



NSF®



NSF GreenScreen™ Services

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Green Chemistry



NSF is third-party reviewer for:

- **NSF Sustainability Standards (carpet, resilient flooring, etc.)**
- **The U.S. EPA's Design for the Environment (DfE) Program**
- **Clean Production Action's GreenScreen™**



12 Principles of Green Chemistry*



1. Prevention
2. Atom Economy
3. Less Hazardous Chemical Syntheses
4. Designing Safer Chemicals
5. Safer Solvents and Auxiliaries
6. Design for Energy Efficiency
7. Use of Renewable Feedstocks
8. Reduce Derivatives
9. Catalysis
10. Design for Degradation
11. Real-time analysis for Pollution Prevention
12. Inherently Safer Chemistry for Accident Prevention

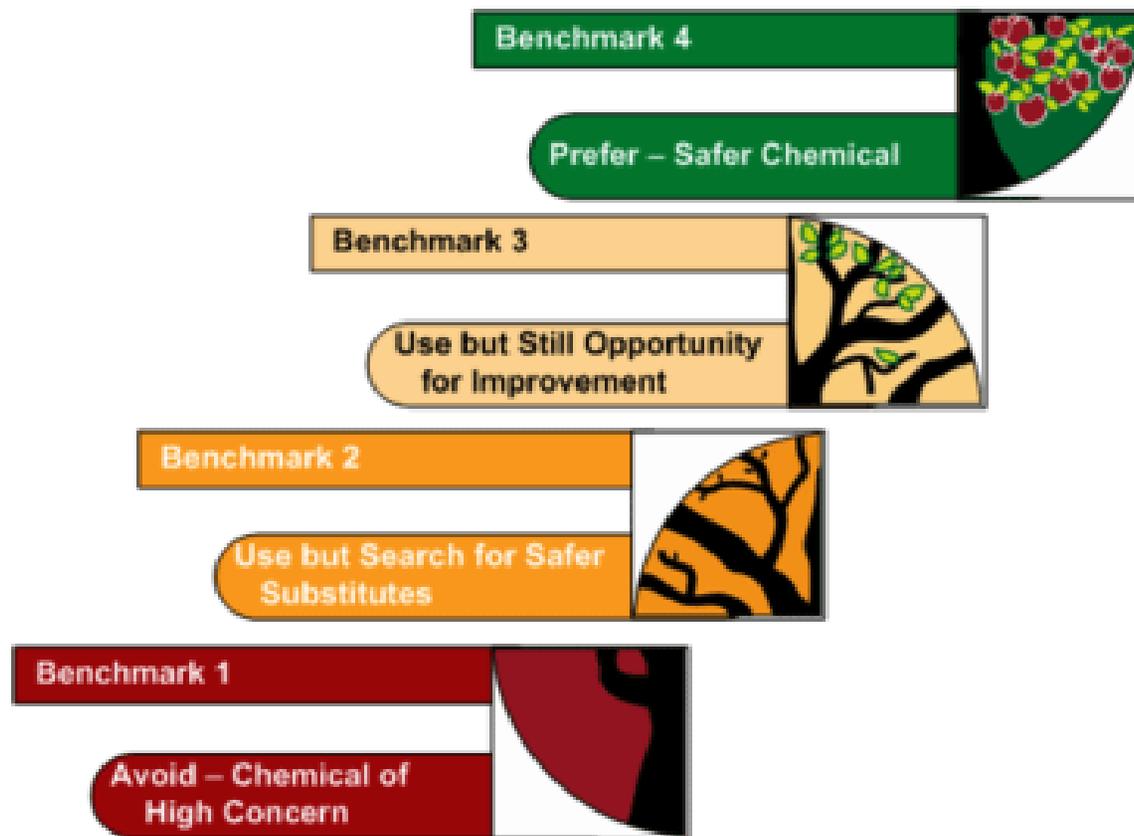
The GreenScreen™ focuses on 3 key principles of Green Chemistry

* Anastas, P. T.; Warner, J. C.; Green Chemistry: Theory and Practice, Oxford University Press: New York, 1998, p.30. By permission of Oxford University Press

Clean Production Action - GreenScreen™



An easy to use Benchmark score facilitates informed decisions



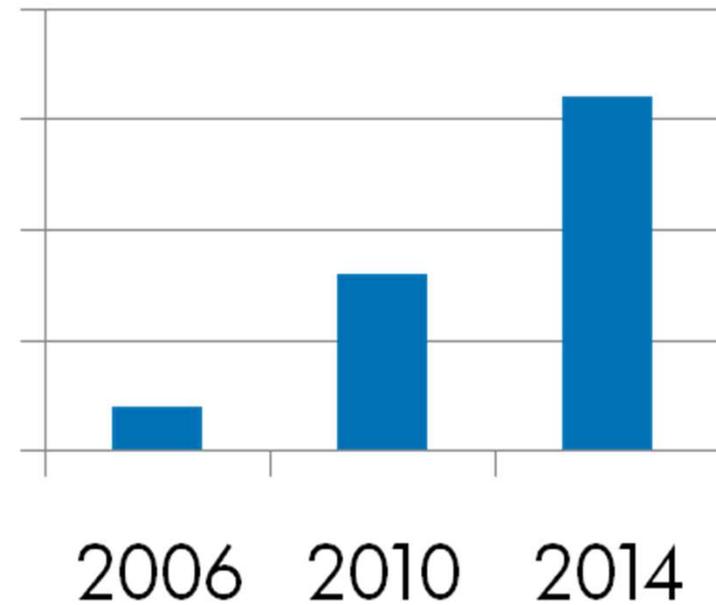
NSF is a third-party licensed profiler and trainer for the GreenScreen™



What is the GreenScreen™?



- A method to compare chemical alternatives
- Builds on the USEPA DfE approach and other national and international precedents (OECD, GHS)
- Publicly accessible, transparent and peer reviewed
- Compliments other sustainability tools including Risk Assessment, Life Cycle Assessment, etc.
- Harmonization is key to navigating increasing regulations



Who is Using the GreenScreen™



Identifying safer substitutes for BFRs, CFRs, and PVC



Platform for their chemical screening program



Basis for state regulatory programs



Aligning hazard thresholds

The GreenScreen™ is NOT a Risk Assessment



- Hazard = the *inherent property* of a substance having the potential to cause adverse effects when an organism, system or (sub) population is exposed to it.
- Risk = the *probability* of an adverse effect in an organism, system or (sub) population caused under specified circumstances by exposure to a substance.

$$\text{Risk} = f(\text{hazard, exposure})$$

Risk and Hazard – Different Questions



- **Risk Assessment is designed to answer the question:**
 - Is this chemical or product safe enough for the intended use (and foreseeable misuse)?
- **Hazard Assessment is designed to answer the question:**
 - Which chemical is inherently safer/lower hazard?
- **The GreenScreen™ addresses hazard only.**

$$\text{Risk} = f(\text{hazard, exposure})$$

Avoid Regrettable Substitutions



Don't replace a chemical of concern with an unknown

Clean Production Action - GreenScreen™



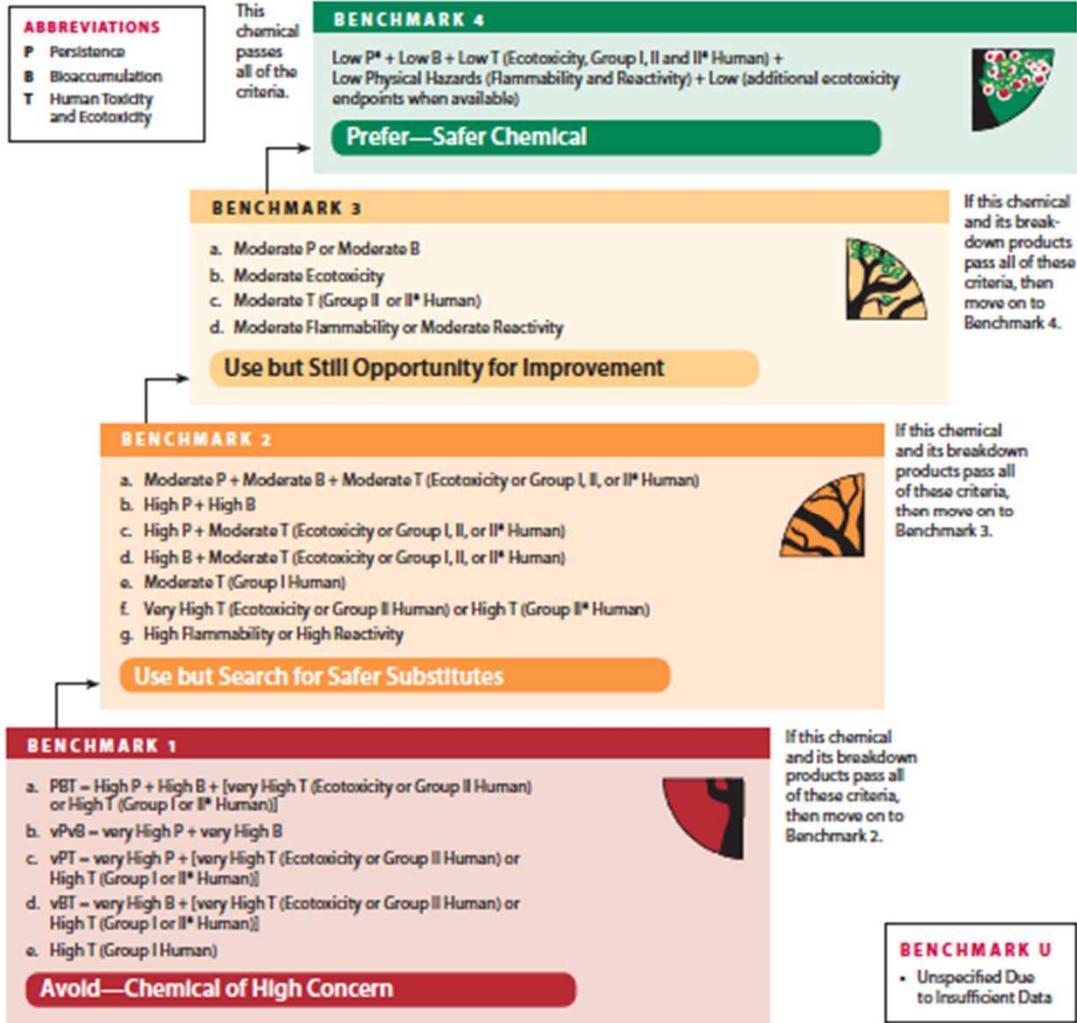
Green Screen Hazard Endpoints and Ratings

Group 1 Human				Group II and II* Human								Ecotox		Fate		Physical			
Carcinogenicity	Mutagenicity	Reproductive toxicity	Developmental toxicity	Endocrine activity	Acute toxicity	Systemic toxicity		Neurotoxicity		Skin sensitization*	Respiratory sensitization*	Skin irritation	Eye irritation	Acute aquatic toxicity	Chronic aquatic toxicity	Persistence	Bioaccumulation	Reactivity	Flammability
						S	R	S	R										
L	L	L	M	M	L	L	L	vH	H	L	L	L	L	H	H	vL	L	M	L

Endpoints are scored as very low (vL), low (L), moderate (M), high (H), or very high (vH). Bold letters represent greater confidence in the hazard ranking.



Determine Benchmark Score



The GreenScreen™ Benchmarking system is simple and transparent.



Assessing Mixtures



- **No overall Benchmark**
- **Results table reflects benchmark score of all constituents**
- **Reporting**
 - Report all constituents
 - Report BM score for each
 - Report % of mixture at each BM score



Reporting Results for Mixtures



Chemical	CAS	% by weight	Benchmark	BM by %
Calcium carbonate	1317-65-3	30-45%	4	30-45%
Acetone	67-64-1	5-20%	2	5-20%
Petroleum distillates	64742-89-8	5-20%	1	10-46%
Toluene	108-88-3	5-20%	1	
Dichloromethane	75-09-2	0-5%	1	
Methyl ethyl ketone	78-93-3	0-1%	1	

Mixtures Best Practices



- **Known and Special Case Impurities < 100 ppm in the parent product:**

Chemical	CAS	Concentration in final product (ppm)	LT Results	Reason for Inclusion
Sulfur	7704-34-9	20	LT-U	Impurity in petroleum distillates
Nickel	7440-02-0	20	LT-1	Impurity in petroleum distillates

GreenScreen™ List Translator



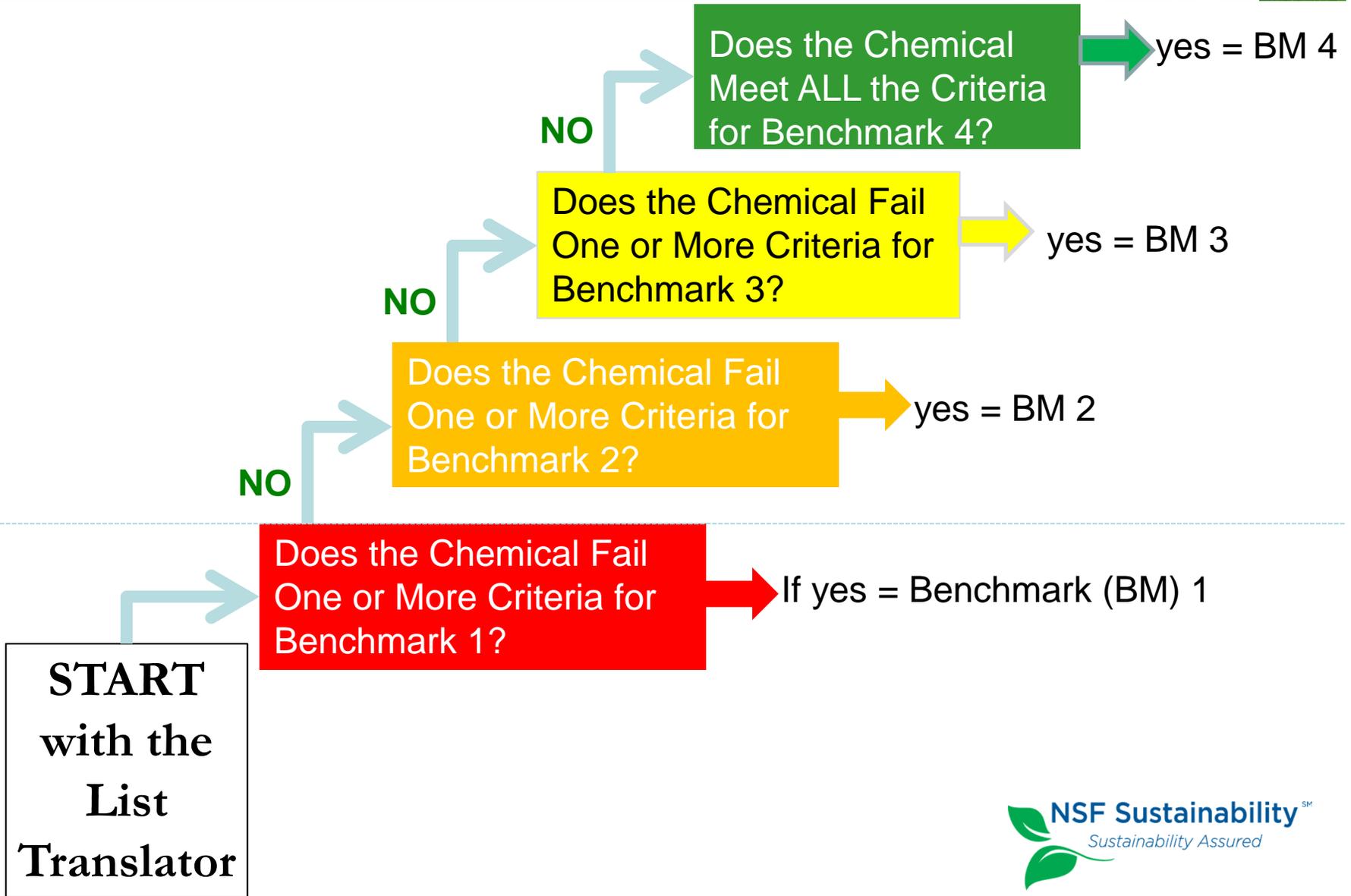
- The List Translator (LT) is a tool that tells if a chemical is a known or possible Benchmark 1 based on **authoritative** lists
- Three possible scores are
 - LT-1** = (expected BM1)
 - LT-P1** (possible BM-1)
 - LT-U** (undetermined from the lists)
- Only a full GreenScreen™ can tell you if a chemical is better than a BM-1 (i.e. a BM-2, BM-3, or BM-4)

Authoritative Lists*

AOEC
DOT
EPA-AMT
EU-CMR
EU-PBT
EU-Risk phrases
IARC
Prop 65
MAK
...

*<http://www.cleanproduction.org/library/greenscreen-translator-benchmark1-possible%20benchmark1.pdf>

Start with the List Translator



NSF GreenScreen™ Options



Full GreenScreen™ Reviews:

- List Translator + a comprehensive literature search of publicly available data
- Review of individual studies for quality and conclusions
- Requires identification and analysis of transformation products
- Requires analysis of analog data and SAR modeling to fill data gaps
- Deliverable = Benchmark score (**BM-1**, **BM-2**, **BM-3**, **BM-4**, or **BM-U**).

BM-U = undetermined, too many data gaps

Drivers for the GreenScreen™



- **Upstream users in certain industries (electronics, textiles, automotive, building products)**
- **Corporate responsibility**
- **International sales**
- **Voluntary standards**
 - LEED certification – materials optimization
 - Health Product Declarations (HPDs)
- **California, Maine, Washington - regulations**



Challenges for the GreenScreen™



1. Requires training

- Training is publicly offered several times per year across the USA. This training is facilitated by Clean Production Action and licensed profilers, including NSF.
- On-site private and/or customized training is also offered by NSF.

2. Supplier disclosures

- NSF as a third-party offers a variety of options to assist manufacturers with gathering and reviewing proprietary supplier information.

3. Lack of data

- NSF has expertise in identifying analogs and utilizing SAR modeling programs as a first choice.
- NSF can also help to prioritize test efforts for maximum efficiency with timing and costs.

Exercise – Making Informed Decisions



SCENARIO: You have a Benchmark 1 chemical of concern that you need to replace. You are considering two alternatives that are both Benchmark 2 chemicals. The chemical of concern is an additive in a polymer.

OBJECTIVE: Determine the best substitute for the chemical of concern.

INSTRUCTIONS: Review the Hazard Summary Table below and answer the three questions on the next page.

Chemical	CAS#	%	GS BM	Group I Human					Group II and II* Human							Ecotox		Fate		Physical			
				C	M	R	D	E	AT	ST		N		SnS*	SnR*	IrS	IrE	AA	CA	P	B	Rx	F
										single	repeat*	single	repeat*										
Chemical 1	XXX-XX-X	100%	1	H	H	M	M	DG	vH	L	M	L	M	H	H	H	H	vH	vH	vH	vH	L	L
Alternative 1	XXX-XX-X	100%	2	L	M	L	L	DG	L	M	M	M	M	M	L	M	M	M	L	L	M	M	M
Alternative 2	XXX-XX-X	100%	2	M	DG	L	L	M	H	DG	DG	M	M	M	M	M	H	M	M	H	M	M	M

L = low hazard, M = moderate hazard, H = high hazard, vH = very high hazard, DG = data gap

Group I Human: C = cancer, M = mutagenicity, R = reproductive toxicity, D = developmental toxicity, E = endocrine activity

Group II and II* Human: AT = acute toxicity, ST = systemic toxicity, N = neurotoxicity, SnS = skin sensitization, SnR = respiratory sensitization, IrS = skin irritation, IrE = eye irritation

Ecotox, Fate, and Physical: AA = acute aquatic toxicity, CA = chronic aquatic toxicity, P = persistence, B = bioaccumulation, Rx = reactivity, F = flammability