Innovative Business / University Partnership: The Safer Plasticizer Assessment Project

GC3 Green Chemistry & Commerce Council
Moving Business Toward Safer Alternatives

TUR Planner Continuing Education Conference
April, 12 2012

TURI
TOXICS USE REDUCTION INSTITUTE
UMASS LOWELL

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Overview of Presentation:

1. The Green Chemistry & Commerce Council (GC3)

2. Innovative Business / University Partnerships: The Safer Plasticizer Assessment Project

2. Future Partnership Projects

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1. **The Green Chemistry & Commerce Council (GC3)**
2. **Innovative Business / University Partnerships: The Safer Plasticizer Assessment Project**
3. **Future Partnership Projects**

GC3 Green Chemistry & Commerce Council

Moving Business Toward Safer Alternatives

What is the GC3?

A cross sectoral, B-2-B network of more than 60 companies and other organizations formed in 2005 with a mission to promote green chemistry and design for environment (DfE), nationally and internationally

What is the GC3? (cont.)

A dynamic forum for leading edge companies to:

- **Share best practices and push the frontier of business practices that promote green chemistry**
- **Work collaboratively on projects to develop new business strategies, technologies, tools and information**

Who Runs the GC3?

- The Lowell Center for Sustainable Production (LCSP) at the University of Mass. Lowell
- Executive Director – Dr. Joel Tickner
- 2 Full-time Staff and Contractors

How does the GC3 Work?

- Advisory Board
- Membership dues
- Project groups that meet by teleconference to work on projects that further the mission of the GC3
- Annual Meeting

  2012 @ NSF International, Ann Arbor, MI

  May 9 – 11!

GC3 Members

Chemical/Specialty Chemicals
Alpha Chemical Service, Inc.
BASF Corporation
Bayer MaterialScience LLC
The Dow Chemical Company
Kluber Lubrication
The HallStar Company
Hubbard Hall
ACS Green Chemistry Institute
Diversey
DuPont
ecoSolv Technologies, Inc.
Rivertop Renewables

Apparel & Footwear
Anvil Knitwear
Nike, Inc.

Retail
Walmart
Staples
Target
Green Depot

Outdoor Industry
REI

Consumer Products
Avon Products, Inc.
Johnson & Johnson
Henkel/Dial
Method Products, Inc.
Seventh Generation, Inc
Colgate-Palmolive Company

Office Furniture
Steelcase
Herman Miller
Designtex

Building Products
Construction Specialties

Aerospace
Lockheed Martin

Electronics
Bose Corporation
HP
Intel
Dell
EMC Corporation

Pharmaceutical
BWC Pharma Consulting

GC3 Members

Software
Actio Software
The Wercs

Product Standards & Certification
Bureau Veritas
Green Seal
EPEAT, Inc.
NSF International

Consulting
Inside Matters
Pure Strategies
ToxServices, LLC
Environmental and Public Health Consulting
Daley International
Sustainable Research Group

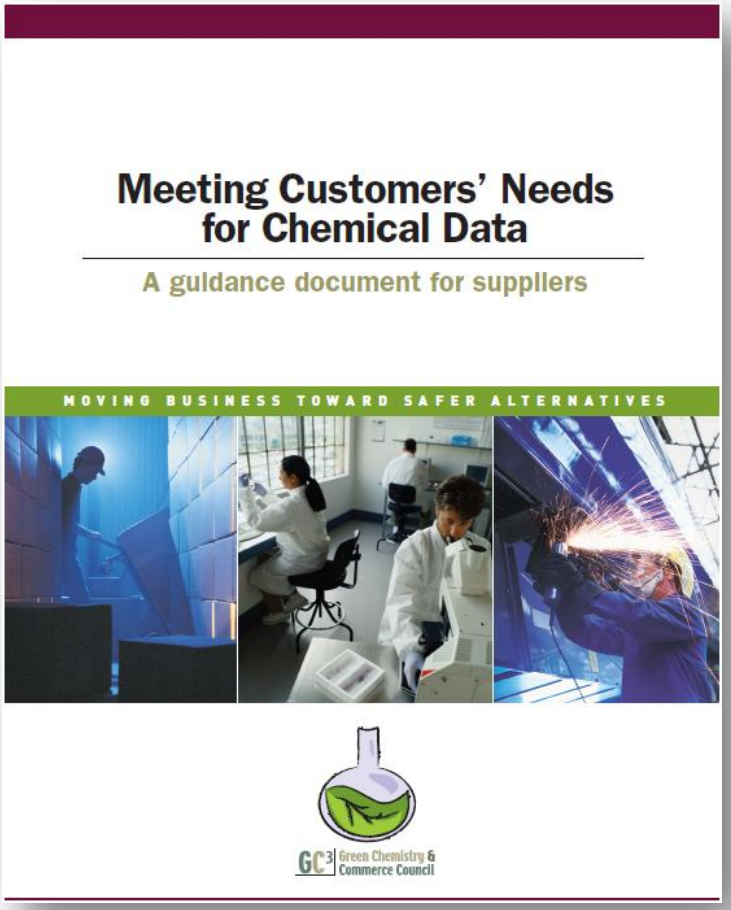
Government
Minnesota Pollution Control Agency
Environmental Protection Agency
German Federal Environment Agency
Mass. Toxics Use Reduction Institute
Washington State Department of Ecology

Non Governmental Organizations
Investor Environmental Health Network
Center for Environmental Health
Clean Production Action
Cradle to Cradle Products Innovation Institute
GreenBlue
Environmental Health Fund
Pacific Northwest Pollution Prevention Resource Center

Current Projects

1. Facilitating Chemical Data Flow Along Supply Chains
2. Retailer engagement to advance safer chemicals and products
3. Business and Academic Partnerships for Safer Chemicals: “The Plasticizer Project”
4. Green Chemistry Higher Education

Publications & Other Resources



GC3 Green Chemistry & Commerce Council

Moving Business Toward Safer Alternatives

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You a

RETAILER PORTAL DATABASE

Tools to Evaluate Chemical Ingredients in Products

Key: Restricted Substances Lists | Standards, Certifications & Labels | Third-party Evaluation Tools

Apparel & Footwear						
Tools relevant to this product sector	Restricted Substances Lists (RSLs) e.g., AAFA RSL, ETAD	bluesign®	EcoLogo	Global Organic Textile Standard (GOTS)	Oeko-Tex® Standard 100	Outdoor Industry Association (OIA) Eco Index Beta
Tools relevant to all product sectors	Cradle to Cradle® Certification	3E Green Product Analyzer™ (GPA)	Actio Material Disclosure	Chemical Compliance Systems (CCS) Tools	GreenWERCS™	IHS Chemical Inventory Greening Solutions
Automotive						
Tools relevant to this product sector	Restricted Substances Lists (RSLs) e.g., GADSL	EcoLogo	EPA Design for Environment (DfE) Safer Product Labeling Program	Green Seal		
Tools relevant to all product sectors	Cradle to Cradle® Certification	3E Green Product Analyzer™ (GPA)	Actio Material Disclosure	Chemical Compliance Systems (CCS) Tools	GreenWERCS™	IHS Chemical Inventory Greening Solutions
Building Materials & Products						
Tools relevant to this product sector	Restricted Substances Lists (RSLs)	EcoLogo	Greenguard	Green Seal	SMaRT© 4.0 Sustainable Product Standard	Pharos Project

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Business / University Partnership Project

Project Objectives: To develop and pilot a collaborative process, with university and business partners, to evaluate safer alternatives to toxic chemicals.

Build on prior work in the TURI, Lowell Center for Sustain. Prod.

Approach:

1. Choose a category of chemicals of concern and an industrial application to be the focus of a pilot
   - Something of high interest to GC3 members
   - Leverage capabilities of U. Mass. Lowell
2. Choose potential safer alternatives, of interest to GC3 members;
3. Conduct collaborative EH&S assessments on selected alternatives; and
4. Conduct collaborative technical performance and economic evaluations on top performers from Step 3;
5. If none of the candidates in Steps 3 & 4 are acceptable, develop new chemicals/materials

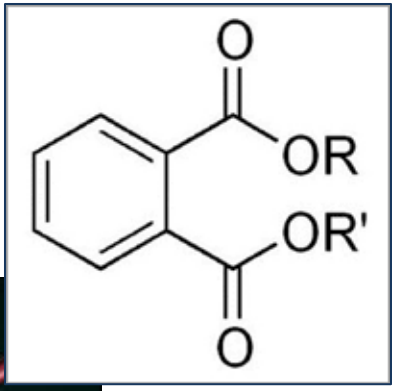
Business / University Partnership Project

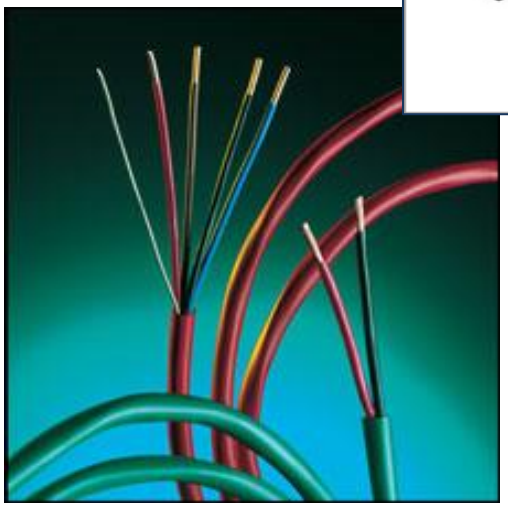
- Chose phthalates as a chemical category, with broad interest to GC3 members
  - As a class, phthalates are a concern
  - Used in many applications – flooring, wire & cable, footwear, adhesives, toys, etc.

- Chose wire and cable for electronics as application
  - Leverages UML's expertise in plastics engineering

Business / University Partnership Project

Focus: Alternatives to known toxic phthalate plasticizers in PVC & non-PVC wire & cable applications

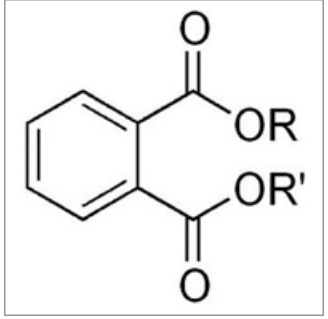




Digression…

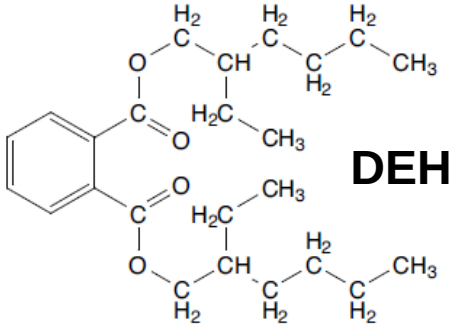
A bit about phthalates

What are “Phthalates”?



Chemically: Esters of phthalic acids, or phthalate esters

R, R’ groups can be linear, branched or linear/branched or cyclic ring



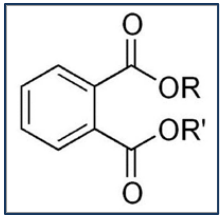
DEHP

Industrially: Many uses!

Ex: Coatings on pills and vitamins, in adhesives and glues, electronics, agricultural products, building materials, personal-care products, medical devices, detergents and surfactants, packaging, children's toys, modeling clay, waxes, paints, printing inks and coatings, pharmaceuticals, food products, and textiles.

Commonly used as *plasticizers* - substances added to plastics to increase their flexibility, transparency, durability, and longevity

Very common in polyvinylchloride (PVC) products – approximately 30-35 % of a PVC formulation is plasticizer.



Why is there concern over Phthalates?

Toxicity

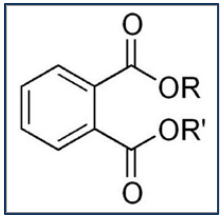
- particularly endocrine affects in humans and animals, and carcinogenicity (e.g., DEHP/DOP – “reasonably anticipated to be a human carcinogen”)

- concern over cumulative effects of several phthalates on reproductive systems in exposed organisms

Widely used & high exposure potential

- easily released into the environment because no covalent bond between the phthalates and plastics
- as plastics age and break down, the release of phthalates accelerates
- detected in food and also measured in humans.

Which phthalates are of high concern?



Most “potent” pthalates are those with linear ester side chains having 4 – 6 carbons. Shorter or longer chain lengths typically exhibit less severe or no effects; however, branching of ester side chain is important.

EPA is most focused on these eight phthalate esters:

-dibutyl phthalate (DBP)
-diisobutyl phthalate (DIBP)
-butyl benzyl phthalate (BBP)
-di-n-pentyl phthalate (DnPP)
-di (2-ethylhexyl) phthalate (DEHP)
-di-n-octyl phthalate (DnOP)
-diisononyl phthalate (DINP)
-diisodecyl phthalate (DIDP).

- EPA is addressing these in their “Pthalates Action Plan”.

- EU REACH Directive has added DBP, DEHP, BBP, DIBP to their Authorization List – which will restrict sale or use in the EU

- Six are banned in children’s products in U.S. and E.U.

How is industry responding?

Some companies are defending their products

DEHP
Information Centre

info@dehp-facts.com Notification by RSS

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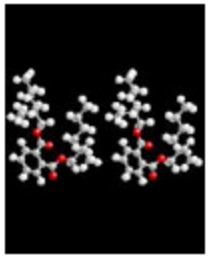
An information resource on the plasticiser di(2-ethylhexyl) phthalate (DEHP)

Di(2-ethylhexyl) phthalate (DEHP) is a cost effective general purpose plasticiser which is used mainly for making PVC soft and pliable. In Western Europe it accounts for about 15% of all plasticiser usage. It is also known as di-octyl phthalate (DOP).



More information

DEHP - the choice of medical device manufacturers

Soft PVC in medical devices saves thousands of lives and increases the comfort and safety of millions of patients every year. No other material meets all the vital performance qualities demanded by health professionals and at such affordable prices.

More information

Safe to use

The European Union authorities have confirmed that DEHP poses no general risk to human health.

[Click for more information]

DEHP - and REACH

Europe's new chemicals legislation: DEHP can continue to be used with confidence

[Click for more information]

Essential softeners

Plasticisers are an essential part of our everyday lives.

[Click for more information]

How is industry responding?

Some chemical companies have shifted their plasticizer product portfolios

BASF
The Chemical Company

News Release

BASF to close DEHP and 2-EH plants

20 June 2005 00:01 [Source: ICB]

Continuing sharp decline in demand for plasticiser diethylhexylphthalate (DEHP) has forced BASF to discontinue manufacture in Europe from the third quarter of this year. It makes the material at its Feluy site

FLORHAM PARK, N.J., September 1, 2006

BASF brings on-stream new 2-propyl heptanol plant in Pasadena, Texas

Key milestone for company's plasticizer platform restructuring in North America

As the first part of plasticizer platform restructing effort at the Pasadena site announced in 2005, this alcohol production unit is based on the company's domestic production of its new flagship plasticizer Palatinol® DPHP.

How is industry responding?

Some Chemical companies are developing new alternatives

DOW

DOW ECOLIBRIUM™ Bio-Based Plasticizers

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Product Name: PARAPLEX® A-8000

POLYESTER ADIPATE

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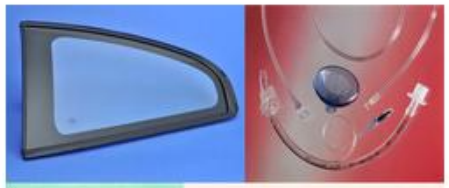
Teknor Apex to Introduce Full Range of Vinyl Compounds Made Flexible with Dow ECOLIBRIUM Bio-Based Plasticizers

Feb 13, 2012

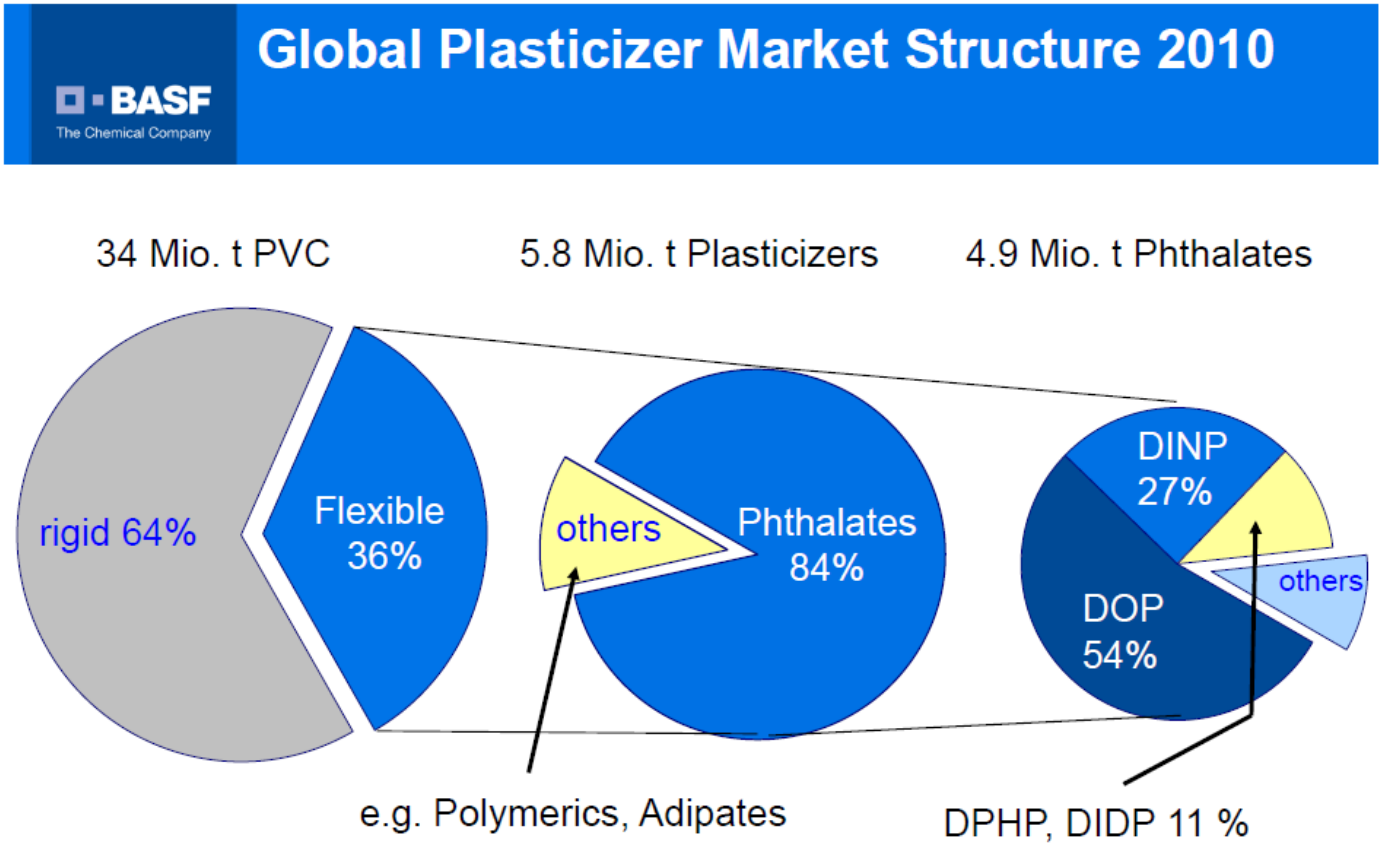
BioVinyl™ Compounds Will Span the Range of Applications for Standard Flexible Vinyl, with Comparable Physical Properties and Petrochemical Content of 35% or Less



How is industry responding?

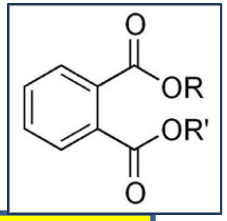
The stakes are very high for producers:

Phthalates are an $11 Billion Business!



Source: SRI, CMAI, BASF estimates

How is industry responding?



The stakes are very high for <u>users</u>:

Users want to avoid "regrettable substitutions"

<u>Quotes from electronic's OEMs:</u>

"It takes 2 years and costs several millions of dollars to switch from one plasticizer to another"

We don't want to switch over to an alternative only to find out several months later that the chemical shows up on regulatory list or becomes a target for NGO's

Now back to the GC3 Business/University Partnership Project…

Business / University Partnership Project

Partners:

Suppliers

BASF

Dow Chemical

Hallstar

Teknor Apex

OEMs/Retail

Dell

EMC

HP

Staples

University Partners

- Lowell Center for Sustainable Production

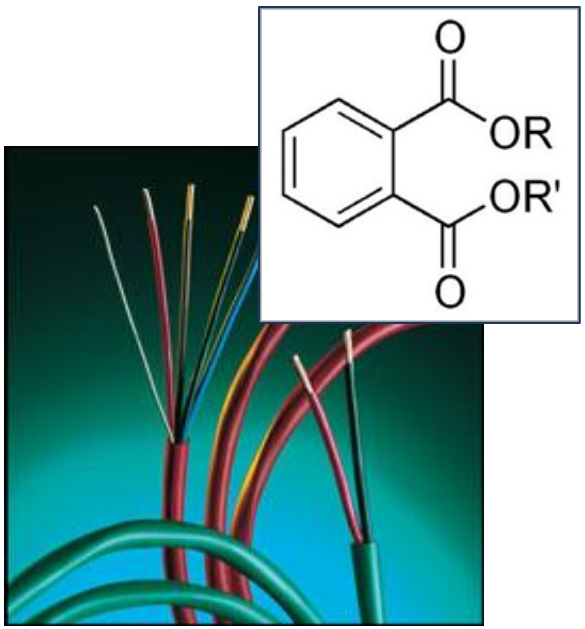
- Faculty of Univ. of Mass Lowell

Government & NGOs

- Washington State

- Clean Production Action

- Pacific Northwest Pollution Prevention Resource Center



Overview of Presentation:

1. The Green Chemistry & Commerce Council (GC3)

2. **Innovative Business / University Partnerships: "The Plasticizer Project"**
   a. **Selection of alternative plasticizers**
   b. Hazard screening using the GreenScreen™
   c. Technical & economic evaluation

3. Future Partnership Projects

Selection of alternative plasticizers

Step 1. Conducted research to identify commercially available plasticizers for wire & cable

Step 2. Surveyed GC3 members to determine which plasticizers are of most interest - 10 companies and 1 trade association responded

Step 3. Plasticizers of interest were screened using "Red Lists" (see next slide). Chemicals on the red list were dropped from consideration.

Step 4. Chemicals that remained were discussed with workgroup and list was reduced to 10

Step 5. 10 Chemicals were screened using the QCAT to further screen out bad actors

- Several were cut because of insufficient EH&S data,
- Workgroup added a few that they were particularly interested in having tested

"Red List" – Lists of chemicals, compiled by government entities, that identify chemicals with one or more of the following hazards:

- Persistent, Bioaccumulative and Toxic (PBT),
- very Persistent and very Bioaccumulative (vPvB),
- very Persistent and Toxic (vPT)
- very Bioaccumulative and Toxic (vBT) or known or likely to be:
    - carcinogenic,
    - mutagenic,
    - reproductive or developmental toxicant,
    - neurotoxicant or
    - endocrine disrupting.

Final List of Plasticizers

Hexamoll® DINCH™ - BASF

DEHT

DINP

DOZ

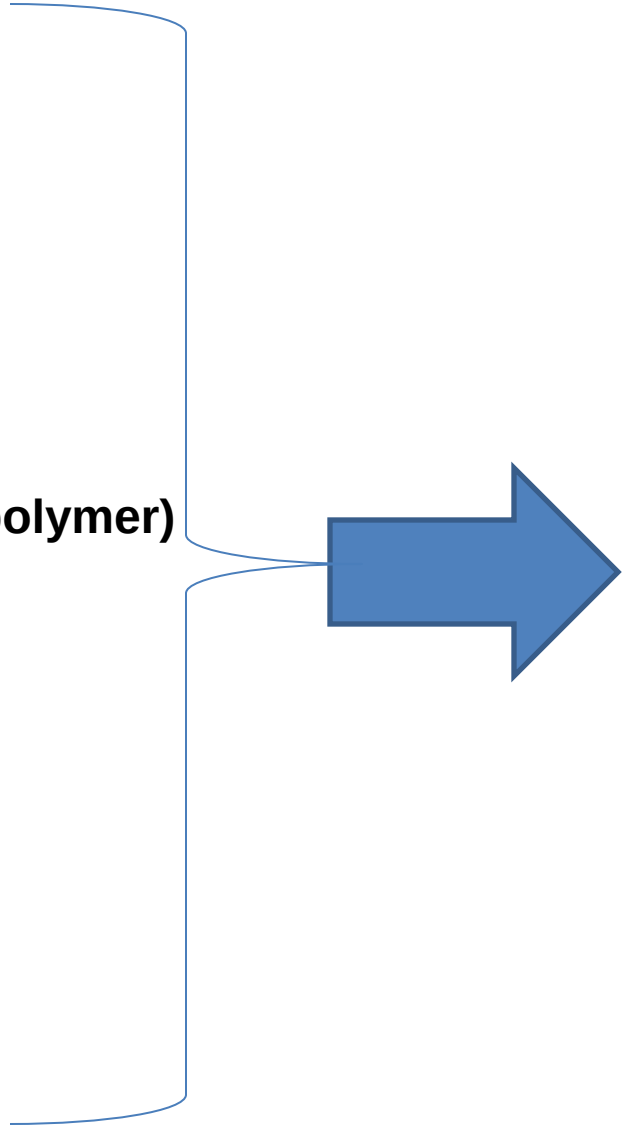
Dow Ecolibrium™ (biobased polymer)

DPHP

TEHTM

HallStar (polyester adipates)

- **Dioplex**
- **Paraplex**



Chemical Hazard Screening using the GreenScreen™ - (conducted by licensed GreenScreen Profiler)

Funding for the Project

Sources:

- Companies in the GC3 Project Group provided cash
  - Plasticizer manufacturers
  - Electronics companies (i.e., users of wire & cable)

- The GC3 & LCSP contributed significantly from its operating budget through in-kind contributions

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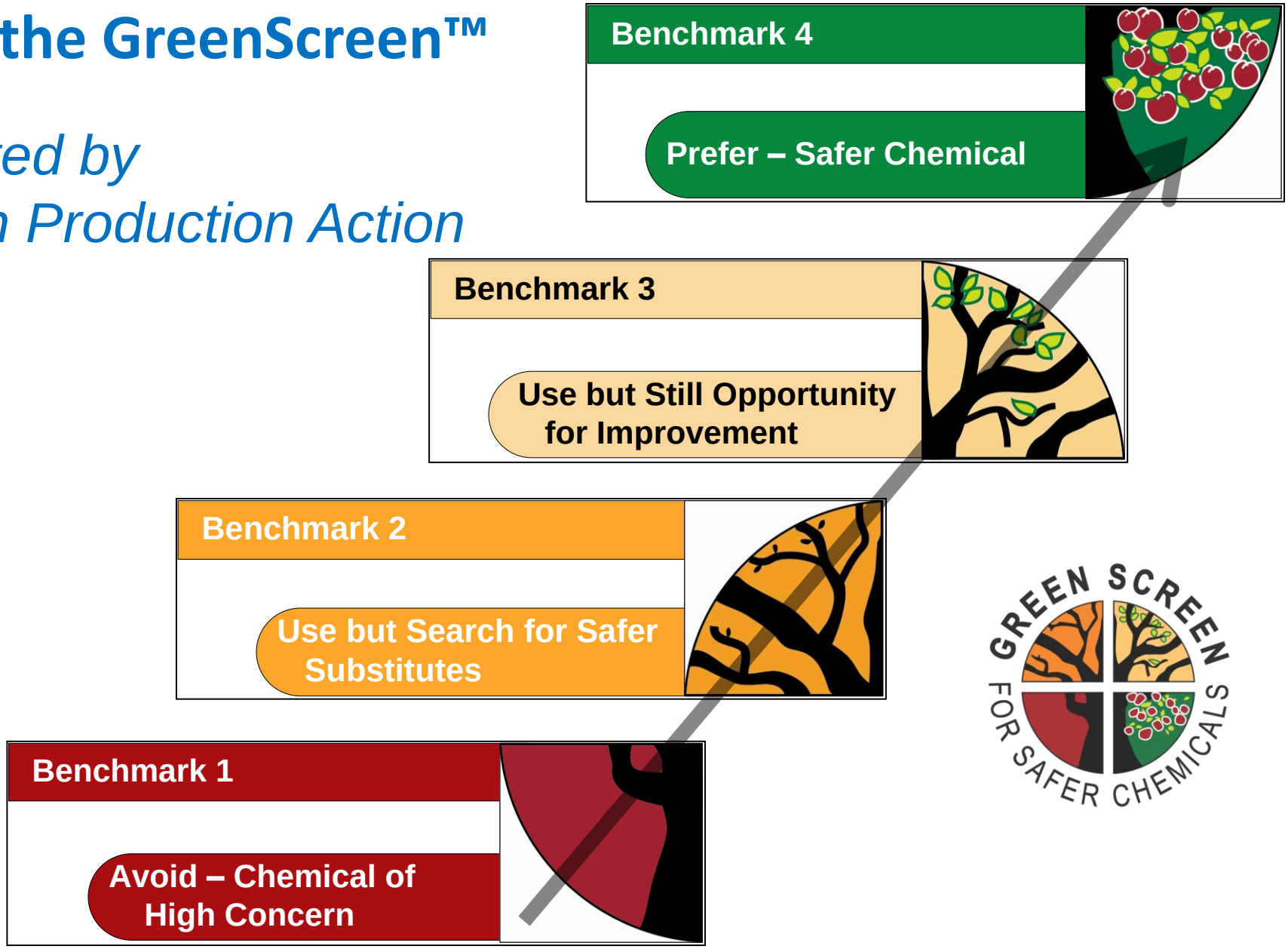
Chemical Hazard Assessment with the GreenScreen™

Created by
Clean Production Action



Green Screen for Safer Chemicals:

What is it?

- Comparative chemical hazard assessment tool
- Uses criteria based on national and international precedents (Globally Harmonized System for Classification and Labeling (GHS), EPA and OECD)
- Makes use of all available toxicological data, QSAR, expert judgment and use of analogs; indicates weight of evidence
- Looks at particular hazards and *combinations of* hazards for an overall chemical benchmark score

Green Screen for Safer Chemicals:
What is it?

- Incorporates life-cycle thinking with a focus on use and end-of-life phases in the product life-cycle
- Open source, transparent and publicly accessible method
- Can be applied to chemicals in products and processes

Green Screen for Safer Chemicals: Hazard Endpoints

Environmental Fate	Environmental Toxicity	Human Health Priority Effects	Human Health Non-Priority Effects	Physical Properties
Persistence	Acute Aquatic Toxicity	Carcinogenicity	Acute Toxicity	Reactivity
Bioaccumulation	Chronic Aquatic Toxicity	Mutagenicity - Genotoxicity	Systemic or Organ Effects	Flammability
Evidence of long range transport		Reproductive toxicity	Immune System Effects	Particle size, form, (i.e. respirable)
Found in env and bio-monitoring studies		Developmental toxicity	Corrosion or Irritation of Skin/Eyes	Mobility (i.e. solubility)
		Endocrine Disruption	Sensitization of Skin/Respiratory System	Moieties; degrad products, metabolites
		Neurotoxicity/Neu rodevel tox		

Green Screen for Safer Chemicals:
Hazard Thresholds (examples)

Hazard	High (H)	Moderate (M)	Low (L))
Carcinogenicity See Test Methods	•GHS Category 1A (Known); OR •GHS Category 1B (Presumed); OR •On specified list(s)	•GHS Category 2 (Suspected): OR •On specified list(s)	•Meets USEPA DfE Master Criteria for Carcinogenicity
Mutagenicity/ Genotoxicity See Test Methods	•GHS Category 1A (Known); OR •GHS Category 1B (Should be regarded as); OR •On specified list(s)	•GHS Category 2 (Possible): OR •On specified list(s)	•Meets USEPA DfE Master Criteria for Genetic Toxicity
Reproductive & Developmental Toxicity (R/D) including Developmental Neurotoxicity (DNT) See Test Methods	**•Reproductive or developmental effect as defined in GHS (i.e. GHS Cat 1 or 2) or developmental neurotoxic effect as defined by the USEPA Risk Assessment Guidelines for the following guidance doses (LOAEL's):** Oral < 50 mg/kg-bw/d Dermal < 100 mg/kg-bw/d Inhalation (vapor) < 1.0 mg/L/d Inhalation (dust/mist/fume) < 0.1 mg/L/d Inhalation (gas) < 50 ppm/d; OR **•On specified list(s)**	**•Reproductive or developmental effect as defined in GHS (i.e. GHS Cat 1 or 2) or developmental neurotoxic effect as defined by the USEPA Risk Assessment Guidelines for the following guidance doses (LOAEL's):** Oral ≥ 50 - < 250 mg/kg-bw/d Dermal ≥ 100 – < 500 mg/kg-bw/d Inhalation (vapor) ≥ 1.0 – < 2.5 mg/L/d Inhalation (dust/mist/fume) ≥ 0.1 – < 0.5 mg/L/d Inhalation (gas) ≥ 50 – < 250 ppm/d; OR **•On specified list(s)**	**•Meets USEPA DfE Master Criteria for Reproductive and Developmental Toxicity** **•No Reproductive or Developmental Effects (including Developmental Neurotoxic effects)** i.e. not GHS Cat 1 or 2; OR **•Reproductive or developmental effect as defined in GHS (i.e. GHS Cat 1 or 2) or developmental neurotoxic effect as defined by the USEPA Risk Assessment Guidelines above the following guidance doses (LOAEL's):** Oral ≥ 250mg/kg-bw/d Dermal ≥ 500 mg/kg-bw/d Inhalation (vapor) ≥ 2.5 mg/L/d Inhalation (dust/mist/fume) ≥ 0.5 mg/L/d Inhalation (gas) ≥ 250 ppm/d; OR **•On specified list(s)**

Green Screen for Safer Chemicals:

Hazard Summary Table

TABLE 5: Hazard Profiles of Phosphorous-based and DecaBDE Flame Retardants (and their breakdown products)

Chemical	Chemical Abstract Servios Registry Number (CAS#)	% in Formulation	Human Health Effects													Ecotox.		Fate		Breakdown Products	
			Priority Effects																		
			Carcinogenic	Mutagenic	Reproductive	Developmental	Endocrine Disruption	Neurological	Acute Toxicity	Systemic/Organ Effects	Sensitization (skin)	Sensitization (respiratory)	Irritation/Corrosion (skin)	Irritation/Corrosion (eyes)	Immune System Effects	Acute	Chronic	Persistence	Bioaccumulation	Metabolites	Degradation Products
Bisphenol A diphosphate (BPADP/BAPP) - CAS# 181028-79-5																					
Phosphoric acid, (1-methylethylidene) di-4, 1-phenylene tetraphenyl ester	5945-33-5	~85	L	L	L	L	nd	L	L	M	L	nd	L	M	L	L	L	H	L	nd	phenol + bisphenol A
Phosphoric acid, bis[4-[1-[4-[(diphenoxyphos-phinyl)oxy]phenyl]-1-methylethyl]phenyl] phenyl ester	83029-72-5	~11	L	L	L	L	nd	L	L	M	L	nd	L	M	L	L	L	vH	L	nd	phenol + bisphenol A
Triphenyl Phosphate	115-86-6	<3	L	L	L	L	nd	L	L	M	L	nd	L	M	L	H	H	L	M	nd	diphenyl phosphate + phenol
Breakdown Products																					
Bisphenol A: contaminant and degradation product	80-05-7		L	L	M	M	H	nd	L	M	M	M	L	H	M	M	M	L	L			
Phenol: contaminant and degradation product	108-95-2		L	M	L	L	L	M	M	H	L	L	H	H	M	M	M	L	L		
Diphenyl phosphate	838-85-7		*insufficient data for evaluation*																		
Resorcinol bis(diphenylphosphate) (RDP) - CAS# 125997-21-9																					
Phosphoric acid, 1, 3-phenylene tetraphenyl ester	57583-54-7	65-80	L	L	L	L	nd	L	L	M	L	nd	L	M	L	L	H	M	H	nd	phenol + resorcinol
Phosphoric acid, bis[3-[(diphenoxy-phosphinyl)oxy]phenyl] phenyl ester	98165-92-5	15-30	L	L	L	L	nd	L	L	M	L	nd	L	M	L	L	L	H	L	nd	phenol + resorcinol
Triphenyl Phosphate	115-86-6	<5	L	L	L	L	nd	L	L	M	L	nd	L	M	L	H	H	L	M	nd	diphenyl phosphate + phenol
Breakdown Products																					
Phenol	108-95-2		L	M	L	L	L	M	M	H	L	L	H	H	M	M	M	L	L		
Resorcinol	108-46-3		L	L	L	L	M	M	M	nd	M	nd	M	M	nd	M	M	L	L		
Diphenyl phosphate	838-85-7		*insufficient data for evaluation*																		

Determining the Green Screen Benchmark Score

This chemical passes all of the criteria.

BENCHMARK 4

ready biodegradability (low P) + low B + low Human Toxicity + low Ecotoxicity
(+ additional ecotoxicity endprints when available)

Prefer—Safer Chemical

BENCHMARK 3

a. moderate P or moderate B
b. moderate Ecotoxicity
c. moderate Human Toxicity
d. moderate Flammability or moderate Explosivenesness

Use but Still Opportunity for Improvement

If this chemical and its break-down products pass all of these criteria, then move on to Benchmark 4

BENCHMARK 2

a. moderate P + moderate B + moderate T
(moderate Human Toxicity or moderate Ecotoxicity)
b. high P + high B
c. (high P + moderate T) or (high B + moderate T)
d. moderate Human Toxicity for any priority effect or high Human Toxicity
e. high Flammability or high Explosiveness

Use but Search for Safer Substitutes

If this chemical and its break-down products pass all of these criteria, then move on to Benchmark 3

BENCHMARK 1

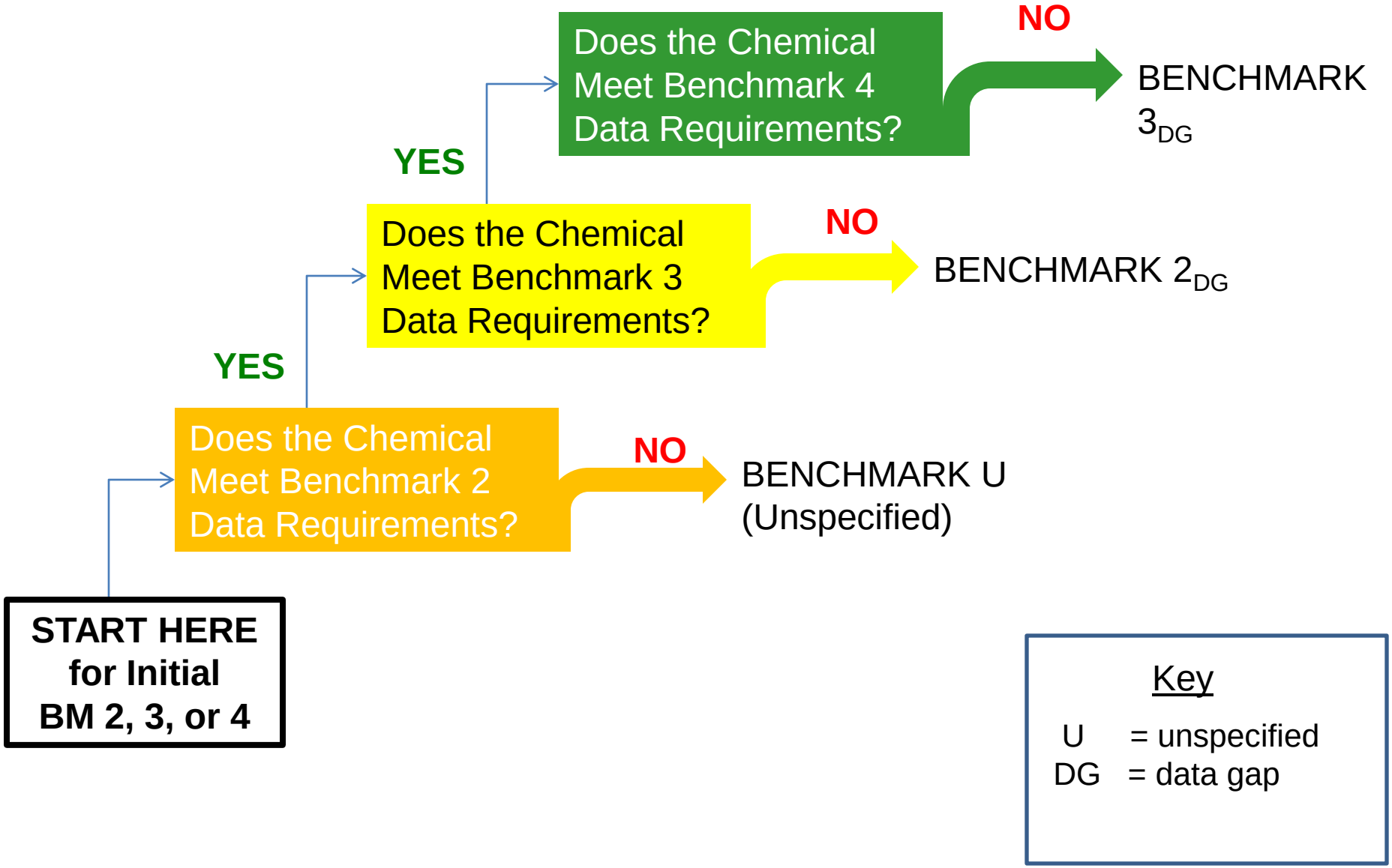
a. PBT: high P + high B + high T[1] (high Human Toxicity[2] or high Ecotoxicity)
b. vPvB: very high P + very high B
c. vPT (vP + high T) or vBT (vB + high T)
d. high Human Toxicity for any priority effect[1]

Avoid—Chemical of High Concern

If this chemical and its break-down products pass all of these criteria, then move on to Benchmark 2

Determining the GreenScreen Benchmark Score

Step 2 – Determining Highest Benchmark Achievable Based on Data Requirements



Users of the Green Screen

Include:

- HP
- Walmart
- PolyOne
- Dow Chemical
- US State Regulatory Agencies
  - Washington State
  - Maine
  - California
- U.S. Environmental Protection Agency: Design for Environment

Process Followed for GreenScreen Assessments in the Partnership Project

1. GreenScreen Licensed Profiler conducted assessments - ToxServices;
2. Draft reports were posted on a webpage and partners were invited to comment. Comments also posted. Comments included recommendations to include additional data sources, opinions on expert judgment.
3. Profiler revised GreenScreens as required, based on comments received, but in keeping with GreenScreen guidelines.

Process Followed for GreenScreen Assessments: Project Webpage

Lessons from the GreenScreen™ assessments

Benefits of the collaborative model, according to participants

1. Suppliers find value in a third party assessment for internal communication and marketing
2. OEMs find value in a third party assessment, to avoid “regrettable substitutions”

    - Want a “consensus” around the safety of potential substitutes before spending years/millions of dollars switching over

Lessons from the GreenScreen™ assessments

3. Differences in managing the process for commodity vs. newer chemicals/proprietary formulations

- GSs for proprietary formulations done under NDA (between supplier and profiler) – lack of transparency

- GSs for commodity chemicals are more transparent, though some data sources may be proprietary

4. Lack of consensus over whether companies with proprietary formulations should be allowed to participate in this type of project

Overview of Presentation:

1. The Green Chemistry & Commerce Council (GC3)

2. **Innovative Business / University Partnerships: "The Plasticizer Project"**
   a. Selection of alternative plasticizers
   b. Hazard screening using the GreenScreen™
   c. **Technical & economic evaluation**

3. Future Partnership Projects

Technical & economic evaluation:

TBD

Overview of Presentation:

1. The Green Chemistry & Commerce Council (GC3)

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   a. Selection of alternative plasticizers
   b. Hazard screening using the GreenScreen™
   c. Technical & economic evaluation

3. **Future Partnership Projects**

Future Partnership Projects

Ideas Welcome!

7th Annual

GC3 Green Chemistry & Commerce Council

Innovators Roundtable

MAY 9–11 • 2012

Ann Arbor, Michigan

Hosted by NSF International

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Click here to register & pay by credit card online

http://greenchemistryandcommerce.org/events.roundtable.overview.php?pid=68

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Thank You!

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