Life Cycle Environmental Assessment of Engineering Plastics compounds: towards an advanced level of data quality.

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Agenda

- Rhodia Engineering Plastics
- Our commitment to sustainability: ongoing program for environmental impact assessment of Technyl® range
- How to go further? fields for improvements
Solvay- Rhodia Engineering Plastics: Leading positions to capture upcoming market growth

**Technyl® range** Based on polyamide matrices

- **FIRE RESISTANCE**
- **FLUID RESILIENCE**

- **Automotive & Transportation**: 61%
- **Electrical & Electronics**: 17%
- **Construction & Industrial equipment**: 15%
- **Consumer Goods**: 7%

Our conviction: sustainability is a key performance, serving all markets
For supporting our commitment to sustainability: Environmental Evaluation: the 3E team

**Vision**

1. To become a relevant partner in the field so as to act either defensively or proactively
2. To objectively assess the impact of our processes and products at each step of life cycle
3. To contribute to our customers’ process environmental assessment
4. To promote production routes more environmentally friendly

**Missions**

- Position our key processes and products vs. our competitors
- Propose simplified methods to facilitate the selection of process routes
- Survey the changes in methods, norms and indicators

With its roots in LCA process and methodology
Following LCA methodology, one of our objectives is to provide high quality assessments of our operations (cradle-to-gate)

As bricks for building with our partners full LCA (cradle-to-gate) of our products
A unique collaboration between industrial companies all along the value chain:

A guarantee for high quality data
A full Life-cycle Assessment

Chemical company + Plastic compounding

Production of NON-RECYCLED Technyl®

Production of RECYCLED Technyl®

Two different LCAs (since formulations are different)

A single LCA (since design and weight are identical)

Vehicle assembly

Use

End of life

Seven environmental indicators reflected in the Life-cycle Assessment

Acidification (kg SO2 Equiv.) = contribution to acid rain

Eutrophication (kg PO_4^{3-} Equiv.) = disturbance of aquatic environments

Climate change (kg CO_2 Equiv.) = greenhouse gas emissions

Depletion of non-renewable resources (kg Sb Equiv.) = depletion of fossil and mineral resources

Depletion of the ozone layer (kg CFC11 Equiv.) = aggravation of the hole in the ozone layer

Primary energy consumption (MJ of primary energy) = consumption of terrestrial energy resources

Photochemical oxidation (kg ethylene Equiv.) = contribution to ozone peaks in ambient air

A single collaborative approach with a multi-criteria analysis reflecting the whole value chain
Equip all Peugeot 208 produced in a year (400 000 vehicles) with a FMA made of recycled Technyl® allows to save:

**Dissemination in fresh water of the equivalent of 300 kg of phosphate, equivalent to effluents linked to the cultivation of 50t of wheat in France (6.7 ha).**

**Greenhouse gas emissions (in CO₂ equivalent) by 400,000 cars traveling around the Paris ring road.**

**Photochemical ozone production (in C₂H₄ equivalent) by 2,200,000 cars traveling around the Paris ring road.**

**The emission of 3600 kg of SO₂ eq. into the atmosphere, equivalent to the emissions from the production of 2500 MWh by a coal power plant in Germany, about 400 times the German annual per capita consumption (2009).**

**Consumption of 18 million mega joules of primary energy, equivalent to the primary energy consumption linked to the production of 1400 MWh of electricity in France, or nearly 200 times the French annual per capita consumption (2009).**

**As compared to a standard Technyl®**
Such studies particularly rely on an accurate assessment of Technyl® “cradle-to-gate” environmental impact developed by Rhodia

From a generic model (example based on polyamide 6-6):

As described in data bases

Raw Materials

- Adiponitrile
- Hexamethylene diamine
- Energy recovery
- Material recovery
- Cyclohexanol
- Cyclohexanone
- Adipic acid

- Energy
- Water
- Transportation
- Additives & fibers

Monomer

Polyamide 6-6

... To:

- complete inventories of all our operations,
- based on data with increased relevance for raw materials
Progresses in our assessments follow a comprehensively designed program

<table>
<thead>
<tr>
<th>Raw materials for polymers</th>
<th>Primary level</th>
<th>Basic level</th>
<th>Advanced level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Available in databases</td>
<td>From database</td>
<td>Model from literature data</td>
<td>From suppliers</td>
</tr>
<tr>
<td>Not available in databases</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Compound additives</th>
<th>Primary level</th>
<th>Basic level</th>
<th>Advanced level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Available in databases</td>
<td>Only major additives (ex: glass fiber)</td>
<td>All additives available in databases</td>
<td>From suppliers</td>
</tr>
<tr>
<td>Not available in databases</td>
<td>Model from literature data</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Material flows</th>
<th>Primary level</th>
<th>Basic level</th>
<th>Advanced level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major flows; by-products &amp; emissions</td>
<td>Major flows; by-products &amp; emissions Site-specific</td>
<td>All flows including exhaustive inventory of water flow</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Process description</th>
<th>Primary level</th>
<th>Basic level</th>
<th>Advanced level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Only the major chains</td>
<td>All sites, considering intermediate flows between sites Site-specific energy recovery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Significant energy recovery</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Range coverage</th>
<th>Primary level</th>
<th>Basic level</th>
<th>Advanced level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generic compounds for the major segments</td>
<td>Generic compounds of all segments</td>
<td>Entire core range</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transportation</th>
<th>Primary level</th>
<th>Basic level</th>
<th>Advanced level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation of intermediates between Rhodia sites</td>
<td>Transportation of intermediates between Rhodia sites</td>
<td>+ Transportation of raw mat.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Update</th>
<th>Primary level</th>
<th>Basic level</th>
<th>Advanced level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Each year (analysis of improvements)</td>
<td>Each year (analysis of improvements)</td>
<td>Each year (analysis of improvements)</td>
<td></td>
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</tbody>
</table>

Continuous improvement process
The present level of our analyses offers a full mapping of the environmental impact of our operations

Example of Polyamide 6-6 production over Rhodia worldwide production capacities

- The simplified model (preliminary level) provides a consistent assessment
- All calculated footprints are lower than those proposed in the databases for PA 6-6 (need for update)
- Differences in environmental footprints result from site specificities, different origins of raw materials as well as energy production mixes
Updating the assessment reveals to be necessary, due to huge effects process improvements can have on environmental impacts.

Example of the effect of N$_2$O abatement at Adipic Acid synthesis on Polyamide 6-6 CO$_2$ footprint

N$_2$O is a strong greenhouse gas, emitted as a chemical by-product at adipic acid synthesis. Since 1997, Rhodia has launched a series of investments in order to gradually reduce N$_2$O emissions.

This abatement has a dramatic effect on Polyamide 6-6 CO$_2$ footprint

Today, abatement efficiency reaches more than 98,5%
How to go further in high quality assessments? And really reach an advanced level

Environmental impact of our products comprises a high contribution of:
- raw materials
- additives

Example of Rhodia engineering plastics compounds

<table>
<thead>
<tr>
<th>Technyl® for automotive applications</th>
<th>Technyl® for flame retardant applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>11%</td>
<td>7%</td>
</tr>
<tr>
<td>24%</td>
<td>27%</td>
</tr>
<tr>
<td>4%</td>
<td>3%</td>
</tr>
<tr>
<td>14%</td>
<td>34%</td>
</tr>
<tr>
<td>46%</td>
<td>30%</td>
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Split of CO₂ footprint of 2 major types of Technyl® compounds according to the contribution of basic items:
- emissions
- energy
- other
- additives
- raw materials for PA

From measured data ("scope 1" & "scope 2")
From databases or simplified modeling (part of "scope 3")

Need for improved sources of data

Solvay/Rhodia contribution:
- Participation to database update programs: ecoprofiles, ERASM, ...
- Collaboration to projects including LCA: ELIBAMA, ENFIRO, ...
- Partner of CIRAIG (o/w database workshop)
- Building partnership with customers and SUPPLIERS
- ...
Thanks for your attention!