

Critical Analysis of Benchmark-1 GreenScreen® Hazard Combinations

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What is a Chemical of Concern?

- A chemical of concern displays one or more of the following traits:

- Carcinogenicity, mutagenicity, reproductive or developmental toxicity
- Potential concern for children's health
- Used in children's products
- Neurotoxic

Human Health

- Persistent, bioaccumulative, and toxic (PBT)
- Very persistent or very bioaccumulative in the environment (vPvB)
- Very persistent and Toxic (vPT)
- Ozone depleting
- Detected in biomonitoring programs

Environmental Health

- Chemicals of concern are challenging to phase out:
 - Switching to a chemical with unknown hazards may result in a chemical that is more hazardous

What is a Benchmark-1 Chemical?


Benchmark-1 (BM-1) chemicals are defined as chemicals of high concern to human health and the environment based on high or very high endpoint-specific rankings

- Organic BM-1 chemicals are further classified into five subclasses BM-1A, BM-1B, BM-1C, BM-1D, and/or BM-1E, based on a chemical's hazard characteristics

GREENSCREEN BENCHMARK-1

- a. PBT = High P + High B + [very High T (Ecotoxicity or Group II Human) or High T (Group I or II* Human)]
- b. vPvB = very High P + very High B
- c. vPT = very High P + [very High T (Ecotoxicity or Group II Human) or High T (Group I or II* Human)]
- d. vBT = very High B + [very High T (Ecotoxicity or Group II Human) or High T (Group I or II* Human)]
- e. High T (Group I Human)

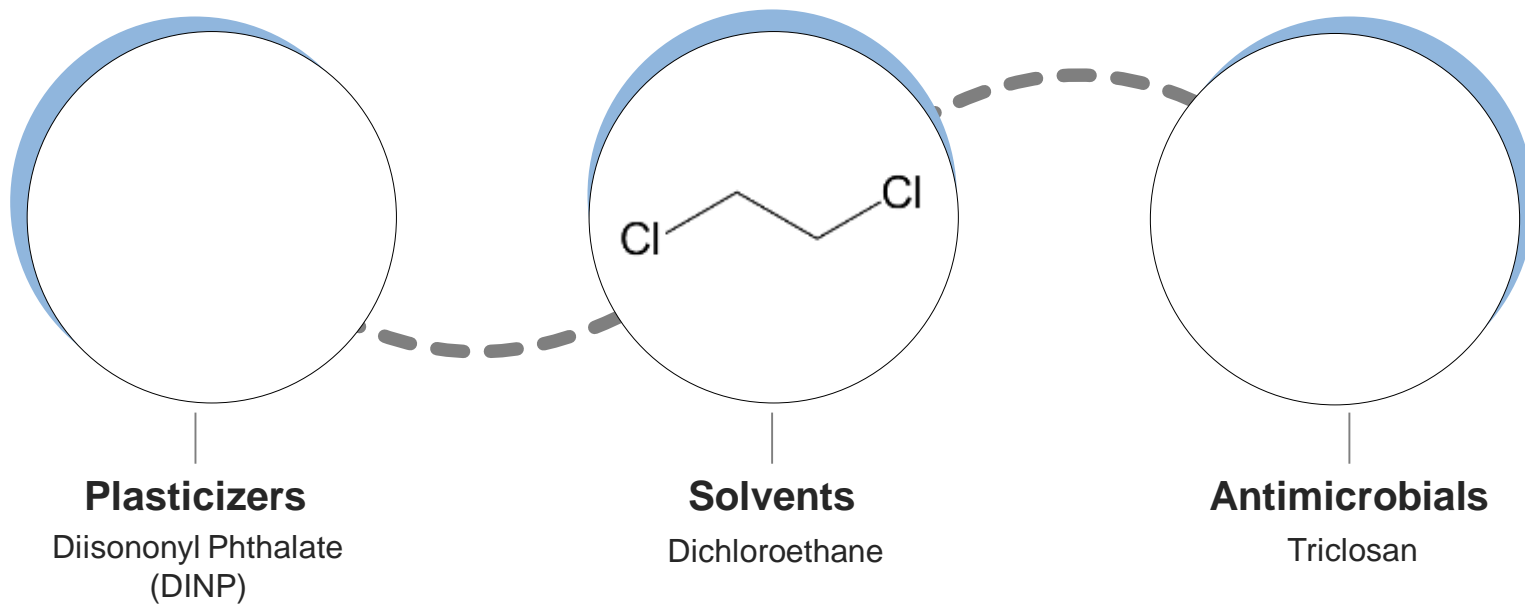
Avoid—Chemical of High Concern



- Inorganic BM-1 chemicals are classified into four subclasses BM-1A, BM-1B, BM-1C, BM-1D with no subclass for vPvB since inorganic compounds are recalcitrant (persist in nature and do not biodegrade)

What is a Benchmark-1 Chemical?

Example BM-1 chemicals include commonly used:



Industry Bans on Chemical Classes

sweetgreen

Sweetgreen and Chipotle will remove “forever chemicals” from their bowls by the end of 2020

by Joe Tassler
03.16.2020, 10:53am

Environment



Does Chick-fil-A's packaging contain PFAS?

Chick-fil-A is working to eliminate intentionally added PFAS from all newly produced packaging going forward in our supply chain. Products with oil and grease resistant coatings containing PFAS are expected to be phased out by the end of summer of 2022. We've spent the last four years working closely with our suppliers, an independent lab and 3rd party validator to provide our customers with innovative packaging products that meet all applicable regulatory standards. This is one important step in our ongoing journey to use more sustainable materials in our restaurants. Chick-fil-A is dedicated to offering the best food, packaging and overall experience to our guests.

[DI-SA-INC](#)



Made without PFCs / PFAS

We're converting all of our durable water-repellent membranes and finishes to non-fluorinated alternatives by 2025.



BLOG

Whole Foods, Trader Joe's Pledge Initial Action on Nonstick PFAS

December 12, 2018



Starbucks Innovates, Tests and Learns from Store Partners to Achieve Waste Goals

In further single use packaging optimization, we continue to replace traditional plastic straws with new compostable options around the globe. By the end of this year, will have eliminated PFAS from all packaging in the US and will eliminate PFAS globally in 2023.

LOWE'S SAFER CHEMICALS POLICY

As a responsible corporate citizen, Lowe's takes product safety and environmental sustainability very seriously. To manage chemicals more responsibly, Lowe's implements this safer chemicals policy through a number of strategic actions and commitments.

- All vinyl flooring is free of ortho-phthalates
- All indoor wall-to-wall carpet is free of triclosan, organotins, ortho-phthalates, vinyl chloride, nonylphenol ethoxylates, coal fly ash, formaldehyde, added heavy metals
- All indoor residential carpet and rugs are free of PFAS chemicals

Flooring

TRADER JOE'S

PHASING OUT PRODUCTS CONTAINING PFAS

September 17, 2019 [in](#) [x](#) [f](#) [+](#)

In partnership with suppliers, The Home Depot is working diligently to offer products that are innovative and safer for the environment. The Home Depot is committed to minimizing the environmental impact of the products on its store shelves and has led the industry in creating chemical standards to do just that.

To build upon this strategy, The Home Depot will be phasing out Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) December 31, 2019 in the U.S. and Canada in carpets and rugs.



Where to Find Benchmark-1 Chemicals?

ToxServices' ToxFMD Screened Chemistry® Library

Search by functional class*

TOXSERVICES
TOX SCREENED CHEMISTRY LIBRARY

GreenScreen® Hazard Summary:

Group 1 Hazard: Group 2 and 3 Hazard: Status: Fate: Physical:

Embryotoxicity, Mutagenicity/Bioactivity, Reproductive Toxicity, Developmental Toxicity, Endocrine Activity, Acute Toxicity, Systemic Toxicity, Neurotoxicity, Skin Irritant/Corrosive, Respiratory Irritant/Corrosive, Skin Irritation, Eye Irritation, Acute Aquatic Toxicity, Chronic/Aquatic Toxicity, Persistence, Bioaccumulation, Health, Hazardous

Enter CAS# or Chemical Name:

Clear TI-43-2 Go

TI-43-2 (Review)

3 indicates single exposure. P* indicates repeated exposure. Hazard levels in (ALL) indicate low confidence. Hazard levels in (OCC) indicate medium confidence. Hazard levels in (H) indicate high confidence.

Search Result

CAS #	CHEMICAL NAME	FUNCTIONAL CLASS	BM SCORE
100-41-4	Ethylbenzene	Publicly Accessible Green Screens	1
100-44-7	Benzyl Chloride	Publicly Accessible Green Screens	1
105-72-4	M-isopropyl-N-phenyl-p-phenylenedamine (IPPD)	Publicly Accessible Green Screens; Antioxidant; Stabilizer	1
102-76-1	Triacetin	Publicly Accessible Green Screens; Preservative; Antimicrobial/Antibacterial/Antifungal	300
103-11-7	2-Ethylhexyl Acrylate	Publicly Accessible Green Screens; Monomer; Binder	2
105391-33-1	Bis[2-ethyl-5-methyl-4-maleimidophenyl]methane	Publicly Accessible Green Screens; Coupling Agent/Cross-Linking Agent	1

Search by CAS number or chemical name

<https://database.toxservices.com/>

*All BM-1 chemical GreenScreens are available via the “Publicly Accessible GreenScreens” functional class

Benchmark-1 Analysis



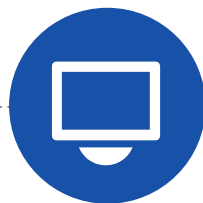
ToxServices' ToxFMD Screened Chemistry[®] Library

The ToxFMD Screened Chemistry[®] Library¹ contains GreenScreen[®] chemical hazard assessments for over 1,000 chemicals



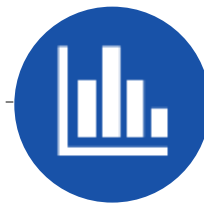
Data Mining

Of the 1,000+ GreenScreen[®] chemical hazard assessments performed by ToxServices, the library contains 204 BM-1 chemicals



Chemical Classification

The 204 BM-1 chemicals were assigned a chemical class using ClassyFire², a web-based application for structural classification



Subscore Hazard Combination Analysis

The 204 BM-1 chemicals were assigned a total of 278 subscores (1A, 1B, 1C, 1D, and/or 1E)

¹ <https://database.toxservices.com/>

² Djoumbou Feunang Y, Eisner R, Knox C, Chepelev L, Hastings J, Owen G, Fahy E, Steinbeck C, Subramanian S, Bolton E, Greiner R, and Wishart DS. ClassyFire: Automated Chemical Classification With A Comprehensive, Computable Taxonomy. *Journal of Cheminformatics*, 2016, 8:61. DOI: [10.1186/s13321-016-0174-y](https://doi.org/10.1186/s13321-016-0174-y)

ClassyFire

ClassyFire is a web-based application for automated structural classification of chemical entities. This application uses a rule-based approach that relies on a comprehensible, comprehensive, and computable chemical taxonomy.

Query type:
 Chemical (Use this option when providing valid SMILES or IUPAC as input)
 Protein/DNA/RNA (Use this option when providing valid FASTA sequences as input)
 IUPAC Name (Use this option when providing valid IUPAC names as input)

Test Input Draw Structure Upload a SDF/Txt File

Example:

Input:

Provide one entity per line containing a SMILES or an IUPAC string, although preceded by an identifier (Index), the identifier MUST precede the structure representation. The file must be tab-separated.

Label (optional):
Provide a name for the data sample. You can provide multiple labels.

Displaying 1 entity query

Classification Results

Export to:

Identifier	Input	Classified?
Q49244-1	C1=CC=CC=C1	Yes

```
"identifier": "Q49244-1",
"smiles": "C1=CC=CC=C1",
"iupackey": "InChIKey=UHQWQNZJYSORIB-UHFFFAQYSA-N",
"kingdom": {
  "name": "Organic compounds",
  "description": "Compounds that contain at least one carbon atom, excluding isocyanide/cyanide and
  ide, carbon suboxide, and dicarbon monoxide.",
  "chemoot_id": "CHEMONTID:8000000",
  "url": "http://classyfire.wishartlab.com/tax_nodes/C0000000"
},
"superclass": {
  "name": "Benzeneoids",
  "description": "Aromatic compounds containing one or more benzene rings.",
  "chemoot_id": "CHEMONTID:8002448",
  "url": "http://classyfire.wishartlab.com/tax_nodes/C0002448"
},
"class": {
  "name": "Benzene and substituted derivatives",
  "description": "Aromatic compounds containing one monocyclic ring system consisting of benzene.",
  "chemoot_id": "CHEMONTID:8002279",
  "url": "http://classyfire.wishartlab.com/tax_nodes/C0002279"
},
"subclass": null,
"intermediate_nodes": [],
"direct_parent": {
  "name": "Benzene and substituted derivatives",
  "description": "Aromatic compounds containing one monocyclic ring system consisting of benzene.",
  "chemoot_id": "CHEMONTID:8002279",
  "url": "http://classyfire.wishartlab.com/tax_nodes/C0002279"
}
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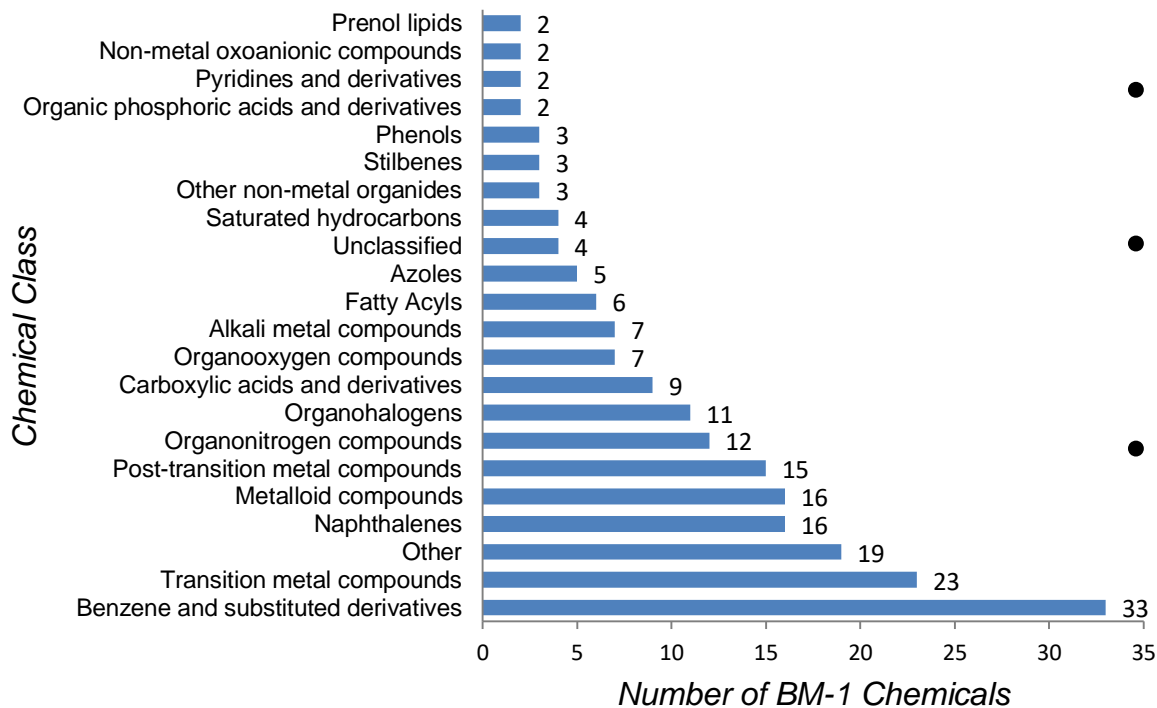
<http://45.88.80.180/>

ClassyFire's output is a hierarchical chemical classification of a chemical entity

Djombou Feunang Y, Eisner R, Knox C, Chepelev L, Hastings J, Owen G, Fahy E, Steinbeck C, Subramanian S, Bolton E, Greiner R, and Wishart DS. ClassyFire: Automated Chemical Classification With A Comprehensive, Computable Taxonomy. *Journal of Cheminformatics*, 2016, 8:61. DOI: [10.1186/s13321-016-0174-y](https://doi.org/10.1186/s13321-016-0174-y)

Benchmark-1 Analysis

Breakdown of BM-1 Chemicals by Chemical Class

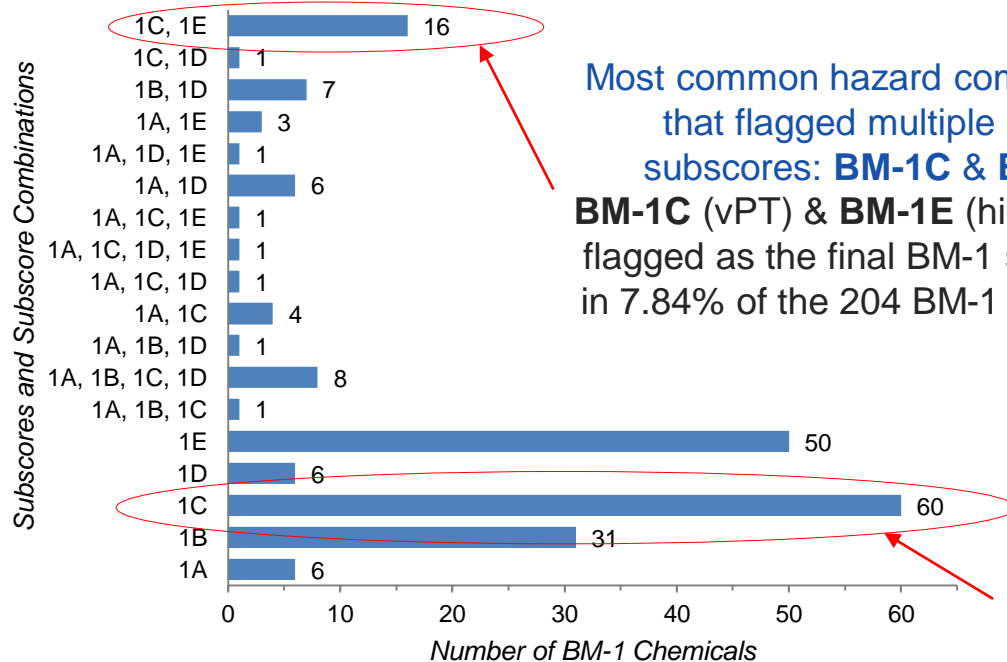


- ClassyFire identified 57 different chemical classes for these 204 BM-1 chemicals
- For simplicity, these 57 chemical classes were further grouped into 22 different categories
- The most common chemical class for BM-1 chemicals are benzene and substituted derivatives, and transition metal compounds
- As the BM-1 chemicals span a wide range of classes, there is no singular chemical class to avoid

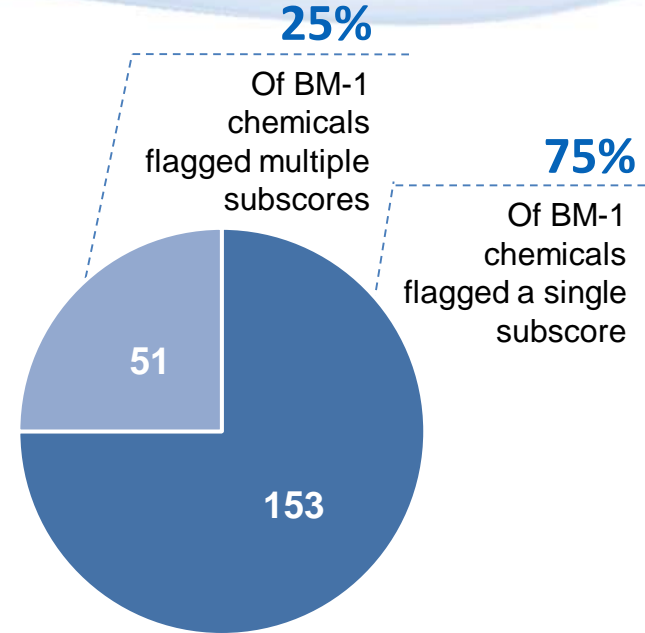
** Other represents any chemical class only present once among the 204 BM-1 chemicals*

Benchmark-1 Analysis

Breakdown of BM-1 Chemicals by Final Subscore/Subscore Combinations



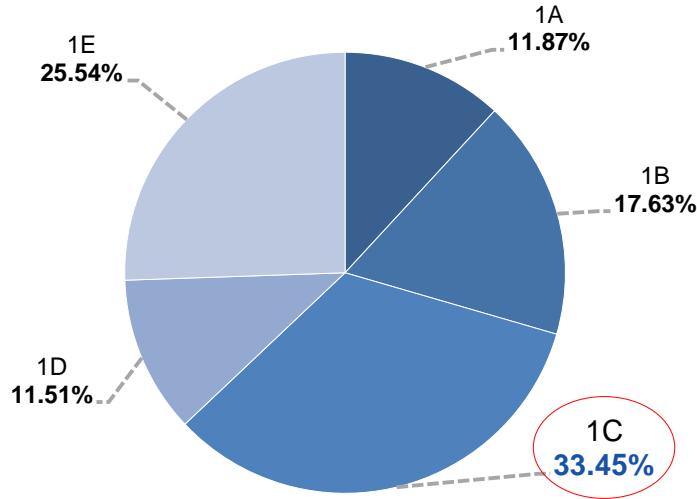
Most common hazard combinations that flagged multiple BM-1 subscores: **BM-1C & BM-1E**
BM-1C (vPT) & **BM-1E** (high T) were flagged as the final BM-1 subscores in 7.84% of the 204 BM-1 chemicals



Most common hazard combination that flagged a single BM-1 subscore: **BM-1C**
BM-1C (vPT) was flagged as the final subscore in 29.41% of the 204 BM-1 chemicals

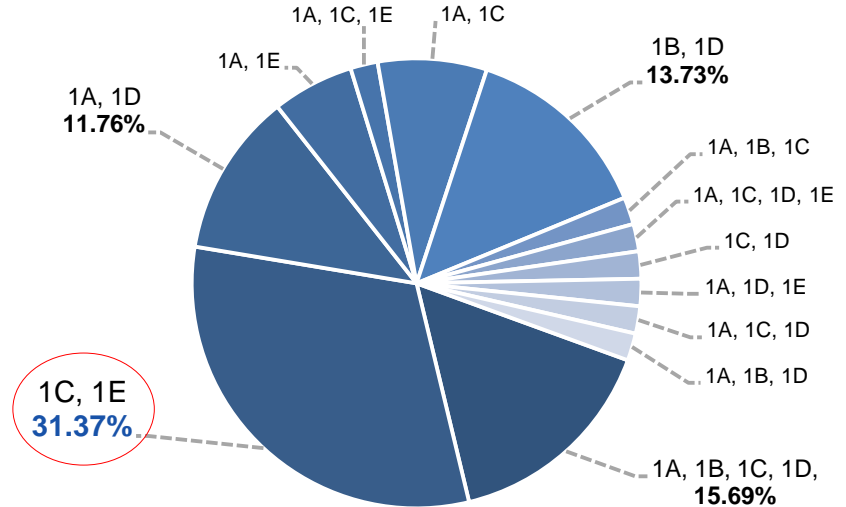
Benchmark-1 Analysis

BM-1 Chemicals by Singular Subscore Only



Most common hazard combination that flagged a BM-1 subscore: **BM-1C**
BM-1C (vPT) was flagged as a subscore in 93 of the 278 subscores flagged across the 204 BM-1 chemicals (33.45%)

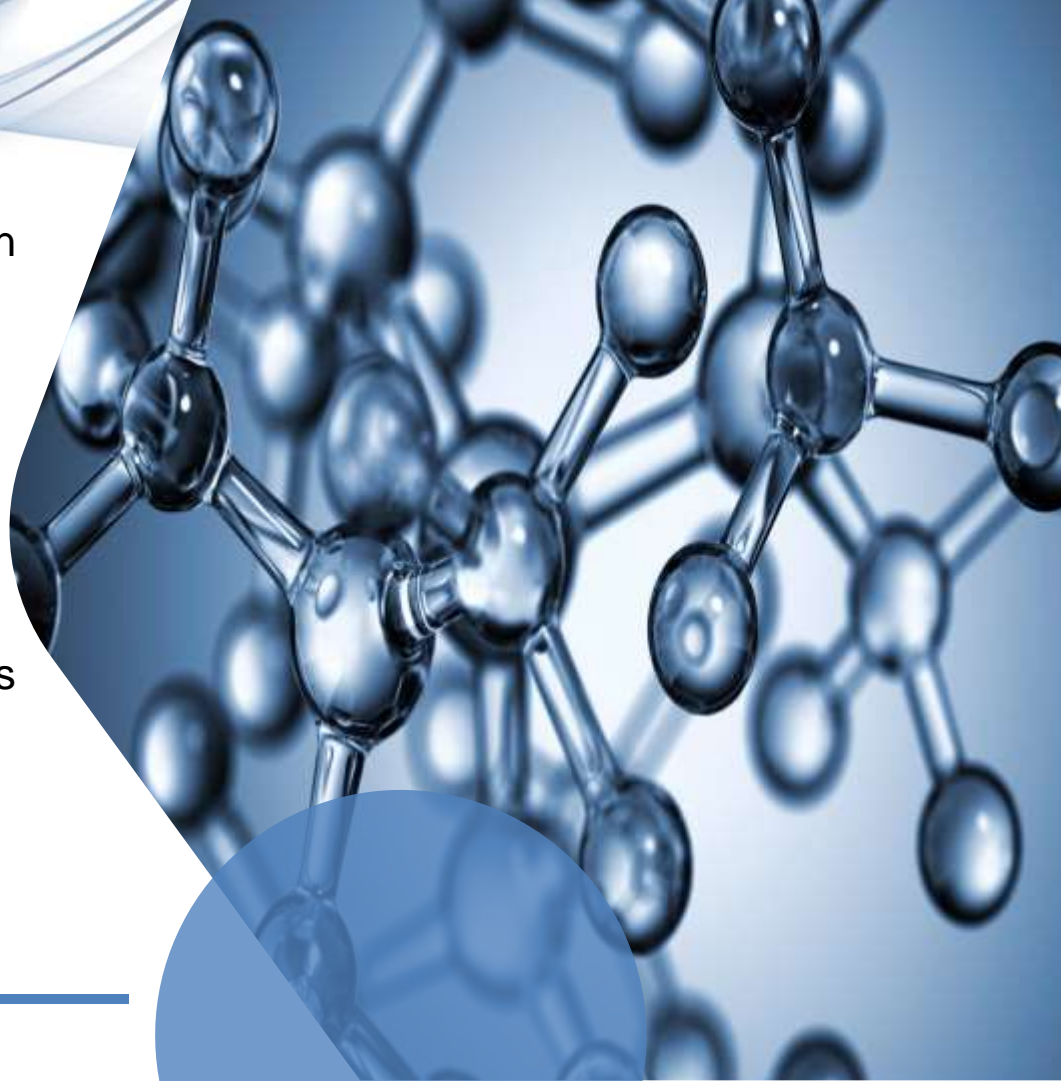
BM-1 Chemicals by Subscore Combinations Only



Most common hazard combinations that flagged multiple BM-1 subscores: **BM-1C & BM-1E**
BM-1C (vPT) & **BM-1E** (high T) were flagged as the final BM-1 subscores in 16 of the 51 BM-1 chemicals with multiple subscores (31.37%)

Conclusions

- Many BM-1 chemicals pose both human health and environmental concerns
- BM-1 classifications effectively identify chemicals of concern and as well as identify candidates for chemical substitution.
- Chemicals from many different classes can be BM-1 chemicals
 - There is no singular chemical class to avoid
 - The implementation of CHAs to guide decision-making is more useful for eliminating chemicals of high concern



Thank You

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