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The Landscape of Green Chemistry Metrics

Green Chemistry & Commerce Council
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GC Metrics: Mapping The Landscape

- **Goal:**
  - summarize and outline approaches to measuring progress towards green chemistry at several levels:
    - Molecular/ Chemical
    - Material, Product
    - Firm, Sector
    - Societal
- **Define:**
  - What do we mean by “green chemistry” and what do we mean by “progress”?

GREEN CHEMISTRY & COMMERCE COUNCIL

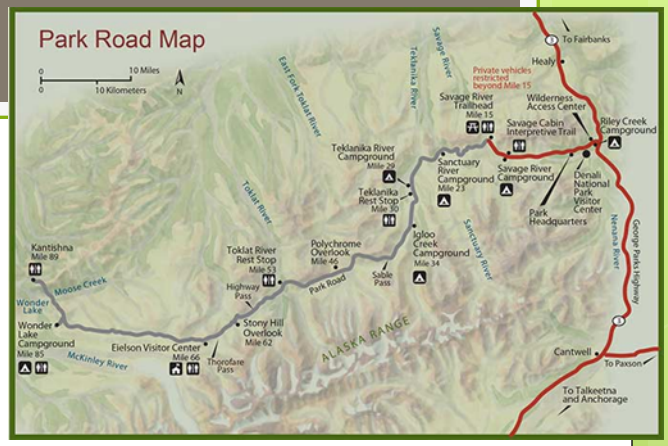
Business Mainstreaming Green Chemistry

GC3 Definition:

- Green Chemistry is a growing practice that **reduces or eliminates the use or generation of hazardous substances** in the design, manufacture, and application of chemical products.

- The application of Green Chemistry **results in products and processes that protect and benefit the economy, people, and the planet** and help us make significant strides toward a more sustainable future. Following the principles of green chemistry **leads to the use of more sustainable feedstocks, development of less toxic products and processes, a reduction of energy and waste**, and can lead to other manufacturing efficiencies

What we found….



- Available metrics are all over the map, although options exist at each level
- Most measures are **proxy measures**: e.g.,
  - use/ release, concentration in biota,
  - economic, health outcome, etc.
- Many tools are available for measuring movement away from Chemicals of Concern
- Fewer tools for moving towards preferable, chemicals/ materials/ products, but some moving that way, others with potential
- **We have an opportunity to be more intentional about what we measure.**
  - **And in the process define more clearly where we want to go**

A Quick (Not Intended to be Comprehensive!) Tour

- Company level metrics, internally generated:
  - Sigma Aldrich: example of process metrics
  - Singlotex: translating Green Chemistry principles to products
  - SC Johnson's GreenList: chemical ingredient level tracking, rolled up to product and firm
- Externally derived tools & benchmarks
  - Material, product level
- Societal Level
  - Human health and environment

certain products may be more sustainable than others. Currently, there is no reasonable quantitative standard in our industry that explains a product's environmental impact. A consistent and easy-to-understand system is an important tool to help consumers make informed decisions about "greener" products.

To address this issue, we launched a project to quantitatively determine relative "greenness" of a product based on the 12 Principles of Green Chemistry.

Green Chemistry

Sweet potatoes are an excellent source of β-amylase, which is an enzyme that degrades starch into sugar. Sigma-Aldrich re-engineered how we manufacture β-amylase using the 12 Principles of Green Chemistry to minimize environmental impacts and improve production. Here's what we did:

Reduce Raw Materials

Reduced the amount of raw materials (sweet potatoes) needed by 4,000 lbs

Eliminate Acetone

Eliminated the use of 1,700 gallons Acetone in the preparation

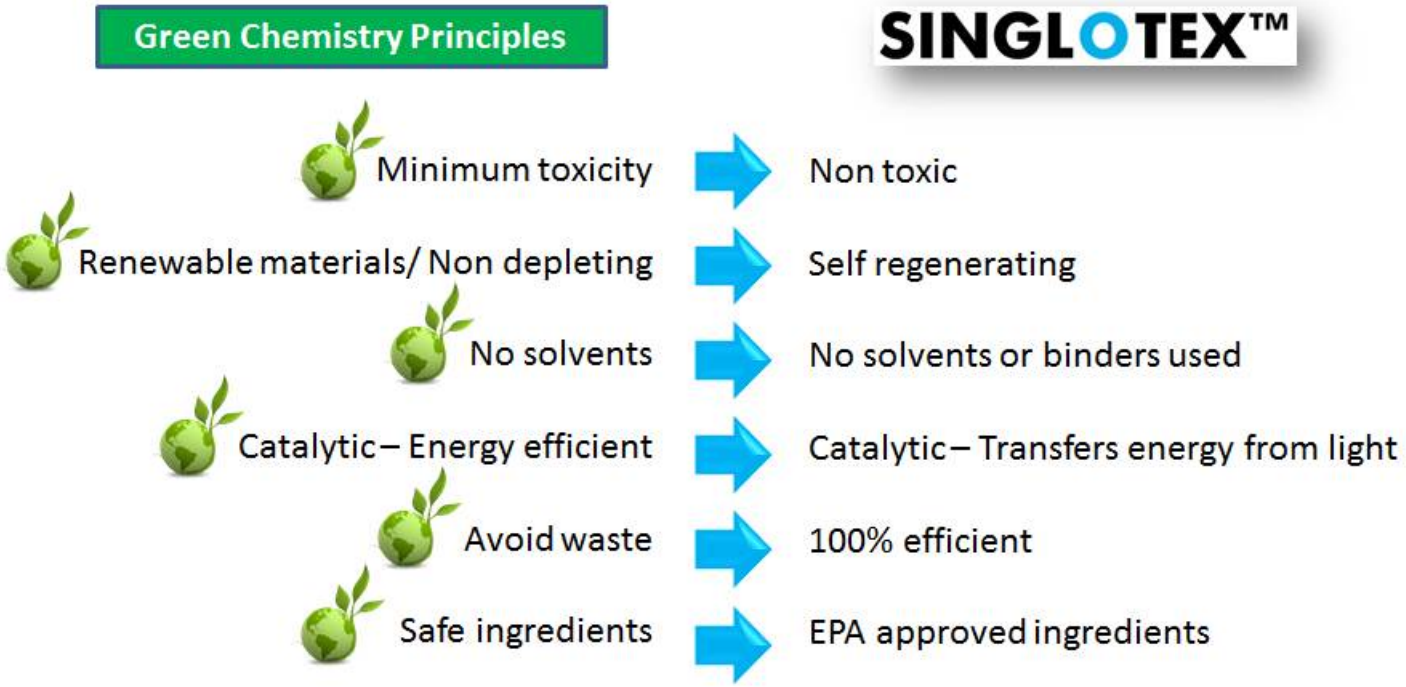
Reduce Energy Usage

Eliminated the need for elevated temperature and pressure, reducing energy usage

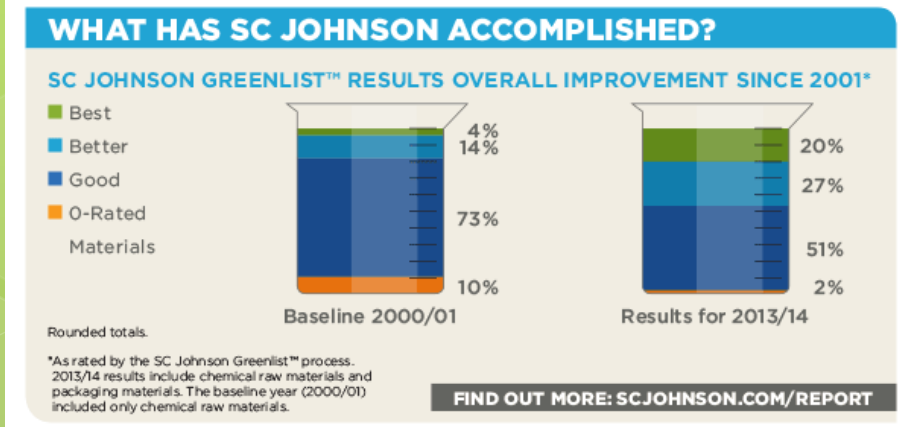
Increase Product

Increased the yield of the product

Translating GC Principles to Products



SC Johnson's Greenlist



- "The goal was to go beyond taking out "bad" ingredients and instead focus on choosing "better" options and continuously improving formulas based on information about ingredients' impact on the environment and human health."

MATERIAL IQ

GREENBLUE®

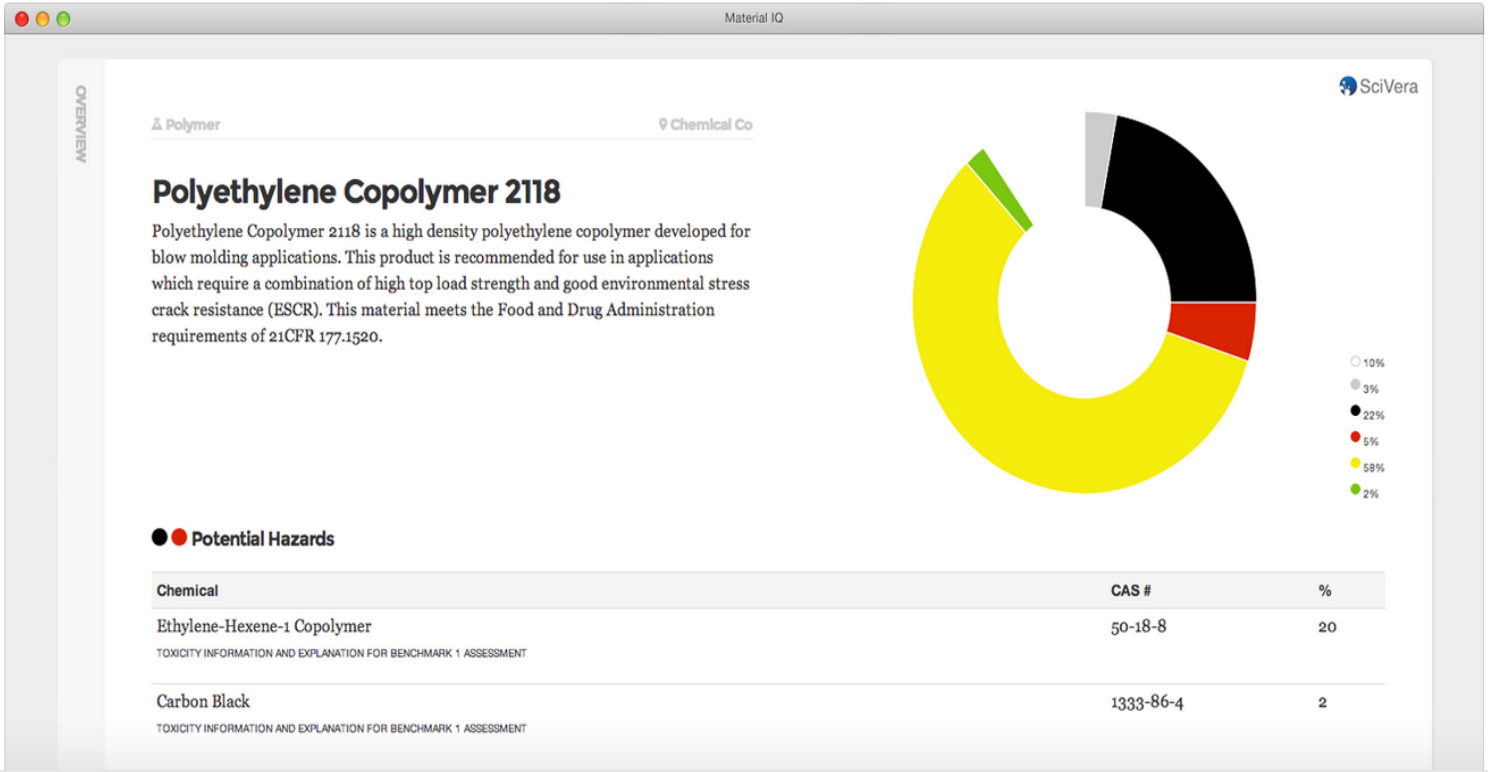
cradletocradle℠

Ingredient/ Material/ Product

- **Not metrics per se, but tools that could be utilized to track progress to greener chemistry:**
- **Material in Product:**
  - **Cradle to Cradle Material Health Assessment:** "Knowing the chemical ingredients of every material in a product, and ***optimizing towards safer materials"***
- **Comparing Materials:**
  - **Green Blue's Material IQ**: "…designed to facilitate more effective communication of chemical and material level data between all stakeholders in a product value chain."
- Comparative Hazard in a **Material Class**
  - BizNGO/ Clean Production Action's **Plastics Scorecard**
    - Hazard based assessment of polymer process chemistry
    - Next phase: hazard assessment of functional additives

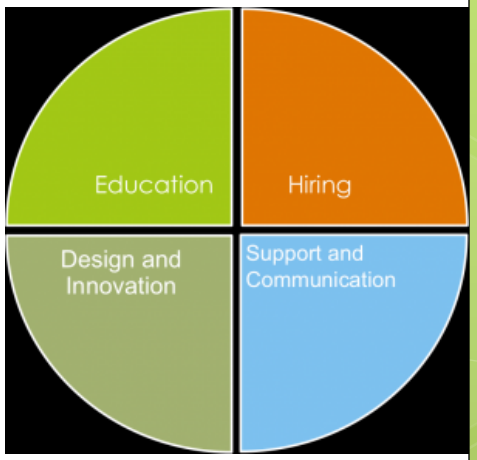
Each Product Profile in MiQ offers a comprehensive, third party-validated hazard evaluation of chemical, mixture or material level products.

- Screening methodologies include ListTranslator™, SciVera Lens™ or GreenScreen™ for Safer Chemicals
- Summary view of potential chemical hazards that may be cited on regulatory lists, restricted substance lists or certifications
- Suppliers can report the "preferable characteristics" of their products without disclosing confidential information
- Trade name of products with full description of common applications
- Hazard information conveyed in a simple interface to easily facilitate comparisons
- Material IQ is intended to be a design tool for all manufacturers, providing insight in how to improve their products



Externally Derived Firm Level Metrics

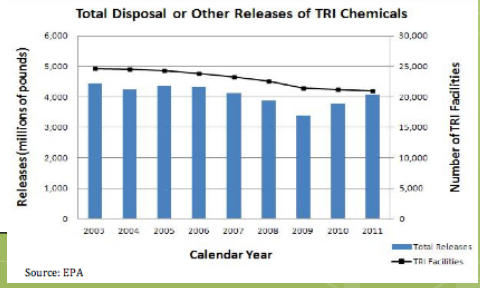
- **Michigan Business Green Chemistry Checklist**
  - **Education**
    - Internal training opportunities for staff, awards, etc.
  - **Hiring**
    - Explicit reference to green chemistry in job postings
    - Include GC in performance requirements
  - **Design and Innovation**
    - New green chemistry products and processes
    - Progress towards green chemistry goals
  - **Support and Communication**
    - Collaboration with local academic institutions
    - Communicate GC goals to suppliers
- **Chemical management at firm level:**
  - **Chemical Footprint Project** (CPA, Lowell, Pure Strategies): "tool for benchmarking companies as they select safer alternatives and reduce their use of chemicals of high concern".



cfp
the chemical footprint project

Societal Metrics, examples

- Monitoring of humans and other biota
  - PBDEs in Swedish breast milk, San Francisco Bay shellfish
  - Nordic SPIN: Substances in Products in Nordic Countries
  - Washington Children's Safe Products Act
- US EPA's Toxics Release Inventory
  - Reduction in use of specific chemicals or class of chemicals
  - Reduction of use of reportable chemicals by a company or facility
  - Reduction of use of certain chemistries by sector
    - E.g., pharmaceuticals
      - (possibly from process efficiency, not changes to more benign chemistries)



If the Vision is….

- Products and processes that protect and benefit the economy, people and the planet then:
- **Metrics should move us towards these goals**
- Existing work and metrics fit into this:
  - Ingredient disclosure and supply chain transparency lets to better characterized chemistry, which leads to opportunities for improvement….

This is an opportunity:

- **What could a "better " measure look like?**
  - Different metrics at different parts of the supply chain:
    - **Molecular/ Process:** adherence to 12 principles
    - **Firm/ Sector:** number/volume of products containing greener chemistries
    - **Societal:** lifting of specific disease burden, environmental contamination
  - Some Other Ideas:
    - Potential **Health** metrics:
      - Reduction of cancer and other diseases for most impacted populations
      - Challenge: tying individual chemicals to specific diseases; tracking regrettable substitutions
    - **Economic** metrics: jobs, R&D spending, patents, investment (in products, education, etc.)
  - Connect with parallel health and economics-focused efforts
    - Cancer-Free Economy, First 1000 Days

Moving Forward: For Safer Materials:

- US EPA Presidential Green Chemistry Award Criteria
  - Reduce toxicity (acute or chronic) or the potential for illness or injury to humans, animals, or plants
  - Reduce flammability or explosion potential
  - Reduce the use or generation of hazardous substances, or their releases to air, water, or land
  - Improve the use of natural resources, for example, by substituting a renewable feedstock for a petroleum feedstock
  - Save water or energy
  - Reduce the generation of waste, even if the waste is not hazardous

Moving forward:

- Other potentially useful starting points:
  - Emerging sector chemical disclosure/ tracking efforts (if transitioned from tracking "bads" to moving to better chemistries)
    - Apparel/ footwear: ZDHC
      - Data Schema work stream: in data-gathering phase
    - Built Environment: Health Product Declaration
    - Natural Products Association
      - Lists of banned **AND** preferred ingredients and processes
      - >1,100 products currently meet these standards

Ø ZDHC
Zero Discharge of Hazardous Chemicals

Health Product Declaration Collaborative

NATURAL PRODUCTS ASSOCIATION CERTIFIED

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For Discussion

- Where do you think we need to develop better metrics?
- What key indicators would GC3 need to track for "progress in Green Chemistry"?

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