care buildings, PVC is used in resilient flooring, ceiling tiles coatings, carpet backing, pipes and conduit, siding, window treatments, furniture, wall and corner guards, wiring and cable sheathing, wall covering and upholstery fabric. It is also used in medical devices including IV tubing, blood bags, and catheters.

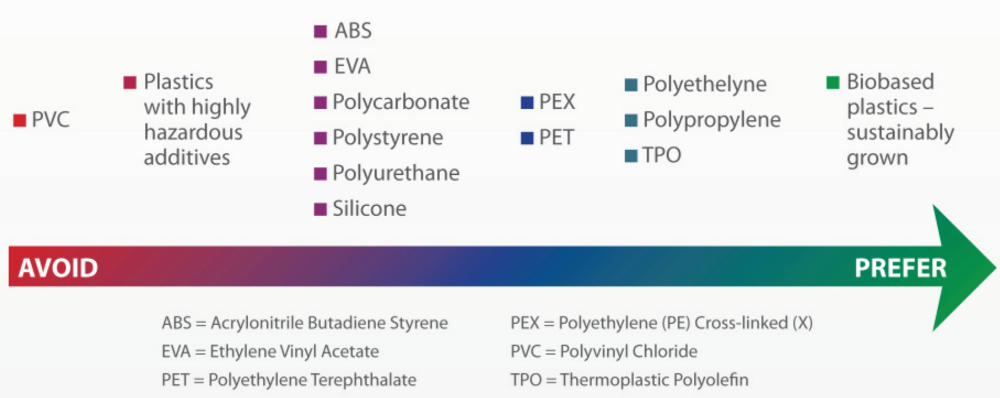
POLYURETHANE

Polyurethane is generally considered one of the least preferable of the primary alternatives currently in use to replace chlorinated plastics. 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.[17] TPU is made from a variety of highly hazardous intermediary chemicals, including formaldehyde (a known carcinogen[18]) and phosgene (a highly lethal gas used as a poison gas in World War I that, in turn, uses chlorine gas as an intermediary).[19] In combustion, polyurethanes emit hydrogen cyanide and carbon monoxide.[20]

Polyurethane can be found in a wide array of building materials, including rigid foam (board and sprayed insulation, flexible foam (padding for furniture and bedding), coatings and paints, adhesives, sealants and elastomers (such as wood sealers and caulks), window treatments, resin flooring, gaskets and other thermoplastics, and fabrics.

In the analysis of plastics used in health care (see Figure 1), polyurethane may be more preferable than PVC on the spectrum, but is still more problematic than other plastics, including polyethylene (non-chlorinated types), polypropylene, and thermoplastic polyolefins. Research and development dollars invested toward sustainably grown bioplastics are even more promising because they move us away from our over-reliance on petrochemical plastics.

Figure 1: Plastics: Environmental Preference Spectrum



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)

What Are the Alternatives to PVC?

The market has responded to concerns about PVC in building materials, offering an array of alternatives to PVC, including upholstery (primarily polyurethane), carpet backing (alternatives include a non-chlorine plastic recycled from auto safety glass), wall and corner guards, and resilient flooring. Mainstream business institutions such as Wal-Mart have moved to replace PVC with alternative materials. In most building material categories, there are PVC-free alternatives. The Healthy Building Network and Health Care Without Harm have put together a list of PVC-free interior flooring and finishes products that are compatible to health care needs, which can be found at www.healthybuilding.net.

An analysis of plastics commonly used in health care placed PVC as the least preferable plastic of all those studied.[16] Many of the alternative materials currently offered by the market, however, still raise health and safety issues associated with the lifecycle of the materials. Polyurethane is one such example. (See Sidebar on polyurethane.)

Additives and Treatments

Many chemicals are added to building materials to provide them with qualities often sought after in health care and other industries. Many of these chemical additives and treatments fall into one of three categories of problematic compounds:

- Volatile Organic Compounds (VOCs);
- Semi volatile Compounds (SVOCs); and
- Heavy metals.

Volatile Organic Compounds

What Are Volatile Organic Compounds?

Volatile organic compounds (VOCs) are carbon compounds that can vaporize (become a gas) at normal room temperatures[21] and hence will tend to evaporate from a building product into the air over time where humans can breathe them in. VOC-type chemicals are used as feedstocks for some plastics and used in binders and other resins for products such as composite wood or insulation, in paints, coatings and adhesives, and treatments to provide water resistance or to enhance stain repellence. Some typical problematic VOC compounds released from building materials include formaldehyde, acetaldehyde, toluene, isocyanates, xylene, and benzene.

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, fabric, furniture and furnishings emit more slowly initially and maintain a low level of emissions over a longer period of time. Building materials wrapped in plastic at point of manufacture and unwrapped at the project site can emit concentrated VOCs when uncovered.

Why Are VOCs a Problem?

Scientists first raised concerns over VOCs because many of them participate in atmospheric photochemical reactions, making smog. Many of them have direct health effects as well. 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.[22]

One of the VOCs of greatest concern is formaldehyde, a known human carcinogen.[23] 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.[24] Several countries have taken steps to regulate formaldehyde emissions in fabrics including Japan, The Netherlands,[25] Germany,[26] Finland[27] and Norway.[28]

In addition to formaldehyde, other VOCs such as benzene, acetylaldehyde, toluene, and xylene raise health and environmental concerns. The solvent benzene, for example, is associated with the increased risk of leukemia,[29] toluene (another solvent) is associated with lung cancer,[30] and benzene, toluene and xylene are all associated with an increased risk of non-hodgkin's lymphoma.[31]

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.[32] Often, the regulatory limits do not account for all health impacts or for the synergies of mixtures of VOCs that contribute to sick building syndrome and other health concerns even at low levels.

Where Are VOCs Used in Health Care Buildings?

Building materials finishes and furniture that can contain VOCs include carpet, resilient flooring, fabrics, furniture, wall covering, ceiling tiles, composite wood products (built-in and modular casework), insulation, paints and coatings, adhesives, stains, sealants and varnishes. Formaldehyde is used as a binder in composite wood and batt insulation, and in the fabric manufacturing process to prevent fabric from shrinking, for improved crease resistance, dimensional stability and color fastness. It is also used as a component of some finish treatments to enhance stain resistance.

What Programs Are in Place to Help Source Low VOC Materials?

Companies are employing all sorts of technologies to reduce or eliminate VOC emissions. Some companies are committed to eliminating VOCs from their products altogether, while others reformulate their products to reduce VOC emissions. There are many certification programs that measure VOC emissions and/or certify low VOC content for building materials and products, using a variety of different standards. Currently the best programs for evaluating long-term exposure hazards are generally based, at least in part, upon the California Special Environmental Requirements Section 01350 Standard for Emissions Testing. This standard, known as Section 01350, sets emissions testing protocol and exposure standards for formaldehyde and 80 other individual VOCs. (The Section 01350 test is a 14 day process that only addresses long term chronic exposure, not the short term acute exposure risks from the intense emissions during and immediately after installation.) There are a number of certification programs that follow California Section 01350 standards. (See Figure 2 for a listing). These certification programs provide lists of products that have met their certification standards.

The Section 01350 should be considered a minimum requirement for VOC emissions and should be used in conjunction with other screenings for the other chemicals of concern described below.

Semi-volatile Organic Compounds

What are Semi-volatile Organic Compounds (SVOCs)?

Semi-volatile organic compounds (SVOCs) are compounds with higher vapor pressures than VOCs and are released as gas much more slowly from materials and are likely to be transferred to humans by contact or by attaching to dust and being ingested. Semi-volatile organic compounds are used in building materials to provide flexibility (phthalates), water resistance or stain repellence (perfluorochemicals), as well as to inhibit ignition or flame spread (halogenated flame retardants).

Whereas VOCs tend to be emitted rapidly in the first few hours or days after installation of a product then taper off over time, SVOCs are released by products more slowly and over a longer period of time.

Why Are SVOCs a Problem?

A range of chemicals of concern used in building materials are showing up in increasing concentrations in human milk, blood and tissue samples, raising concerns about their growing potential for causing cancer or other health effects. Some of those chemicals are SVOCs, which have also been found in household dust released into the environment from building materials.[33] While there are many SVOCs in building products, phthalates (softeners used in PVC plastic), halogenated flame retardants (chemicals added to products to inhibit ignition), and perfluorochemicals (added to products for stain resistance or water repellency), warrant special concern.

FIGURE 2
California Section 01350 Comparable Indoor Air Quality Certification Programs for Building Materials

Collaborative for High Performance Schools (CHPS)—CHPS maintains a table listing products that have been certified by the manufacturer and an independent laboratory to meet the CHPS Low-Emitting Materials Criteria-Section 01350-for use in a typical classroom, including adhesives, sealants, concrete sealers, acoustical ceilings, wall panels, wood flooring, composite wood boards, resilient flooring (includes rubber) and carpet. This list also includes paint listings, but CA 01350 is not currently considered a robust standard for wet applied products and therefore not a replacement for low VOC paint screening. www.chps.net/manual/lem_table.htm

FloorScore—Scientific Certification Systems (SCS) certifies for the Resilient Floor Covering Institute (the trade association that promotes resilient flooring) that resilient flooring meets the 01350 VOC emission requirements. www.scscertified.com/iaq/floorscore_1.html

GreenGuard: Certification for *Children & Schools*—Air Quality Sciences (ACS) certifies for GreenGuard that furniture & indoor finishes meet the lower of 01350 VOC emission requirements or 1/100 of TLV (Threshold Limit Value an industrial workplace standard developed by the American Conference of Governmental Industrial Hygienists (ACGIH)) that covers many VOCs not covered by 01350. Ask for the *Children & Schools* Certification. GreenGuard's basic certification program (under which many more products have been certified) is significantly less rigorous. www.greenguard.org

GreenLabel *Plus*—The Carpet & Rug Institute (the trade association that promotes carpet) certifies that carpets, adhesives, and cushions meet 01350 VOC emission requirements. Ask for GreenLabel *Plus*. CRI's basic GreenLabel standard is significantly less rigorous. www.carpet-rug.com/News/040614_GLP.cfm

Indoor Advantage *Gold*—Scientific Certification Systems (SCS) certifies that wall coverings, systems furniture, casework, insulation and other non-flooring interior products meet 01350 VOC emission requirements. Ask for Indoor Advantage *Gold*. SCS's basic Indoor Advantage program is significantly less rigorous. www.scscertified.com/iaq/indooradvantage.html

VOC content-based standards

Green Seal Certified Products—Paints & coatings that meet the GreenSeal VOC (volatile organic compounds) content standards do not contain certain excluded chemicals and meet certain performance requirements. This is a VOC content certification only and does not deal with emissions. www.greenseal.org/certproducts.htm#paints

Phthalates

PVC plastic is a source of phthalate exposure in health care settings. Inherently rigid, PVC requires additives including phthalates (or softeners) to make it flexible enough for use in IV bags, wall covering, flooring, shower curtains, and upholstery. Some phthalates used to soften PVC are known reproductive and developmental toxicants.[34] Because they do not permanently bind to the PVC, phthalates can migrate out of the product into the air, soil and water. Emerging evidence links phthalates in PVC interior materials to respiratory problems such as rhinitis and asthma in adults and children,[35 36] and both obesity and insulin resistance in adults.[37] PVC production uses the vast majority of phthalates in the United States.[38]

Perfluorochemicals (PFCs)

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,™ Stainmaster,® and Scotchguard,™ PFC finishes are popular for their performance in the high traffic environment associated with hospitals and 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 ten 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 development damage. The U.S. EPA conducted a risk assessment of perfluorooctanoic acid (PFOA), and in the EPA's draft risk assessment found "suggestive evidence" that PFOA could cause cancer in humans.[43] The EPA's Science Advisory Board (SAB), in turn, recommended that the agency should classify PFOA as a "likely" carcinogen in humans.[44] Still, little is understood about the pathways of exposure to PFCs. We do know that humans are exposed, even in the womb. In a study from Johns Hopkins Bloomberg School of Public Health, researchers analyzed blood samples from the umbilical cord of 300 newborns in Baltimore and found PFOS and PFOA in 99% and 100% of newborns, respectively.[45]

Flame Retardants

The widespread use of petrochemical plastics and other synthetic materials, has increased the flammability of electronic products, foams, and textiles, making it necessary to add chemical treatments to meet fire safety standards, either through application to the finished product or as a component of the material production process. The most common approach has been to add halogenated flame retardants (HFRs), such as PBDEs, to many products to meet fire safety standards. Recent research, however, has raised concerns about the persistence and toxicity of many flame retardant chemicals.[46 47 48] Some flame retardants are now ubiquitous in the environment, including in remote areas such as the Arctic[49] and deep in the oceans.[50] 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.[51] 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,[52] 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[53] as well as in our rivers, lakes and streams.[54]

Where Are SVOCs Used in Health Care Buildings?

Phthalates are found in soft PVC building products, including vinyl flooring, upholstery, wall coverings, and shower curtains. (They are also used in non-building materials such as medical devices including IV tubing, blood bags, and catheters.) PFCs can be found in carpets, upholstery, fabric and furniture, and other places where stain resistance or water repellency is preferred. Halogenated flame retardants are found in fabric and furniture, electronic equipment, and foam cushions.

What Are the Alternatives to SVOCs?

Health care organizations throughout the country have been making strides to replace PVC flooring, vinyl composition tile (VCT), carpet backing, wall coverings, and other interior finishes and furniture with non-PVC alternatives, thus eliminating exposure to phthalates.

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 precautionarily based on scientific warning signs and removing or reducing the use of PFCs from 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.[58]

With HFRs found increasingly in biomonitoring of wildlife and humans, states are moving to ban some of the most commonly used HFRs from use in consumer and commercial products. Leading companies such as Dell and Hewlett Packard have pledged to remove HFRs from their electronic equipment by redesigning products or replacing HFRs with other, less volatile, compounds.

HALOGENATED FLAME RETARDANTS & PBDES

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. Polybrominated diphenyl ethers (PBDEs) are halogenated flame retardants 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, reproductive, nervous, and endocrine systems.[57]

Heavy Metals

What Are Heavy Metals?

Heavy metals are a group of metallic elements extracted from mined ores that can be highly toxic in their elemental form or in compounds. Definitions of the heavy metals vary, but some of the ones that have raised most concern about human and/or aquatic toxicity include arsenic, antimony, cadmium, chromium, copper, cobalt, lead, mercury and zinc. Heavy metals are used as stabilizers in vinyl plastic materials, most

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notably wire insulation and other PVC products, and can be found in a variety of other uses in roofing, solder, radiation shielding, and in dyes for paints and textiles.

Why Are Heavy Metals a Problem?

The use of heavy metals in building products leads to the release of these toxics into the environment during extraction, production, use and disposal and can have serious effects on human and ecosystem health. Because heavy metals bioaccumulate and often enter the water system, human exposure is a concern.

Lead and Mercury

Lead and mercury are potent neurotoxicants, particularly damaging to the brains of fetuses and growing children.[59] The reliance on lead and mercury in the building industry has reduced significantly over the past twenty years, but lead continues to be used in some building materials. Although health care organizations have made tremendous strides to reduce mercury in medical devices, you can still find some mercury in building products.

Cadmium, Chromium and Antimony

Cadmium is a carcinogen and can damage the kidney and lungs.[60] One type of chromium used in stainless steel production, known as chromium VI or hexavalent chromium, is listed by the International Agency for Research on Cancer (IARC) as a carcinogen.[61] Antimony trioxide, used as a synergist in flame retardants, is classified as a carcinogen under California Proposition 65.[62] Antimony is also used as a catalyst to make polyethylene teraphthalate (PET)—polyester.

Where Are Heavy Metals Found in Health Care Builidngs?

Heavy metals are found throughout a building system. Lead is in flashing terne, copper and other roof products, solder, batteries, and in some PVC products such as wire insulation jacketing and exterior siding. Mercury can be found in thermostats, thermometers, switches, and fluorescent lamps, Chromium VI can be found in chrome or stainless steel components of furniture. Cadmium, cobalt, antimony trioxide, and other metals may be incorporated into paint, dyes and pigments, fabric, and some PVC products such as resilient flooring.

What Are the Alternatives to Heavy Metals?

Because there are a wide range of heavy metals incorporated into building materials for a variety of applications, it is hard to identify all of the alternatives that can be used in lieu of heavy metals. Manufacturers such as Rohner Textile Company, have been successful at removing heavy metals from their products and still remaining viable on the market.[63]

Emerging Areas of Concern

While science is learning more and more about the human health hazards from dioxins, VOCs, SVOCs, and heavy metals (and finding more of these problem chemicals in biomonitoring testing of humans), new chemicals are introduced into the marketplace with little or no testing for safety or efficacy. Some of the emerging areas of concern in building materials include the recent marketing of antimicrobials, epoxy products made from bisphenol A, and nanotechnology for use in building products.

Antimicrobials

Antimicrobials are emerging 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, wallcovering, wall protection, and door hardware/handles. 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 bacterial resistance.[64] 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.

Serious questions are being raised in the industry however as to whether antimicrobials serve a measurably useful function in interior flooring and finishes for health care. The efficacy of antimicrobials 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."[65] Kaiser Permanente (KP) 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 there is "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.[66]

Bisphenol A

Epoxy resin is the primary compound used to make epoxy paint coatings, adhesives, and other products. A wide range of chemicals go into the manufacture of epoxy resins. Identifying all of the chemicals in an epoxy resin is a difficult and uncertain task. Material Safety Data Sheets (MSDS) and Technical Data Sheets (TDS) are notoriously inconsistent in their level of detail and generally fail to reveal proprietary blends and processes. Nonetheless, we know that epoxy resins tend to have two chemicals of concern in common in their manufacture: bisphenol A (BPA) and epichlorohydrin. Both of these chemicals pose significant known occupational hazards. They are intermediary chemicals only - used in the manufacture of the resin but not intentionally included in the final product. Nonetheless, there are indications that users are still at risk, at least from BPA. A Japanese study of workers spraying epoxy resin products in a factory at least three hours per day found that the epoxy resin in question may break down to BPA in the human body and further that the BPA may disrupt secretion of gonadotrophic hormones in men and suggested that the "[c]linical significance of the endocrine disrupting effects of bisphenol A should be further investigated in male workers."[67]

Bisphenol A is also used to make polycarbonate plastics and has come under increasing levels of scrutiny by scientists and researchers who are concerned that bisphenol A is leaching from polycarbonate plastics used in baby bottles and food can liners and may be implicated in interference with the endocrine system.[68]

Nanotechnology

Nanotechnology is the infusion of microscopic nano-materials directly into a product so that it can have certain attributes (depending on the product goals). For example, nano-materials are added to fabric fibers to provide inherent 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.[69] Among other attributes, their small size means that they can penetrate the defenses of cells in the body and carry other chemicals with them. 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."[70] 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.[71]

Conclusion

While we cannot expect the building 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, manufacturers can reduce or remove problem chemicals quickly without compromising the performance and aesthetics of the building material. Perhaps innovative efforts can bring to market more sustainable products with even greater performance and aesthetic characteristics than the industry is accustomed to.

With greater awareness of the health issues in relation to building materials, end users and designers can make more informed decisions and collectively help move the market by their specifications and purchasing power. The marketplace for alternatives to hazardous chemicals in building products increases daily. More and more large market players, such as Wal-Mart, Dell, and H &M, are publicly committed to sourcing products made without the use of chlorinated plastics, VOCs, SVOCs, and/or heavy metals. Health care institutions are uniquely positioned to play a leadership role in moving away from toxic building products by sourcing healthier materials and signaling the marketplace that the use of dangerous chemicals will no longer be tolerated.

APPENDIX A

Green Materials Hierarchy for Healthcare[72]

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:

1. Persistent, bioaccumulative, toxics (PBTs) or
2. Very persistent, very bioaccumulative (vPvB) chemicals

b. Avoid materials that contain:

1. Carcinogens
2. Mutagens
3. Reproductive or developmental toxicants
4. Neurotoxicants
5. 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:

1. Grown without the use of genetically modified organisms (GMOs).
2. Grown without the use of pesticides containing carcinogens, mutagens, reproductive toxicants, or endocrine disruptors.
3. Certified as sustainable for the soil and ecosystems.
4. 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.

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ENDNOTES

1 This paper is based on previous publications from the Healthy Building Network and/or Health Care Without Harm, including The Future of Fabric; Health Care (2007), which was co-written with Jean Hansen, HDR, Inc.

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