Sports Turf Alternatives Assessment: Preliminary Results
CHEMICALS IN ALTERNATIVE SYNTHETIC INFILLS: THERMOPLASTIC ELASTOMER (TPE)

Massachusetts Toxics Use Reduction Institute
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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.

TURI has received numerous requests for information about artificial turf fields as an alternative to natural grass fields. In response, TURI is developing an alternatives assessment for sports turf. Preliminary sections of the assessment are being published in the order in which they are developed.

The section presented here covers information on chemicals found in one type of synthetic infill: thermoplastic elastomer (TPE). TPE is marketed as an alternative to crumb rubber made from recycled tires (also referred to as styrene butadiene rubber, or SBR). Information for this section has been drawn from government agency reports, peer reviewed literature, technical experts, and industry publications. This information may be updated over time as new information becomes available.

For background on the types of materials that can be used in infills, as well as the regulatory standards that are sometimes referenced by manufacturers and others, see "Chemicals in Artificial Turf Infill: Overview."[1]

TPE: Material description

Thermoplastic elastomer (TPE) is a general term that can encompass a variety of materials. As a family of polymers, TPEs are characterized by their ability to maintain their form after being stretched, and generally do not require curing or vulcanization during manufacturing.[2] Vulcanization is a process by which additives are used to modify and strengthen a polymer by forming cross-links among polymer chains.[*]

According to a description in an industry source, TPEs are composed of two materials: one that is "hard at room temperature and fluid when heated," and one that is "soft and rubber-like at

[*] Note: Although TPE's are generally characterized by not being vulcanized, some TPE's contain a vulcanized material as one part of the mix, further complicating the distinctions among material types.

room temperature." The two materials can be either chemically bonded or blended together. Examples of chemically bonded TPEs include "styrenic TPEs, thermoplastic polyurethanes (TPUs), copolyester-ether elastomers and polyamide elastomers." Examples of blended TPEs include "thermoplastic polyolefins (TPOs) and thermoplastic vulcanizates (TPVs)."[3]

Based on the limited information available on TPE used in synthetic turf infill materials, it appears to contain lower levels of toxic chemicals than crumb rubber made from recycled tires. In particular, measurements indicate that TPE infill emits fewer volatile organic compounds (VOCs). Furthermore, since TPE does not require vulcanization, it is generally expected to be free of the vulcanizing agents that are used in crumb rubber made from tires.[4] However, TPE infill can contain and emit some chemicals of concern.

TPE infills are available from a number of manufacturers. Table 1 shows examples of brands currently on the market. This list is not intended to be comprehensive, and new brands may enter the market frequently.

Table 1: TPE infill products: Examples

Manufacturer	Brand Name	Descriptive information
FieldTurf	EcoMax	"An extruded composite of thermoplastic elastomer (TPE)"
FieldTurf	EcoGreen	"built from virgin TPE"
Celanese SOFTER	Holo	"special Thermoplastic Elastomers compounds (TPE)"
TTII	Pro-Max 37 TPE Infill	"polyethylene-based polymer"

Sources: FieldTurf. "ECOSPORT: High Quality Alternative Infill Systems." Web page accessed at http://www.fieldturf.com/de/ecosport, May 31, 2017; Target Technologies International Inc. (TTII). "Pro-Max 37 TPE Infill." Web page accessed at http://www.ttiionline.com/products/pro-max-37-tpe-infill/, May 31, 2017. Celanese SOFTER. "Holo: TPE Infill Solutions." Web page accessed at http://www.tpeinfill.com/viewdoc.asp?co_id=40, June 2, 2017.

Recycled tires vs. TPE infill: Norwegian Pollution Control Authority Study

A 2006 study by the Norwegian Pollution Control Authority concluded that TPE infill was superior to crumb rubber infill based on the chemicals examined in the study. However, the authors were not able to make a broad recommendation about TPE infill because they did not know what other chemicals it contained.[5]

The study compared three indoor fields: two containing crumb rubber (SBR) infill made from tires, and one containing TPE infill. The study focused on airborne dust, volatile organic compounds (VOCs), and polycyclic aromatic hydrocarbons (PAHs). In testing the airborne dust specifically, the researchers considered the presence of rubber, vulcanization compounds, preservative compounds, phthalates, and PAHs. Over all, they found that the SBR infill produced more air quality contaminants than the TPE infill, based on the limited parameters they were able to examine in the study. The study parameters were designed on the basis of existing knowledge about chemicals found in SBR.

Table 2, below, summarizes the comparison among the fields studied by the Norwegian researchers. As shown in the table, in measurements of airborne dust, the quantity of particulate matter ($PM_{2.5}$) was elevated for the two SBR fields, while quantities were in the expected ranges for an indoor setting for the TPE field. In analyses of the chemical composition of the airborne dust, the researchers found that the SBR fields generated dust containing a large amount of rubber from the granulate, while the dust generated by the TPE field contained less rubber.[*] They noted that the dust generated by the TPE field was free of the vulcanization compounds, preservative compounds, and carbon black found in the SBR fields. Dust from all locations contained PAHs, but the levels in the dust generated by the TPE field were lower than those in the SBR dust.

The researchers found that total volatile organic compounds (TVOCs) in air were very high for the SBR fields. TVOCs were slightly elevated in the location with the TPE field, but much lower than those for the SBR fields. PAHs were also present in the air at all locations, but were lower in the location with the TPE field.

Among specific VOCs highlighted in the discussion, the authors noted that both benzothiazole and toluene were present in the air and dust associated with all three fields, although the levels were lower for the location with the TPE field. Another VOC they highlighted, 4-methyl-2-pentanone, was present at the SBR field locations but low or absent at the TPE field location. Phthalates were present at comparable levels at all locations; phthalates measured in airborne dust during one time period were slightly lower at the TPE field, but were higher at the TPE field during another time period.

The authors note that for all three field areas, they also found “the presence of organic chemicals which have not been identified or reported.” They did not test for the presence of inorganic compounds (e.g. lead or other metals).

The researchers concluded that the TPE infill appeared to be superior to the SBR infill with regard to over-all indoor air quality, but did not conclude by recommending TPE infill “as the study was not broad enough to give such a recommendation.”[6]

[*] Note: In the Norwegian Pollution Control Authority study, the term “rubber” is used for both SBR and TPE.

Table 2: Comparison: Recycled tire crumb rubber (n = 2 fields) vs. TPE infill (n = 1 field) (Dye et al. 2006)			
		SBR fields (n = 2)	TPE field (n = 1)
Airborne dust	Quantity of dust	Elevated $PM_{2.5}$	Expected levels for indoor air
	Composition of dust: rubber* from granulate	High	Lower
	Composition of dust: Other chemicals	Multiple chemicals present: PAHs, phthalates, SVOCs, benzothiazoles, aromatic amines, unspecified organic & inorganic substances	
	Vulcanization compounds	Yes	No
	Preservative compounds	Yes	No
	Carbon black	Yes	No
Air	TVOCs	Very high to high – exceeds recommended levels	Slightly elevated (lower than SBR)
	PAHs	Yes	Yes (lower than SBR)
Selected chemicals - dust and/or air	Benzothiazole	Yes	Yes (lower than SBR)
	Toluene	Yes	Yes (lower than SBR)
	4-methyl-2-pentanone	Yes	Low or absent
	Phthalates	Yes	Yes
	Unidentified compounds	Present	Present
	Inorganic compounds	not assessed	not assessed

Information summarized from: Dye, C. et al. 2006. *Measurement of Air Pollution in Indoor Artificial Turf Halls.* Trondheim, Norway: Norwegian Pollution Control Authority/Norwegian Institute for Air Research. *Note: In the study summarized here, the term "rubber" is used for both SBR and TPE.

Note: Findings from this study are not necessarily generalizable to other TPE fields. For example, the presence or absence of preservative compounds or of carbon black may vary depending on the type of TPE used.

Specific TPE infill products: composition

As noted above, a variety of specific materials can be broadly categorized as TPE. In order to examine a TPE product with a greater level of specificity, it is necessary to identify the material used in a given product, including both the elastomer itself and any additives it may contain.

In order to gain greater clarity about the composition of TPE infills on the market, TURI examined additional information on the composition of two TPE infill products. These products were selected as examples based on a simple internet search, and they are not necessarily representative of other TPE infill products.

First, TURI researched Pro-Max 37 TPE Infill marketed by Target Technologies International, Inc (TTII).

TTII provided TURI with a Material Safety Data Sheet (MSDS) for this product.[7] The MSDS specifies several components, identifying them by name and with a Chemical Abstracts Service (CAS) number. Table 3 shows the information that is available about the composition of this infill, using the information in the MSDS supplemented by information obtained through the US National Library of Medicine's database, ChemID*plus*. Based on the MSDS and ChemID*plus*, the product is composed of a styrene block copolymer, polyethylene, paraffin oil, calcium carbonate (chalk), carbon black, and unspecified stabilizers/antioxidants.

Table 3: TPE Infill: Sample product		
CAS #	**Name**	**Other information**
9003-55-8	Benzene, ethenyl-, polymer with 1,3-butadiene, a.k.a. 1,3-butadiene, polymer with styrene	Information from MSDS: "Main component(s): Styrene-ethylene/butylene-styrene block copolymer." "Thermoplastic polymer compound based on styrene block copolymer (SBC – CAS no. 009003-55-8; no. 66070-58-4)."
66070-58-4	Hydrogenated styrene/butadiene copolymer	
9002-88-4	Polyethylene	Described on MSDS as: Thermoplastic polymers olefin.
8012-95-1	Paraffin oil	MSDS notes presence of paraffin oil but shows CAS # for calcium carbonate. This appears to be an error in the MSDS. We have interpreted the MSDS to mean that the material does contain paraffin oil. Based on a search in *ChemIDplus**, the term "paraffin oil" could correspond to the CAS number 8012-95-1, or mineral oil. Alternatively, it could also correspond to other materials.
n/a	Stabilizers/antioxidants	Cannot identify based on this information.
471-34-1 or 72608-12 or 72608-12-9	Calcium carbonate	MSDS notes presence of calcium carbonate but provides a CAS # that does not exist (72608-9). However, calcium carbonate can be found with the CAS # 72608-12-9. The CAS # 471-34-1, which is the more common calcium carbonate registry number, is also shown in the sentence that mentions paraffin oil. We have interpreted the MSDS to mean that the material does contain calcium carbonate.
1333-86-4	Carbon black	Carbon black is not mentioned in the Composition section of the MSDS, but it is mentioned by name in the section on Regulatory Information. The CAS # for carbon black is not included. We have interpreted the MSDS to mean that the material does contain carbon black.
Sources: Target Technologies International, Inc (TTII) PRO-MAX 37 TPE Infill: http://www.ttiionline.com/products/pro-max-37-tpe-infill/, viewed August 1, 2016. Material composition is from Material Safety Data Sheet for TTII Pro-Max 37, prepared by Felix Compounds. Provided by Chris Taylor, Sales Coordinator, via email on June 13, 2016. *US National Library of Medicine. ChemIDplus: A TOXNET Database. Available at https://chem.nlm.nih.gov/chemidplus/.		

Based on the limited information obtained about the composition of one TPE infill product, it is possible to identify certain potential health and environmental concerns. For example, carbon black poses potential concerns related to carcinogenicity. Carbon black is identified by IARC as a possible human carcinogen (Group 2B). Many forms of carbon black exist, and carbon blacks frequently contain a variety of adsorbed compounds, including PAHs.[8] If mineral oils are present, they may also pose carcinogenicity concerns.[9]

In addition, the polymer itself could potentially pose concerns if unreacted monomer is present. For example, unreacted styrene would pose concerns if it is present; the International Agency for Research on Cancer (IARC) categorizes styrene as a possible human carcinogen (Group 2B).[10] Finally, the stabilizers and antioxidants are not identified, and thus cannot be assessed for possible health or environmental implications.

TURI also received information from FieldTurf on one of its TPE infill products, ECOMAX. The Safety Data Sheet for ECOMAX states that it is composed of "polymeric and mineral ingredients," without providing any detail on these materials.[11] Based on this limited information, it is impossible to assess the potential health and environmental impacts of the material.

Laboratory tests

Some manufacturers or marketers of TPE infill provide certifications and other documentation to support the argument that their product is preferable from a health and environmental standpoint, compared with other synthetic turf options.

TTII test data

For Target Technologies International, Inc (TTII) PRO-MAX 37 TPE Infill, the manufacturer provides information on a number of tests that have been conducted on its product. In general the tests do not show high levels of the substances tested, although it is not clear how applicable some of the tests are for types of exposures that may occur during play on a turf field or the environmental conditions that could be relevant for an artificial turf field. The tests consider an important, but not necessarily complete, set of relevant chemicals.

Environmental tests. In one test, one liter of distilled water was passed through the infill, then tested for a number of metals.[12] The results showed nondetectable levels of the metals. It is not clear how informative this test is for relevant environmental conditions. Another leaching test found a number of metals to be below the detection limit, with the exception of chromium, which was detected.[13] An aquatic toxicity test using rainbow trout showed signs of stress in the fish exposed to the infill, but no fish mortality.[14]

Human exposure tests – European Toy Safety test (metals). Another test examined the 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." It 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").[15] (For background on this standard, see "Chemicals in Artificial Turf Infill: Overview."[16])

The manufacturer compared its measured values to the requirements for Category III, "scraped-off materials," which has the highest allowable levels of metals. Using Category III, the infill met the standard for all 19 of the metals included in the standard.[17]

It may also be appropriate to consider the standards for Category I, "dry, brittle, powder like or pliable materials" category. Turf infill crumbs are small parts that can easily be swallowed. Using these standards, it is not possible to determine whether the infill meets the standard for all the metals. Specifically, the Category 1 limit for arsenic is 3.8 mg/kg, but the test method used by the laboratory has a 5 mg/kg detection limit. Similarly, the Category 1 limit for hexavalent chromium is 0.02 mg/kg, but the test method has a 0.1 mg/kg detection limit.

Other tests. Another test checked for six metals and six phthalates listed under California's Proposition 65, and found nondetectable levels of all of them, given the detection limits of the particular test that was used.[18]

A test required by Los Angeles Unified School District (LAUSD) Office of Environmental Health and Safety Heavy tested the material for 17 metals, checking them against limits for hazardous waste. The material passes the test for each metal. For most of the metals, the level is below the sample detection limit. For a few, a specific level is shown: barium (1.21 mg/kg); chromium (13.2 mg/kg); zinc (196 mg/kg).[19] LAUSD does recommend use of personal protective equipment for personnel working with the product.[20]

FieldTurf test data

FieldTurf also provides test data using the EN 71-3 standard.[21] TURI reviewed FieldTurf testing data for two TPE products – one simply labeled "TPE," and the other identified by the brand name "ECOMAX."

Of the 19 metals tested for, 10 were detected in the "TPE" sample: aluminum, barium, boron, chromium, copper, lead, manganese, nickel, strontium, and zinc. In the "ECOMAX" sample, the test detected the same elements with the exception of lead and nickel.

Comparing the test results to the Category I standard, both the "TPE" and the "ECOMAX" products meet the standard for nearly all the chemicals on the list. For hexavalent chromium, the detection limit for the test method is 0.2 mg/kg and the standard is 0.02 so it is not possible to determine whether the materials meet the standard.

There are some differences between the two TPE materials. For example, the "TPE" material shows lead at 0.5 mg/kg while the "ECOMAX" material shows no lead detected (with a detection limit of 0.5 mg/kg). The TPE material shows nickel at 68.2 mg/kg, a level not far from the EN 71-3 Category 1 limit of 75 mg/kg, while the "ECOMAX" material shows no nickel detected, also with a 0.5 mg/kg detection limit.

Boundaries of this chapter

As a reminder, this chapter *only* includes information on chemicals that may be found in TPE infill. It does not include an examination of other topics that could be important, such as the potential of the material to create fine particles. Technical characteristics of the infill, including durability, are also not discussed here.

Information on heat-related concerns is covered in a separate chapter. It is important to note that in general, all synthetic turf fields reach higher temperatures than natural grass fields, regardless of infill type.

Summary

In summary, regarding chemicals specifically, TPE infill is likely to contain some chemicals of concern, although full information on the material was not readily available as this chapter was being developed, and there is variation among products. Based on the information that is available, TPE infill contains fewer chemicals of concern than SBR made from recycled tires. Additional information on the specific chemicals contained in TPE infill brands would be helpful. Institutions considering purchasing a TPE infill product may wish to request more detailed information on the specific type of TPE used.

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.

In response to information requests from municipalities, TURI is currently developing an alternatives assessment for sports turf. Preliminary sections of the assessment are being published in the order in which they are developed, and are available on TURI's website at www.turi.org.

Toxics Use Reduction Institute
University of Massachusetts Lowell * 600 Suffolk Street, Suite 501 * Lowell, Massachusetts 01854
Tel: (978) 934-3275 * Fax: (978) 934-3050 * Web: www.turi.org

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