Sports Turf Alternatives Assessment:
CHEMICALS IN ARTIFICIAL TURF INFILL: OVERVIEW

February 2017

Introduction

The Massachusetts Toxics Use Reduction Institute (TURI) conducts alternatives assessments as part of its overall mission to help Massachusetts companies, communities, and municipalities identify and implement toxics use reduction options that will provide safer solutions to the use of toxic chemicals.

This document provides an overview of issues related to chemicals in artificial turf infills. It is one section of a larger series. The documents in this series cover the following topics related to athletic fields: cost analysis; physical and biological hazards; overview of infills; tire crumb infill; EPDM infill; and TPE infill. Together, they form a preliminary alternatives assessment.

This document was written in 2017 and was re-posted on the Lowell Center for Sustainable Production website with minor revisions in 2024. The full series is available at https://www.uml.edu/research/lowell-center/athletic-playing-fields/.

Overview: Infill Materials

The most commonly used artificial turf infill is made from recycled tires. This material is frequently referred to as crumb rubber, or as styrene butadiene rubber (SBR). For purposes of the present discussion, the recycled tire material is referred to as "recycled tires" or "tire crumb."

A number of materials are currently marketed as alternatives to recycled tires. Some are based on synthetic materials, while others are mineral- or plant-based, or contain a mixture of natural and synthetic materials. As shown in Table 1, below, alternative synthetic infills include ethylene propylene diene terpolymer (EPDM), thermoplastic elastomer (TPE), and proprietary products made from waste athletic shoe materials, among others. Mineral-based and plant-derived materials used in infill can include sand, cork, and coconut hulls, among other materials. Among infills that include a combination of sand and synthetic materials, one example is a product made from acrylic-coated sand.

Table 1: Synthetic turf infill materials: Overview

	Material	**Comments**
Synthetic	Recycled tires	Principal material is generally styrene butadiene rubber (SBR). May be referred to as "crumb rubber," "tire crumb," or "SBR."
	Ethylene propylene diene terpolymer (EPDM)	Also referred to as ethylene propylene terpolymer, ethylene propylene diene monomer, or ethylene propylene elastomer.
	Waste athletic shoe materials	Proprietary material; may contain a variety of polymers.
	Thermoplastic elastomer (TPE)	Broad category; can refer to a variety of materials.
Mineral- or plant-based	Sand	May be used in combination with one another or with other materials.
	Cork	

	Coconut hulls	
Combinations	Acrylic-coated sand	A variety of other combinations may be available as well.

Understanding rubber and plastic products: Key concepts

When working to understand the variety of materials that may be used in infills, it is helpful to understand some key concepts related to rubber, plastics, and other polymer materials.

Polymers. Rubber and plastic materials are polymers. Polymers are materials that are composed largely of many similar units bonded to one another.

Multiple materials. Within a given category of infill, a variety of specific materials may be used. For example, the broad categories of EPDM, TPE, and waste athletic shoe materials each can include a variety of specific materials, with a variety of additives and a variety of toxicological profiles. For this reason, it is difficult or impossible to make broad statements about the safety of a given product in any of these categories unless one has access to more detailed information.

Additives. Each material may be used with a variety of additives. These additives can include cross-linking agents, accelerators, stabilizers, plasticizers, fillers, or antimicrobials. The additives can have adverse health and environmental effects. The full list of additives is frequently not disclosed, although it may be possible to obtain guarantees that specific additives are absent, or are below a specified threshold.

Understanding rubber and plastic products: Additional terminology

For those interested in understanding more about rubber and plastic products, the following terminology may be useful.

Thermosets vs. thermoplastics. Both natural and synthetic rubbers are **thermosets**. A key characteristic of a thermoset is that although heat is used in the initial manufacture of the material, once the material has been formed, it cannot be melted. For this reason, tires and other products made from thermosets cannot be melted and re-formed into new products. Among the materials used in artificial turf infills, SBR, EPDM and shoe sole materials are all thermosets.

Thermoplastics, in contrast, are materials that can be melted and re-formed into new shapes. Thermoplastic elastomers (TPEs) are one broad category within the larger category of thermoplastics.

Curing/crosslinking/vulcanization. Thermosets gain their stability through a process of **curing**, also referred to as crosslinking or vulcanization. Curing is a process of creating links among polymer strands in order to create a stable, three-dimensional structure. In the case of a thermoset, these links are composed of irreversible chemical bonds.

A variety of chemicals can be used in the curing process. These include chemicals that become part of the crosslinking bond, as well as chemicals that catalyze or accelerate the crosslinking process. The term “vulcanization” is often used specifically to refer to crosslinking with sulfur.

In contrast to the large molecules of a polymer, the molecules added in the curing process are often relatively small. Some of these molecules may remain present as free molecules in the final material, and these may be released during product use.

Plasticizers. Plasticizers are added to stiff or rigid materials to make them more pliable. One important category of plasticizers is the pthalate esters, also referred to simply as phthalates. Mineral oil can also be used as a plasticizer. The specific plasticizers used in a given product are frequently not disclosed.

Other additives. A variety of other additives may be used in rubber and plastic products. **Fillers** such as carbon black or silica can be used to attain specific material properties or simply to extend the volume of the material. **Stabilizers** can be added to decrease the effect of light, heat or other environmental conditions on the material. A range of chemicals can be used as stabilizers. Other additives that may be used include **pigments** and **antimicrobial agents**.

In summary, a variety of chemicals can be found in materials that are marketed for use as infill. Therefore, it is important to conduct thorough research on the materials. In addition to understanding what type of polymer the material is, it is important to investigate what additives are present in it.

Regulatory standards

When testing artificial turf infills for the presence of toxic chemicals, manufacturers, regulators and others sometimes compare their results to a variety of regulatory standards. In the absence of a comprehensive regulatory regime developed specifically for artificial turf, those testing the materials have made an effort to determine which of existing standards may be relevant.

TURI's approach is to seek opportunities to reduce or eliminate the use of toxic chemicals whenever possible; this approach does not require application of any specific threshold or standard, and does not employ any assumptions about acceptable levels of exposure. However, it is useful to note which standards have been used to evaluate a given product, and to consider the relevance and utility of these standards. Therefore, some background information is provided here.

Environmental standards. Some studies compare the infill testing results with regulatory standards for contamination of soil. For example, a study by the Norwegian Building Research Institute compared the infill with regulatory standards developed by the Norwegian Pollution Control Authority for "most sensitive land use," encompassing "areas intended for housing, gardens, nurseries, schools, etc." For chemicals not covered by this standard, the researchers made reference instead to Canadian guidance values for agricultural soil, and to Predicted No Effect Concentrations developed through a European Union risk assessment program.[1]

A study conducted in Connecticut checked lead levels in the artificial turf infill and fibers against values considered by the US EPA to pose a "soil-lead hazard" in play areas.[2] A related study in Connecticut checked zinc levels in stormwater samples from the artificial turf field against federal and state regulatory levels for drinking water, surface waters and groundwater.[3] Other environmental standards sometimes used as a measure against which to compare infill include the Toxic Characteristic Leaching Procedure (TCLP), a standard that simulates leaching conditions that could occur in a landfill and is used to determine whether a material is subject to regulation as a hazardous waste under the Resource Conservation and Recovery Act (RCRA).[4]

Reference is also made in some cases to a German standard for artificial turf, DIN V 18035-7.[5] Individual manufacturers have also cited a variety of other standards.

California Proposition 65. Other tests have compared the artificial turf results with standards for reporting under California's Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65). This law requires disclosure of the presence of chemicals that are identified by the state of California as causing cancer or reproductive harm.

European Toy Safety Standard. A number of tests have been designed to examine infill in relation to the European Standard EN 71-3 – Safety of Toys Part 3: Migration of certain elements. EN 71-3 "specifies requirements and test methods" for migration of 19 metals or categories of metal compounds from "toy materials and from parts of toys."

Since this test is cited frequently, it may be useful to understand its structure. As shown in Table 2, below, the standard divides toy materials into three categories: Category I ("dry, brittle, powder like or pliable materials"), Category II ("liquid or sticky materials"), and Category III ("scraped-off materials").[6]

For each category, certain assumptions have been made about the amount a child may ingest in the course of play. For Category II, the standard is based on an assumption that a child may ingest 400 mg per day of the material. For Category III, the standard is based on an assumption of a much lower level of ingestion of the material, at 8 mg per day. Category I makes an intermediate assumption that a child may ingest 100 mg per day.[7]

Corresponding to these assumptions about ingestion, Category III has the highest values for each metal (i.e. it is the easiest standard for a material to meet) and Category II provides the lowest values (i.e. it is the most difficult standard for a material to meet). For example, for lead, Category III allows the presence of up to 160 mg/kg of lead in the material, while Category II allows up to 3.4 mg/kg.

A number of manufacturers have compared the results of their infill tests against the Category III values. For purposes of TURI's analysis, we have checked those same results against the somewhat more stringent Category I values. Regardless of the category used, it is important to note that the EN 71-3 standard was designed for toys, and may have limited applicability to synthetic turf infill.

Table 2: Categories of toy materials under EN 71-3			
	Category 1	**Category II**	**Category III**
Category description	"Dry, brittle, powder like or pliable materials"	"Liquid or sticky materials"	"Scraped-off materials"

Additional information	"[I]ncludes solid *toy material* from which powder-like material is released during play. The material can be ingested. Contamination of the hands with powder contributes to enhanced oral exposure."	"[I]ncludes fluid or viscous *toy material* which can be ingested and/or to which dermal exposure occurs during playing."	"[I]ncludes solid *toy material* with or without a *coating* which can be ingested as a result of biting, tooth *scraping*, sucking or licking. This category includes those materials which are not covered by category I and II."
Categorization of "common toy materials": Examples	• "Compressed paint tablets, materials intended to leave a trace … (e.g. the cores of colouring pencils, chalk, crayons)" • "Pliable modelling materials, including modelling clays"	• "Liquid paints" • "Glue sticks"	• "Coatings of paints • "Polymeric and similar materials, including laminates" • "Paper and board" • "Textiles" • "Glass, ceramic, metallic materials," • "Other materials … (e.g. wood, fibre board…)"
Assumed ingestion (mg/day)	100	400	8
Sample value: Lead (mg/kg)**	13.5	3.4	160
Source: European Standard EN 71-3:2013+A1. October 2014. ICS 97.200.50. *Safety of Toys – Part 3: Migration of Certain Elements.* Available at https://law.resource.org/pub/eu/toys/en.71.3.2015.html,viewed October 4, 2016. Information shown here is drawn from Table 1 (Cross-reference table for determining category), Table 2 (Migration limits from toy materials), and Annex H (Rationale).			

ASTM standard. In 2016, ASTM International issued a standard for testing infill for certain metals, measuring the amount to which players could be exposed in case of accidental ingestion of the infill.[8] A number of industry groups announced in November 2016 that they would voluntarily adopt the standard, ASTM F3188-16.[9] (Business Wire 2016)

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The Toxics Use Reduction Institute is a multi-disciplinary research, education, and policy center established by the Massachusetts Toxics Use Reduction Act of 1989. The Institute sponsors and conducts research, organizes education and training programs and provides technical support to help Massachusetts companies and communities to reduce the use of toxic chemicals.

The Lowell Center for Sustainable Production uses rigorous science, collaborative research, and innovative strategies for communities and workplaces to adopt safer and sustainable practices and products to protect human health and the environment. The Lowell Center is composed of faculty, staff, and graduate students at the University of Massachusetts Lowell who work with citizen groups, workers, businesses, institutions, and government agencies to build healthy work environments, thriving communities, and viable businesses that support a more sustainable world.