U.S. EPA Design for the Environment (DfE) Program

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Presentation Outline

- **DfE Program**
  - **Tools and methods**
  - **Alternatives Analysis**
- **DfE Product Recognition**
  - How it works
  - Improvements
- **Safer Detergent Stewardship Initiative (SDSI)**

DfE Program Overview

- Focus
  - Green Chemistry
  - Informed Substitution
  - OPPT technical tools and expertise
- Considerations
  - Business client
  - Multi-stakeholder participation
  - Business realities
  - Potential benefits for industry and the environment
- Results
  - Industry partners reduced about 160 million pounds of chemicals of concern last year

Furniture Flame Retardants Partnership
Alternatives Assessment

- **Predominant flame retardant (pentaBDE) was being found increasingly in human tissue, breast milk and the environment.**
  - PentaBDE was phased-out at the end of 2004.
  - Need for fire safety will likely increase based on planned national standards.
  - Decision-making for alternatives to this 19 million pound per year chemical.

- **The Report**
  - Provides data to inform industry.
  - Summary assessments of chemicals in flame retardant formulations.
  - Detailed hazard reviews.

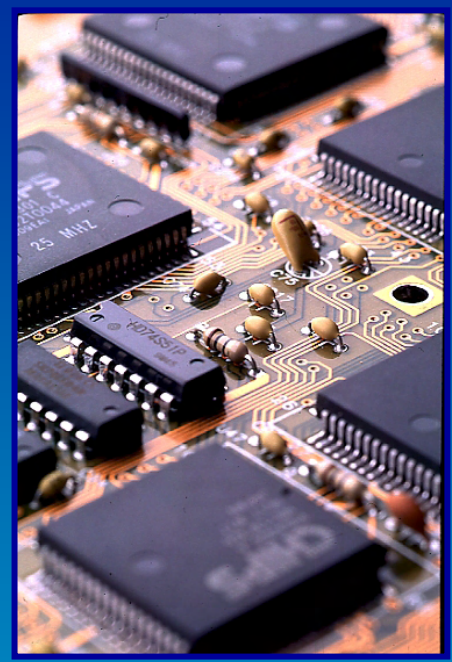
Furniture Flame Retardancy Partnership

Results: Data Presentation

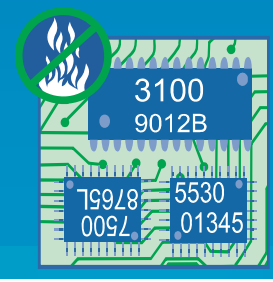
Human Health Hazard Concern | **Ecotoxicity Hazard Concern** | **Environmental Hazard Concern**

Company	Chemical	% in Formulation[3]	Human Health Effects							Ecotoxicity		Environmental		Potential Routes of Exposure							Reactive or Additive?
														Worker			General Population				
			Cancer Hazard	Skin Sensitizer	Reproductive	Developmental	Neurological	Systemic	Genotoxicity	Acute	Chronic	Persistence	Bioaccumulation	Inhalation	Dermal	Ingestion	Inhalation	Dermal	Ingestion	Aquatic	
Albemarle	SAYTEX RZ-243																				
	Proprietary E Tetrabromophthalate diol diester		L	L	L*	L*	L	M*	L	L	H	L[?]	L	N	Y	Y	N	N	Y	Y	Additive
	Proprietary B Aryl phosphate		L	L	M*	M*	M	M*	L	H	H	L	M	N	Y	Y	N	Y	N	N	Additive
	Triphenyl Phosphate CAS # 115-86-6		L	L	L	L	L	M	L	H	H	L	L	Y	Y	Y	Y	Y	Y	Y	Additive
Ameribrom	FR513																				
	Tribromoneopentyl Alcohol CAS # 36483-57-5		M	L	M	M	M	M	M	M	M	L	L	Y	Y	Y	N	N	Y	Y	Reactive
Great Lakes	Firemaster 550																				
	Proprietary F Halogenated aryl ester		L	L	M	M	L	M	L	H	H	L[?]	L	N	Y	Y	N	Y	Y	Y	Additive
	Proprietary G Triaryl phosphate, isopropylated		L	L	M*	M*	M	M*	L	H	H	L	M	N	Y	Y	N	Y	N	N	Additive
	Triphenyl Phosphate CAS # 115-86-6		L	L	L	L	L	M	L	H	H	L	L	Y	Y	Y	Y	Y	Y	Y	Additive
	Proprietary H Halogenated aryl ester		L	L	M	M	L	M	L	H	H	L[?]	L	N	Y	Y	N	Y	Y	Y	Additive

Flame Retardants in Printed Circuit Boards



- Tetrabromobisphenol A / TBBPA is the highest-volume brominated flame retardant in use
- Primary application is in printed circuit boards - at approx. 330 million pounds/year
- Industry need for information on flame retardants
- Concern by some stakeholders over environmental impacts and combustion by-products
- Partnership to identify and characterize commercially available flame retardants and their environmental, health, safety and environmental fate aspects in FR-4 printed circuit boards.
  - Use EPA New Chemicals Program criteria to evaluate hazard and environmental fate concerns
  - Life-cycle thinking provides a more robust context

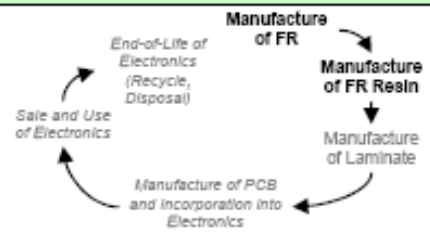


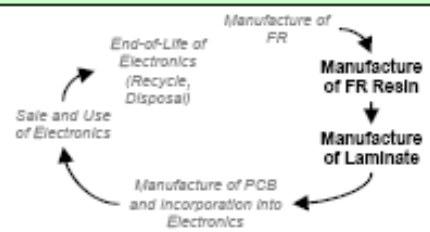
Flame Retardants in Printed Circuit Boards

Results: Data Presentation

Human Health Hazard Concern | **Ecotoxicity Hazard Concern** | **Environmental Hazard Concern**

Chemical	CASRN	Human Health Effects									Aquatic Toxicity		Environmental		Exposure Considerations
		Acute Toxicity	Skin Sensitizer	Cancer Hazard	Immunotoxicity	Reproductive	Developmental	Neurological	Systemic	Genotoxicity	Acute	Chronic	Persistence	Bioaccumulation	Availability of flame retardants (FRs) throughout the lifecycle for reactive and additive FRs chemicals and resins
Reactive Flame Retardant Chemicals[2]															
Tetrabromobisphenol A (TBBPA) (Albemarle, Chemtura, and others)															
TBBPA	79-94-7	L	L	L	L	L	M	L	L	L	H	H	M	L	
DOPO (6H-Dibenz[c,e][1,2] oxaphosphorin, 6-oxide) (Samko Co., Ltd. and others)															
DOPO	35948-25-5	L	L	L	L	L	L	L	L	L	M	M	L	L	
Fyrolflex PMP (Aryl alkylphosphonate) (Supresta)															
Fyrolflex PMP	Proprietary	L	L	L	L	L	L	L	L	L	L	L	H	L	
Reactive Flame Retardant Resins[2]															
Reaction product of TBBPA - D.E.R. 538 (Phenol, 4,4'-(1-methylethylidene)bis[2,6-dibromo-, polymer with (chloromethyl)oxirane and 4,4'-(1-methylethylidene)bis[phenol]) (Dow Chemical)															
D.E.R. 538	26265-08-7	L	M	M◊	L	M◊	M◊	L	L	M	L	L	M	L	
Reaction Product of DOPO - Dow XZ-92547 (reaction product of an epoxy phenyl novolak with DOPO) (Dow Chemical)															
Dow XZ-92547	Proprietary	L	M	M◊	L	M◊	M◊	L	L	M◊	L	L	H	L	
Reaction product of Fyrolflex PMP with bisphenol A, polymer with epichlorohydrin (Representative Resin)															
Representative Fyrolflex PCB Resin	Unknown	L	L	M◊	L	M◊	M◊	L	L	M◊	L	L	H	L	





Lead-Free Solder Partnership

Background

- The U.S. electronics industry is moving away from lead solder (176 millions pounds per year)
- E.U. banned lead in electronics as of June 2006
- Industry approached DfE based on past relationship
- Partnership is helping U.S. industry adopt lead-free alternatives and maintain international competitiveness

Lead-Free Solder Partnership

Goals

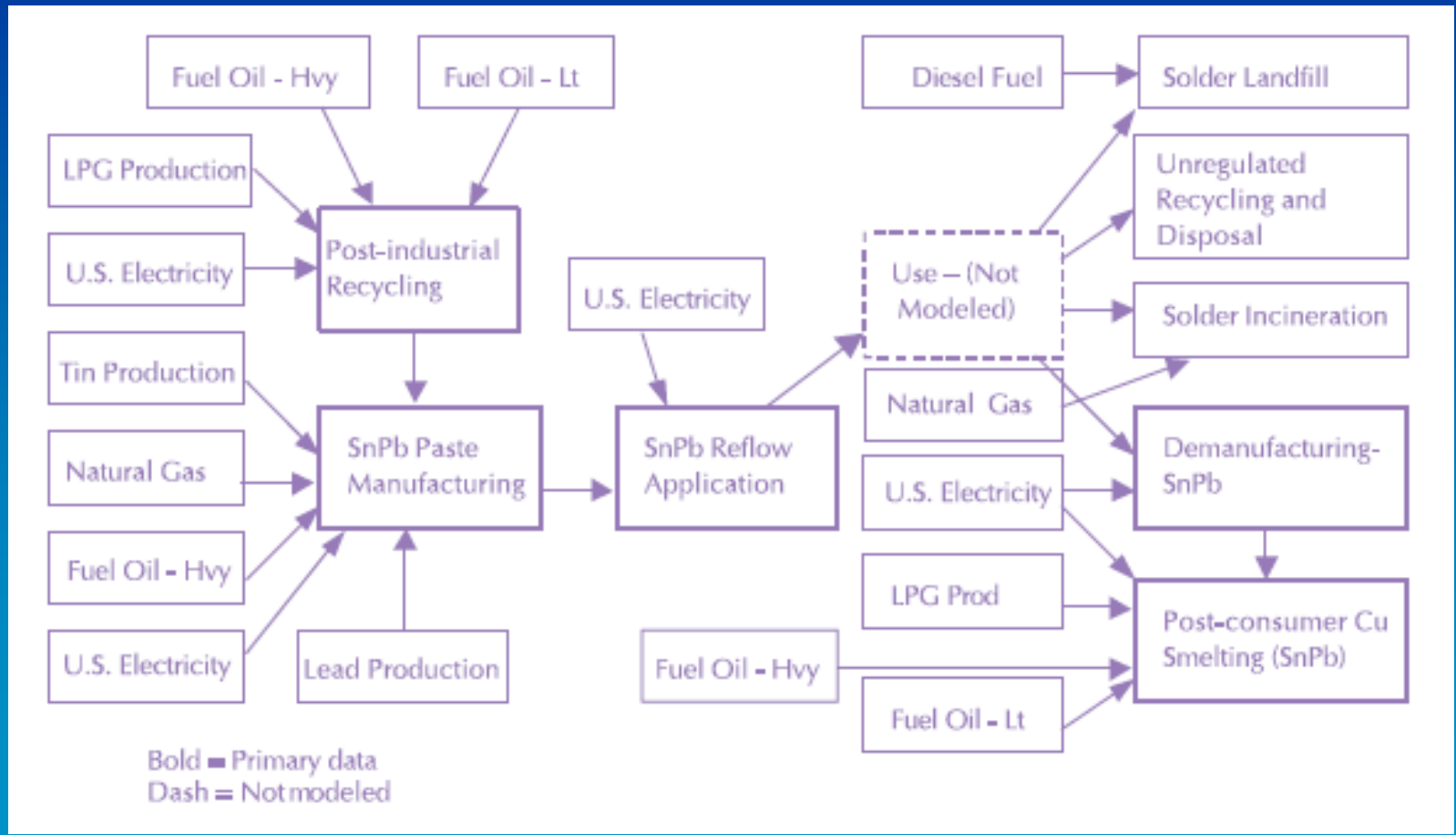
Evaluate:

- The relative life-cycle environmental impacts of Sn/Pb solder and selected Pb-free alternative solders
- Both paste (reflow) and bar (wave) solder technologies – wave solders are lower technology solders than paste solders
- Leachability of solders

Lead-Free Solder Partnership

Life-Cycle Assessment

SnPb Paste Solder Life-Cycle Process

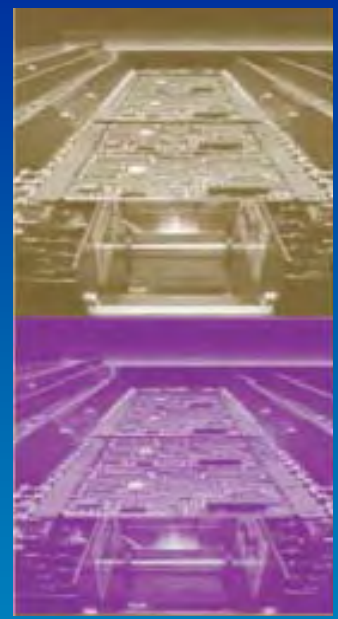


Lead-Free Solder Partnership

Life-Cycle Assessment

Composition of tin-lead and alternative solders:

- 95.5% tin, 3.9% silver, and 0.6% copper
- 57.0% bismuth, 42.0% tin, and 1.0% silver
- 96.0% tin, 2.5% silver, 1.0% bismuth, 0.5% copper
- 99.2% tin and 0.8% copper

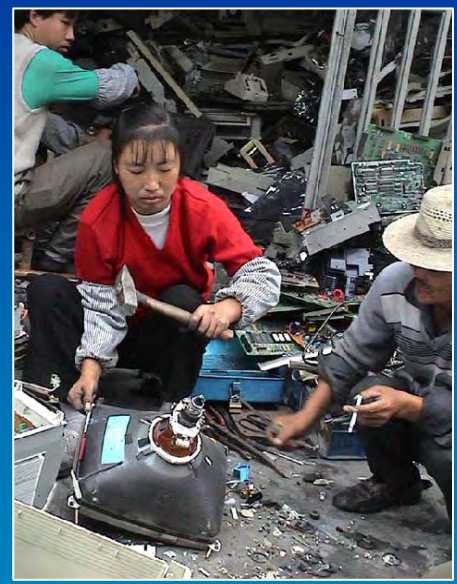


Lead-Free Solder Partnership

Life-Cycle Assessment

Key Findings

- Cost and impacts of mining silver may drive choices
- Energy-efficient ovens will cut manufacturing costs and impacts
- Lead was found to leach to a much greater extent than the other metals in the solders being analyzed in this study

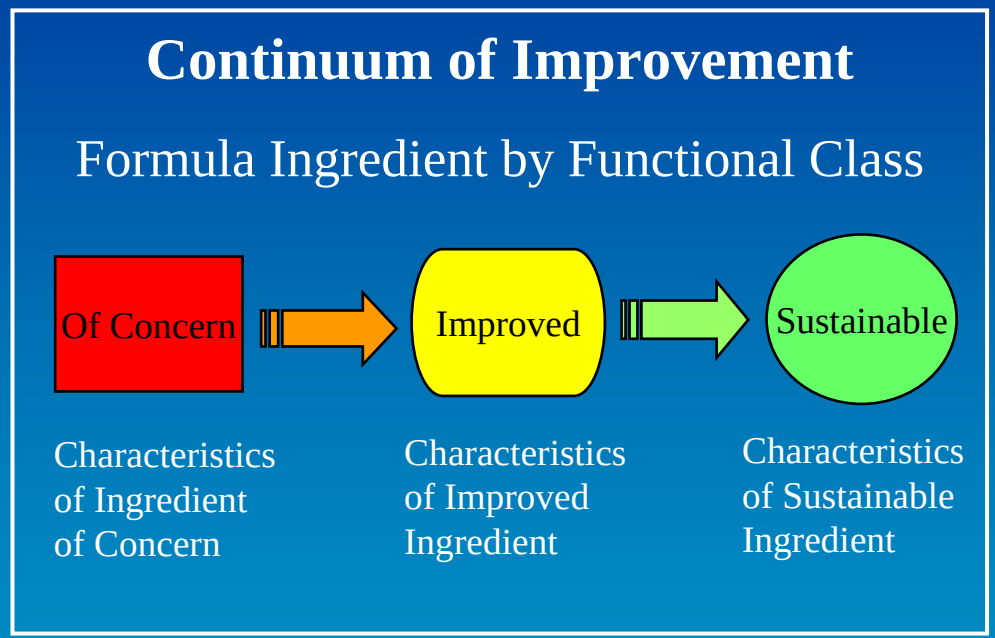


Formulator Program Review
3 Basic Components

1) Review every ingredient by functional use class
   - To promote green chemistry
   - To understand toxicity
     - Data (generated for DfE or unpublished)
     - Literature
     - Analogous chemicals – SAR
2) Review formulation as a whole
   - Negative chemical interactions
   - pH
   - Performance testing
   - Life cycle thinking
3) Partnership Agreement

DfE Product Recognition Program

- Expert Chemical Evaluation
  - Ability to interpret experimental studies
  - Predict hazard and environmental effects in the absence of data – SAR approach
- Discriminating Process Focused on a Given Formulation
  - Review every ingredient by functional use
  - Focus on endpoints of concern and continuous improvement
- Driven by Green Chemistry
  - As Innovation Occurs Continua May Shift



Continuing Improvement

- **Transparency**
  - Screens for safer ingredients document DfE decision logic by functional use class
  - We plan to document the DfE review methodology in the form of a standard
- **Access**
  - Third-party profiler now provides enhanced access to partnership with DfE
  - CleanGredients™ was developed to enhance access chemicals from the green end of the spectrum by functional use class

CleanGredients™

- CleanGredients™ is a marketplace…
  - for suppliers to showcase safer chemical ingredients for cleaning products, and
  - for formulators to find those ingredients.
  - CleanGredients™ houses chemicals that are acceptable in DfE-labeled products
- CleanGredients™ is at the intersection of safer chemistry and high performance ingredients

CleanGredients™ - Marketplace for Green Chemistry Ingredients

- Multi-stakeholder development
  - More than 800 stakeholders
  - Technical Committees define modules for safer functional ingredient classes
    - 15-30 organizations typically represented on each Technical Committee
    - Expertise in formulary chemistry and toxicology
    - Formulators, chemical suppliers, NGOs, and Government
- Steering Committee overseas project development
  - Akzo Nobel
  - BASF
  - Consumer Specialty Products Association
  - Corporate Express
  - Dow Chemical
  - EPA DfE
  - Green Blue Institute
  - International Sanitary Supply Association
  - Investor Environmental Health Network
  - NSF International
  - Reckitt Benckiser
  - SYSCO

DfE Screen for Surfactants

- Safer surfactants degrade quickly to low toxicity degradates.

Acute Aquatic Toxicity (L/E/IC50 Value)	Rate of Biodegradation
≤1 ppm	May be acceptable if biodegradation[1] occurs within a 10-day window
>1 ppm and ≤10 ppm	Biodegradation[1] occurs within a 10-day window
>10 ppm	Biodegradation[1] occurs within 28 days without products of concern[2]

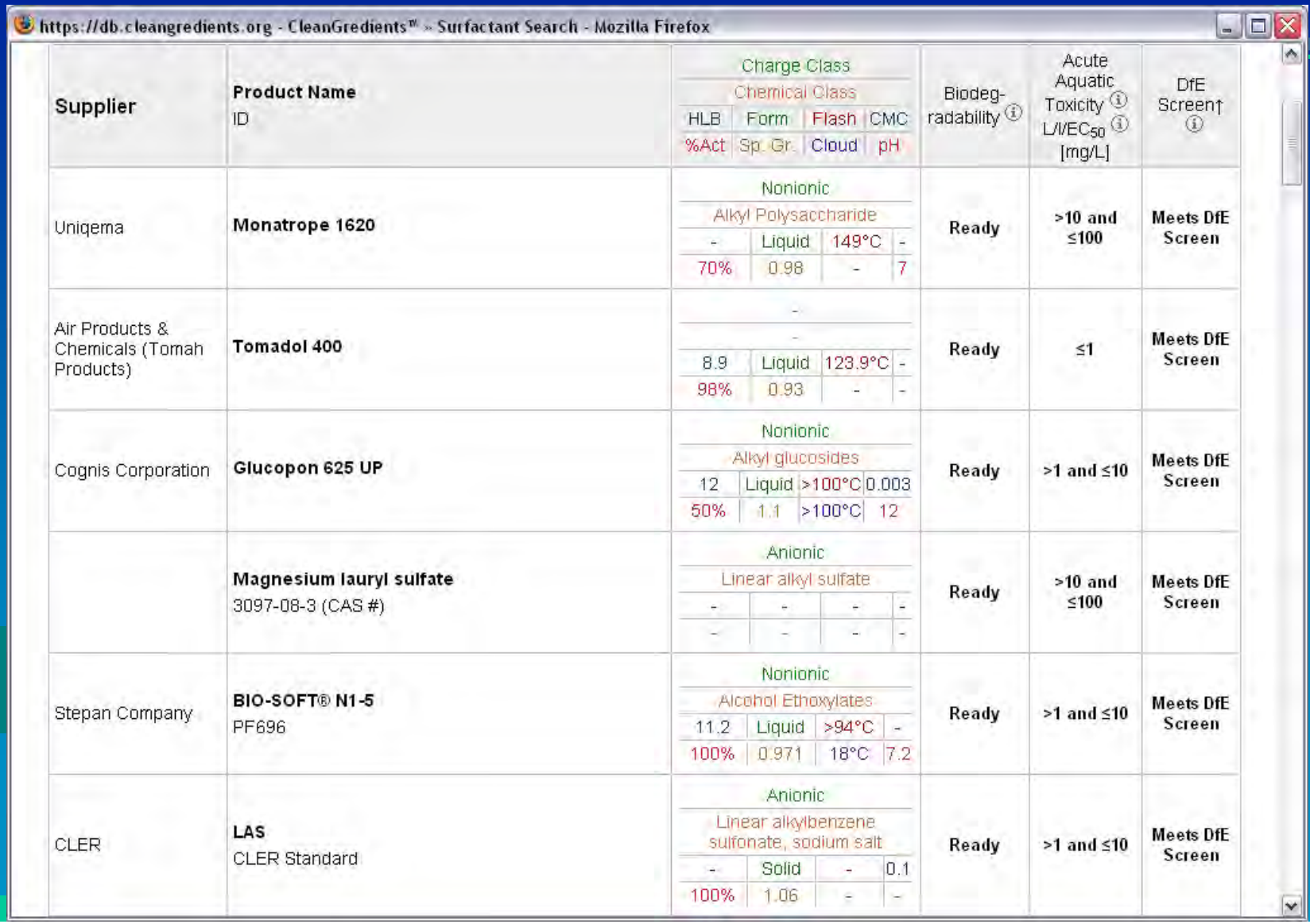
[1] Generally, >60% mineralization (to CO2 and water) in 28 days.
[2] Products of concern are compounds with high acute aquatic toxicity (L/E/IC50 ≤ 10ppm) and a slow rate of biodegradation (greater than 28 days).

DfE Screen for Solvents (draft)

- Safer solvents demonstrate low impacts to human health and the environment.

PHASE I SOLVENT CLASSES	**Alcohols** **Esters** **Ethylene Glycol Ethers (EGEs)** **Propylene Glycol Ethers (PGEs)**
ATTRIBUTES OF CONCERN FOR PHASE I SOLVENTS	**Carcinogenicity** **Neurotoxicity** **Acute Mammalian Toxicity** **Reproductive and Developmental Toxicity** **Repeated-Dose Toxicity** **Environmental Fate and Toxicity**

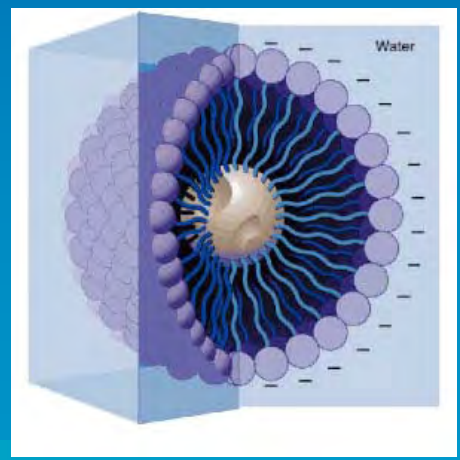
CleanGredients™ Search Results


https://db.cleangredients.org - CleanGredients™ » Surfactant Search - Mozilla Firefox

Supplier	Product Name / ID	Charge Class / Chemical Class	HLB	Form	Flash	CMC	%Act	Sp. Gr.	Cloud	pH	Biodeg-radability	Acute Aquatic Toxicity L/I/EC_{50} [mg/L]	DfE Screen†
Uniqema	**Monatrope 1620**	Nonionic / Alkyl Polysaccharide	-	Liquid	149°C	-	70%	0.98	-	7	**Ready**	**>10 and ≤100**	**Meets DfE Screen**
Air Products & Chemicals (Tomah Products)	**Tomadol 400**	- / -	8.9	Liquid	123.9°C	-	98%	0.93	-	-	**Ready**	**≤1**	**Meets DfE Screen**
Cognis Corporation	**Glucopon 625 UP**	Nonionic / Alkyl glucosides	12	Liquid	>100°C	0.003	50%	1.1	>100°C	12	**Ready**	**>1 and ≤10**	**Meets DfE Screen**
	Magnesium lauryl sulfate 3097-08-3 (CAS #)	Anionic / Linear alkyl sulfate	-	-	-	-	-	-	-	-	**Ready**	**>10 and ≤100**	**Meets DfE Screen**
Stepan Company	**BIO-SOFT® N1-5** PF696	Nonionic / Alcohol Ethoxylates	11.2	Liquid	>94°C	-	100%	0.971	18°C	7.2	**Ready**	**>1 and ≤10**	**Meets DfE Screen**
CLER	**LAS** CLER Standard	Anionic / Linear alkylbenzene sulfonate, sodium salt	-	Solid	-	0.1	100%	1.06	-	-	**Ready**	**>1 and ≤10**	**Meets DfE Screen**

Safer Detergents Stewardship Initiative (SDSI)

- Environmental stewardship program to encourage the use of safer surfactants
- Promotes the goals of EPA's Ambient Water Quality Criteria (AWQC) for Nonylphenol (NP) and harmonizes with international environmental protection efforts
- More than 65 applicants
- Ceremony targeted for late 2008



www.epa.gov/dfe
www.cleangredients.org