From Here to Innovation: Safer Alternatives in Building Product Materials

S. Drake*, T. Lent**

*Perkins+Will, San Francisco, CA, USA, suzanne.drake@perkinswill.com
**Healthy Building Network, Berkeley, CA, USA, tlent@healthybuilding.net

ABSTRACT

The demand for non-toxic building products is encouraging manufacturers to replace "worst offender" chemicals with safer alternatives. This presents an opportunity for manufacturers to innovate with greener chemistry. Transparency (ingredient disclosure) in the building industry has been growing, pressuring manufacturers to disclose more about the composition of products than ever before. The public's alarm about "hidden dangers" lurking in their cleaning products, personal care products, and in the built environment reinforces the need for transparency. A reformulation that utilizes chemistry with a less hazardous class of substances firmly differentiates the new product from the old and offers a competitive advantage in the marketplace. A common obstacle to achieving this innovation, however, is lack of data. The Data Commons is a collaborative effort to identify substances that are hazardous to human and environmental health, in order to find safer alternatives.

Keywords: green chemistry, healthy materials, building products, safer alternatives

1 TRANSPARENCY

Within the building and design industry in North America, the "transparency movement" refers to the growing trend of building owners and design professionals demanding to know what building products are made of. Increasingly, manufacturers are expected to provide a simple ingredient list, like a nutrition label found on food products that provides a standardized disclosure of all intentional ingredients found within the product. The Health Product Declaration (HPD) was developed by the design industry to provide building product manufacturers with a structured format for full disclosure of product content and associated hazards [1]. The HPD reports on the chemical inventory of a product, focusing on the presence of health hazards. That leaves the evaluation of those hazards in the hands of the design professional and their clients. They may use this information to extrapolate what the risk to their client (or the occupant) might be, and offer recommendations of one product over another.

With disclosure beginning to take hold, the challenge for manufacturers and users alike is how to start designing and selecting safer products.

While there are long lists of chemicals to avoid, established by government agencies (such as California Proposition 65 and Canadian EPA Environmental Registry Domestic Substances List) and "red lists" established by non-government agencies (like Cradle to Cradle's Banned List and International Living Futures' Red List) [2], it can be challenging for a design professional to know if one product is actually less toxic than another. These professionals are not trained in toxicology (much less chemistry), nor are the chemists and product designers—the industry is fraught with ambiguity, confusion, misinformation, data gaps, and concern. With good reason: transparency has come to the forefront as design trends focus on human health and wellbeing as a component of environmental sustainability, and as people in general become more aware of the negative impacts of chemicals all around them.

In North America, people spend upwards of 90% of their time indoors [3], exposing us to a wide range of chemicals in the products that create indoor space, some of which are known or suspected to have serious health effects including endocrine disruption, causing cancer, mutating DNA, and more [4]. The interior finishes of a single room—your office, a laboratory, the classroom—may be made up of mixtures of hundreds of chemicals in the plastics (flooring, furniture, wire and cable sheathing), solvents and sealants (paint, adhesives), with many more behind the walls (plastic piping, spray insulation, more adhesives) and on the exterior of the building (plastic roofing membranes, plastic window and door trim, sealants and caulking, metal coatings). Researchers are just beginning to understand that exposures to these chemicals may be affecting our health [4].

With the growing concern about these products and their effect on human health, there is a parallel demand for products that are "clean" (non-toxic) for building projects with sustainability goals. Is a building sustainable if it requires the use of hazardous materials, or exposes occupants to toxic chemicals? Architects, designers, and building owners are answering this question "no." Is there adequate information available to select less hazardous products? The answer too often is "no." In response, the leading green building rating system, Leadership in Energy and Environmental Design (LEED), now incentivizes disclosure and product improvement (optimization). In the first step, the rating system rewards the use of products for which manufacturers have provided content disclosure through an HPD or similar approach [5]. While this step does not require the removal of toxics from products or their supply chains, it does establish the requirement for disclosing all ingredients. The requirement for transparency socializes the act of disclosure of data previously held by manufacturers as trade secrets. In addition, it exposes designers and specifiers to the data—becoming familiar with the terminologies, learning about supply chains, and raising general awareness of product ingredients.

For now, disclosure gains one LEED point and optimization—using products that avoid known hazards—a second.

Three programs may be used to document optimization: GreenScreen, Cradle to Cradle product certification, and the European Chemicals Agency's REACH system.

GreenScreen for Safer Chemicals is a chemical hazard assessment protocol [6]. It includes a screening protocol based on authoritative hazard lists to quickly identify known high hazards, and a more in-depth toxicological assessment to grade chemicals on the level of inherent hazards using a four point scale.

Cradle to Cradle (C2C) is a product certification program [7]. The protocol used to audit products for certification has many similarities to GreenScreen, starting with screening certain high hazard substances, followed by a more in-depth toxicological assessment of the product's content. Unlike the GreenScreen, high hazard substances in C2C certified products or manufacturing might be permitted if the assessor determines that there is no likely exposure. The certification also assesses the manufacturing process across four other categories (water, energy, material reutilization and social fairness), and requires a commitment to optimize the product over time. The manufacturer's trade secrets are protected through non-disclosure agreements.

The REACH program is Europe's chemical regulatory system, which requires hazard avoidance on the part of manufacturers using chemicals in their products. It has established lists of Chemicals of Very High Concern that are banned except for carefully authorized uses. The product manufacturer must publish an ingredient list to demonstrate compliance with this program.

To summarize, design professionals are demanding disclosure from manufacturers, and may use that information to screen products based on the hazards they contain. Manufacturers, product designers, and chemists must undertake assessing specific ingredients and optimizing (replacing with lower hazard content). Toxicologists may be involved to assess levels of hazard and in some cases ascertain exposure risks posed by any given hazard within a given context.

2 REGRETTABLE SUBSTITUTIONS

With growing public awareness of the "hidden dangers" all around them, public calls for bans of specific substances arise periodically. The uproar around the use of bisphenol A (BPA) is one example. While the relative hazards and risks of this chemical were debated at the federal level, many state and local municipalities took action with their own bans. Many manufacturers, feeling the heat from customers began offering "BPA-free" options before regulations forced the issue. One common replacement for BPA was TPP. While TPP had not been previously flagged on hazard lists, toxicological study soon revealed it to be potentially as bad or worse than the BPA it was replacing [8]. Other substitutes for BPA include other endocrine disruptors, mimicking estrogen in breast cancer cells [9]. This is known as a regrettable substitution. What can a manufacturer do to avoid a similar situation?

This example underlines the major problem with substance-specific avoidance through red lists: ban a specific substance, and chemists and material designers will do what they are trained to do—look for or create a structurally similar substance to get similar performance. While this often is convenient in the short term, it raises the likelihood of a regrettable substitution. Similar molecular structures tend to have similar health hazards. More often than not, this approach results in more of the same: eventually the new (same old) hazards will be realized, customer trust will be eroded, and the manufacturer will have to incur new investment to reformulate again.

As a manufacturer or product designer, how can you ensure that a reformulation does not result in a regrettable substitution? If you are going to dedicate research and development to a reformulation or a retooling, how can you be sure hazardous substance x is being replaced with a substance that is actually less hazardous? Perhaps even more important, how can you ensure that your current product formulations do not open you to future business risks like the BPA issue?

The most fundamental way to approach this challenge is to design and formulate products utilizing the principles of green chemistry, which includes waste prevention, energy efficiency, and design for degradation, all at the molecular level [10].

Short of creating new chemistry, however, the easiest way to start down the path of avoiding hazardous content and regrettable substitutions is to review product content and potential alternatives for membership in chemical classes of concern—section 3 below (Class Approach) describes this in more detail.

Simply substituting outside of these classes, however, does not provide assurance of lack of hazard. Section 4 below (Assessment Tools) will describe tools available now to assess the science on any chemical and avoid known and predicted hazards.

3 CLASS APPROACH

Organizing efforts at the level of "chemical class," instead of specific substance, reduces the molecular whack-a-mole, and hence potential regrettable substitutions and unfavorable consumer perceptions.

As noted above, chemicals with similar molecular structures tend to have similar health hazards. This phenomenon can be used to identify chemical compounds that, while not yet fully tested, are likely to be found highly hazardous based upon their similarity to compounds that are known to be hazardous.

Authoritative governmental bodies have long used this phenomenon to extend their determinations on the associations of chemicals with health hazards. For example, the World Health Organization's International Agency for Research on Cancer (IARC), has determined that there is sufficient evidence from the study of a wide range of cadmium-based compounds and polychlorinated biphenyls (PCBs) to classify all members of both of those groups as cancer causing [11].

The Pharos Chemical and Material Library lists over 466 such chemical groupings that have been identified by authoritative state, national, or international governmental bodies as chemical classes with a known or suspected serious health hazard [12].

The Green Science Policy Institute (GSPI) proposes six classes of chemicals as targets to prioritize for elimination from use in industry based on evidence of high hazard among studied members of the class and broad population exposure to these chemicals in consumer products and building materials [13]. The six groupings GSPI identifies are:

- Highly fluorinated chemicals
- Antimicrobials
- Flame retardants
- Bisphenols and phthalates
- Organic solvents
- Certain metals

Molecular structure defines four of the six classes that GSPI suggests to avoid. In two cases, however—antimicrobials and flame retardants—the class is defined by function rather than by molecular structure. These represent a different but complementary design philosophy to that of avoiding specific molecular classes of known concern. "Is it needed?" is a critical question to ask when considering the functionality of each chemical within a formula, using this mode of thinking. For example, antimicrobials have been increasingly heavily promoted in a variety of consumer, health care and building products. Evidence is mounting, however, that they provide no benefit to human health and indeed present a variety of potential hazards and should simply be removed [14].

Manufacturers of flame retardant chemistry have heavily promoted fire codes that virtually require the use of their products, but evidence has shown that the codes miss the mark, the chemicals are highly hazardous to human health, and they do not increase public safety [15]. Their function—flame retardancy—has been the subject of multiple cases of regrettable substitutions with members of several different molecular classes with no fire safety benefit. Hence, the building design industry and their allies have successfully lobbied to change regulations [16], and have moved aggressively to encourage manufacturers to avoid the use of flame retardants from furniture and other building products wherever possible [17].

4 ASSESSMENT TOOLS

Removing chemicals that are members of known hazardous classes is an important step in developing a safer product. This, however, only provides a prioritized place to start. Many highly hazardous substances are not included in any class of concern. Removing hazardous content and avoiding making regrettable substitutions requires a careful screening of all content for hazard. Happily, there are protocols and tools that facilitate this process.

The most thorough public standard for assessing and benchmarking the inherent hazard of chemicals is the GreenScreen for Safer Chemicals. It includes a List Translator that provides guidance for screening product contents against a wide range of authoritative governmental lists that associate chemicals with health hazards. The List Translator can provide sufficient information to confirm that a chemical is a known high hazard, referred to as a Benchmark 1. These authoritative lists cover a limited number of chemicals and health endpoints and cannot be used to affirm that a chemical is low hazard (higher Benchmark). To provide a more complete profile of the potential health impacts of a chemical and affirm a higher benchmark, the GreenScreen provides a protocol for a full assessment, toxicological review using scientific literature, with chemical and modelling techniques to fill data gaps in the literature.

However, one need not be a toxicologist to make use of either the list screening or full assessment tools of the GreenScreen. A number of tools, both public and commercial, are now available that rate chemicals using GreenScreen ratings. The most comprehensive public resource is the Healthy Building Network's Chemical Hazard Data Commons [18]. The Data Commons includes a database of over 40,000 chemicals, screened against all of the authoritative listings of the GreenScreen List Translator and others. It also provides the most comprehensive listing of GreenScreen full assessments that are either in the public domain or available for licensed use. The Commons toolbox includes functions to set up groups of chemicals to compare.

The Data Commons is not just a lookup tool for chemical hazards. It is also a collaborative effort to improve the identification of substances that are hazardous to human and environmental health and find safer alternatives. In addition to being a source for hazard listings, GreenScreen assessments, and physicochemical information, it is a place to share relevant scientific literature, discuss emerging science, and help the community address critical hazard assessment issues. New projects are underway to cross-reference functional use information with hazard to facilitate searches for and assessments of alternatives.

5 CONCLUSION

Rising concern about the health impact of chemicals of concern in our products has turned into an expensive process of whack-a-mole for manufacturers trying to avoid the chemical most recently in the news. Manufacturers can make the process manageable and future-proof their investments by pursuing full understanding of their product content, providing transparency through disclosure, and using the chemical class approach to set product reformulation priorities, complemented by full content screening through tools like the Chemical Hazard Data Commons.

REFERENCES

[1] Health Product Declaration Collaborative http://www.hpd-collaborative.org/

[2] Office of Environmental Health Hazard Assessment (OEHHA), State of California, Proposition 65 List: https://oehha.ca.gov/proposition-65/proposition-65-list

Environment Canada, Domestic Substances List: http://www.ec.gc.ca/lcpe-cepa/default.asp?lang=En&n=5f213fa8-1

Cradle to Cradle Product Innovation Institute, Banned Lists of Chemicals Cradle to Cradle Certified Product Standard Version 3.0 http://s3.amazonaws.com/c2c-website/resources/certification/standard/C2CCertified_Banned_Lists_V3_121113.pdf Accessed 21 Mar. 2017.

International Living Future Institute, Red List: https://living-future.org/declare/declare-about/red-list/

[3] Klepeis, Neil E. et al. "The National Human Activity Pattern Survey (NHAPS): A Resource For Assessing Exposure To Environmental Pollutants". *Journal of Exposure Analysis and Environmental Epidemiology* 11.3 (2001): 231-252. Web.

[4] In addition to authoritative lists naming specific chemicals, the studies listed below are examples of studies that have contributed to the body of knowledge identifying the toxic nature of many chemicals and their presence in the built environment:

Bergman, Ake et al. State Of The Science Of Endocrine Disrupting Chemicals - 2012. United Nations Environment Programme and the World Health Organization, 2013. Web. 23 Mar. 2017.

Thornton, Joe. Environmental Impacts Of Polyvinyl Chloride Building Materials. Washington, DC, USA: Healthy Building Network, 2002. Web. 23 Mar. 2017.

Stapleton, H. M., S. Klosterhaus, et al. (2009). “Detection of Organophosphate Flame Retardants in Furniture Foam and U.S. House Dust.” *Environmental Science & Technology* 43(19): 7490-7495.

[5] Nutcher, Paul. "DCD Insights | What To Expect In The New LEED V4 Materials And Resources Credits". Dcd.com. N.p., 2017. Web. 23 Mar. 2017.

[6] Clean Production Action, GreenScreen for Safer Chemistry http://www.greenscreenchemicals.org

[7] Cradle to Cradle Product Innovation Institute, Cradle to Cradle Certified Product Standard http://www.c2ccertified.org/get-certified/product-certification

[8] Blake, Mariah. "The Scary New Evidence On BPA-Free Plastics". *Mother Jones* 2014. Web. 7 Mar. 2017.

[9] Mesnage, Robin et al. Transcriptome Profiling Reveals Bisphenol A Alternatives Activate Estrogen Receptor Alpha In Human Breast Cancer Cells. 2017. Web. 23 Mar. 2017.

[10] Anastas, P. T., and J. C. Warner. Green Chemistry: Theory And Practice. 1st ed. New York: Oxford University Press, 1998. Print.

[11] World Health Organization’s International Agency for Research on Cancer (IARC) IARC Monographs on the Evaluation of Carcinogenic Risks to Humans Cadmium Monograph: https://monographs.iarc.fr/ENG/Monographs/vol100C/mono100C-8.pdf

[12] Healthy Building Network, Pharos Chemical and Material Library https://www.pharosproject.net/material/chemical 22 Mar. 2017.

[13] www.sixclasses.org

[14] Coffin, Melissa, and Suzanne Drake. Understanding Antimicrobial Ingredients In Building Materials. Perkins+Will, Inc., 2017. Web. 23 Mar. 2017. Healthy Environments.

[15] Callahan, Patricia, Sam Roe, and Michael Hawthorne. "Playing With Fire". *Tribune Watchdog* 2012: n. pag. Print.

[16] Standen, Amy. "It’S Official: Toxic Flame Retardants No Longer Required In Furniture". KQED Science. N.p., 2017. Web. 23 Mar. 2017.

[17] Dedeo, Michel, and Suzanne Drake. Strategies For Avoiding Flame Retardants In The Built Environment. Perkins+Will, 2014. Web. 22 Mar. 2017. Healthy Environments.

[18] Healthy Building Network, Chemical Hazard Data Commons https://commons.healthymaterials.net