What is Global Citizenship?

Maximizing

SIGMA-ALDRICH

Minimizing
Global Citizenship at Sigma-Aldrich

**Es**

**Environmental Sustainability**
- WASTE 20% Intensity Improvement
- EMISSIONS 20% Intensity Improvement
- WATER 30% Efficiency Improvement
- ENERGY 20% Intensity Improvement
- SUPPLY CHAIN TRANSPARENCY Top 200 suppliers surveyed by 2015
- GREENER ALTERNATIVE PRODUCTS 25% increase in sales of our Greener Alternative Products

**Sr**

**Social Responsibility**
- MONETARY GIVING Up to 1% of pre-tax profit
- VOLUNTEERISM 4 volunteer hours per employee by 2015
- TEAM SIGMA-ALDRICH Team 5-A in 37 countries by 2015

**Fa**

**Fiscal Accountability**
- Governance policy development
- Avoiding conflicts of interest
- Compliance with local laws and regulations
- Ethical business practices
- Business code of conduct
Greener Chemistry: Overview

12 PRINCIPLES OF GREEN CHEMISTRY

1. Waste 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

OUR PROCESS

Reengineered Products/Product Scoring → Product Portfolio Expansion → Marketing → Packaging/Labeling → Shipping

Greener Alternatives Platform

- Re-Engineered
- 12 Principles Aligned
- Enabling Technologies
  - Enzyme & MatSci Products for Alternative Energy and Energy Storage
Quantitative Green Chemistry Evaluator
The Sigma-Aldrich Approach to Green Chemistry

Leverage Global Capability to Enable Greener Chemistry

9 Green Chemistry Centers
40 Scientists
25+ Products Re-Engineered
Greener Alternatives: Re-engineered Products

**DOZN™**
Quantitative Green Chemistry Evaluator

**BETA-AMYLASE**

<table>
<thead>
<tr>
<th>PRINCIPLE</th>
<th>% IMPROVEMENTS</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1 Waste Prevention</td>
<td>55</td>
<td>Eliminated organic solvent usage and reduced 50% overall waste generation</td>
</tr>
<tr>
<td>#2 Atom Economy</td>
<td>52</td>
<td>Increased yield and reduced amount of raw materials used</td>
</tr>
<tr>
<td>#3 Less Hazardous Synthesis</td>
<td>96</td>
<td>Replaced organic solvents with water-based solutions and removes toxic filtering agents</td>
</tr>
<tr>
<td>#5 Safer Solvents</td>
<td>100</td>
<td>Eliminated all organic solvent usage</td>
</tr>
<tr>
<td>#6 Energy Efficiency</td>
<td>100</td>
<td>New process eliminated need for elevated temperature and pressure</td>
</tr>
<tr>
<td>#7 Renewable Feedstock</td>
<td>71</td>
<td>More efficient use of sweet potatoes while reducing auxiliary chemicals</td>
</tr>
<tr>
<td>#10 Design for Degradation</td>
<td>No change</td>
<td>No increased environmental impact with new procedure</td>
</tr>
<tr>
<td>#12 Accident Prevention</td>
<td>54</td>
<td>Eliminated flammability and reactivity dangers</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>95%</strong></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>AGGREGATE SCORE</th>
<th>Previous Process</th>
<th>Reengineered Process</th>
</tr>
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<tbody>
<tr>
<td><strong>43</strong></td>
<td><strong>2</strong></td>
<td></td>
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</table>

**SCORING MATRIX**
0 = most desirable
## Greener Alternatives: Re-engineered Products

### 1-AMINOBENZOTRIAZOLE

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<tr>
<td>#1 Waste Prevention</td>
<td>75</td>
<td>Reduced 40% of organic solvent usage</td>
</tr>
<tr>
<td>#2 Atom Economy</td>
<td>72</td>
<td>Increased the yield and reduced amount of raw materials used</td>
</tr>
<tr>
<td>#3 Less Hazardous Synthesis</td>
<td>72</td>
<td>Eliminated the hazardous hydrogenation procedure</td>
</tr>
<tr>
<td>#5 Safer Solvents</td>
<td>72</td>
<td>Used lesser volume of solvents</td>
</tr>
<tr>
<td>#6 Energy Efficiency</td>
<td>77</td>
<td>Eliminated the heating in the procedure</td>
</tr>
<tr>
<td>#7 Renewable Feedstock</td>
<td>72</td>
<td>Used renewables and reduced auxiliary chemicals</td>
</tr>
<tr>
<td>#12 Accident Prevention</td>
<td>96</td>
<td>Eliminated the Pd/C use which in turn eliminated the potential for accident</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>77%</strong></td>
<td></td>
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</table>

### SCORING MATRIX

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<td>94</td>
<td>22</td>
<td></td>
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</table>

0 – most desirable
Greener Alternatives: Aligned

Reduce the generation of Waste and CO₂ emissions with Cyclopentyl methyl ether (CPME)

**CPME PROCESS**

**REACTION**
Product 3MT / CPME 7MT

**EXTRACTION**
Product 3MT / CPME 7MT + H₂O 3MT

**CONCENTRATION**
Product 3MT / CPME 7MT

**PRODUCT 3MT**

**THF PROCESS**

**REACTION**
Product 3MT / THF 7MT

**EXTRACTION**
Product 3MT / AcOEt 6MT + THF 2.8MT + H₂O 6MT

**CONCENTRATION**
Product 3MT / AcOEt 6MT + THF (2.8-3.0) MT

**PRODUCT 3MT**

**Samples-Stored Green**

- Sustainable sample storage
- Ambient transport of samples
- 65% cost savings over ultra cold freezers (-80°C and -20°C)

<table>
<thead>
<tr>
<th>Freezer</th>
<th>Room Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Energy Usage</td>
<td>20 million BTUs</td>
</tr>
<tr>
<td>Annual CO₂ Emissions</td>
<td>1.84 metric tons</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Recovery rate</th>
<th>Waste</th>
<th>CO₂*</th>
</tr>
</thead>
<tbody>
<tr>
<td>THF 60%</td>
<td>14.8 MT</td>
<td>18.8 MT</td>
</tr>
<tr>
<td>CPME 90%</td>
<td>3.7 MT</td>
<td>1.8 MT</td>
</tr>
</tbody>
</table>

**Natural Capital Savings**

11.1 MT Reduction 170 MT

*The figures of CO2 emissions were calculated from the generation of waste solvents.*
You can find these products and more information at www.sigmaldrich.com/greener
Ratings and Rankings
QUESTIONS?