LIFE CYCLE ENVIRONMENTAL ASSESSMENT OF ENGINEERING PLASTICS COMPOUNDS : NEED FOR EXTENDED DATABASES IN THE FIELD OF ADDITIVES.

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1 INTRODUCTION

Rhodia Technyl® engineering plastics range is based on Rhodia polyamide polymers : PA6-6, PA 6 and PA 6-10.

Such polymers have unique intrinsic properties in mechanical performance over a wide range of temperatures, fluid resilience and fire resistance. Those properties are leveraged in Technyl® formulations, reinforced with appropriate high performance additives.

Resolutely committed to sustainable development, Rhodia has included sustainability in the scope of performances of its products and thus developed several years ago an expertise in assessing the environmental impact of its operations and products over their life cycle, based on LCA methodology.

Such assessments allowed highlighting key contributors to the environmental impact of our products, as well as potential levers for significant reductions, such as recycling or use of bio-sourced materials. They will be developed in this paper.

In the same time, those studies brought out several difficulties in building Life Cycle Assessment of industrial products and. They will be also detailed here.

2 A FEW WORDS ABOUT TECHNYL® RANGE.

Technyl ® range is majorly based on Polyamide 6-6 (polycondensate of AH salt, synthesized from adipic acid and hexamethylene diamine) polymer matrices as well as, in a lower extend, on Polyamide 6 (polycondensate of caprolactam) and Polyamide 6-10 (polycondensate of the salt synthesized from sebacic acid – biosourced, obtained from castor oil - and hexamethylene diamine). Special polyamides can also be included in certain matrices in order to adjust some properties.

Additives complement polyamide matrices in Technyl® formulations in order to reinforce their intrinsic properties and turn them into tailored high-performance engineering plastics. Among those additives, the following can be listed :

- for high mechanical properties : glass or carbon (short or continuous) fibers, mineral fillers, elastomers ;
- for fluid resilience : organic and inorganic stabilizers, elastomers, eventually food contact grades, depending on the application ;
- for fire resistance : mineral fillers and flame retardant additives.

All raw materials and additives are procured by Rhodia from suppliers, as schematically shown below for Technyl® based on Polyamide 6-6 :

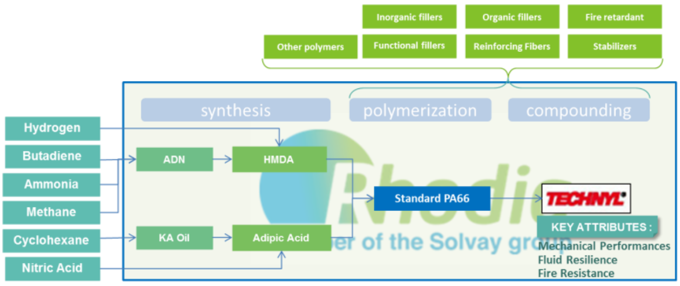

Figure 1

Technyl® compounds have gained – and are still gaining - significant market share over other traditional materials in the three fields of application listed above, due to their remarkable performances allowing :

- gain of weight, especially in the automotive industry, for which it is one of the most critical challenges ;
- ease of process ;
- possibility to reach higher requirements.

These performances make Technyl® materials of choice in many markets such as the automotive industry, electrics & electronics and sports & leisure. In those markets, they bring new, high performance solutions.

We are convinced that sustainability (and more particularly environmental impact reduction) has to be included in the overall envelop of performances. Then, Technyl® contribution to sustainability of systems and functions in which they are involved has to be assessed. This is being done using the LCA methodology.

3 LIFE CYCLE ASSESSMENT OF TECHNYL® COMPOUNDS

Life Cycle assessment of a functional unit covers the entire life of a system implementing the function (from the beginning of its manufacture to its final destruction or storage for recycling).

In the case of Technyl® compounds, Application fields are manifold and “cradle-to-grave” LCAs have to be implemented for each of them. The example of a car under-hood part is schematically presented at figure 2.

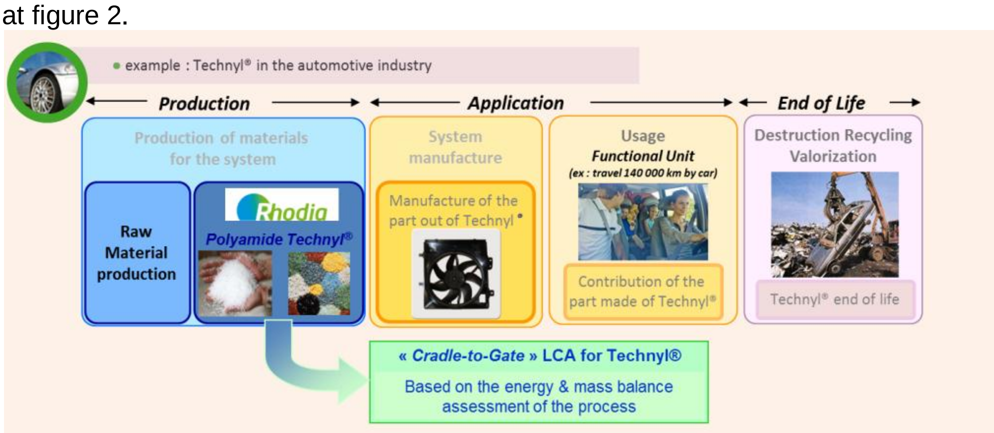

Figure 2

Such a “cradle-to-grave” LCA was conducted with partners of the automotive market : Valeo and PSA. That study was able to highlight the environmental benefits of introducing recycled polymers in plastics parts of automotive. Thanks to the properties of the ex-recycled polymer compound equivalent to those of the ex-primary polymer compound, once the compounds (from primary polyamide 6 in one case and from recycled polyamide 6 in the other case) have been produced, all the steps of the life cycle are identical. However, the benefits of the production and use of recycled material revealed here to be highly significant on 7 major components of the environmental impact all over the life cycle of the automotive part :

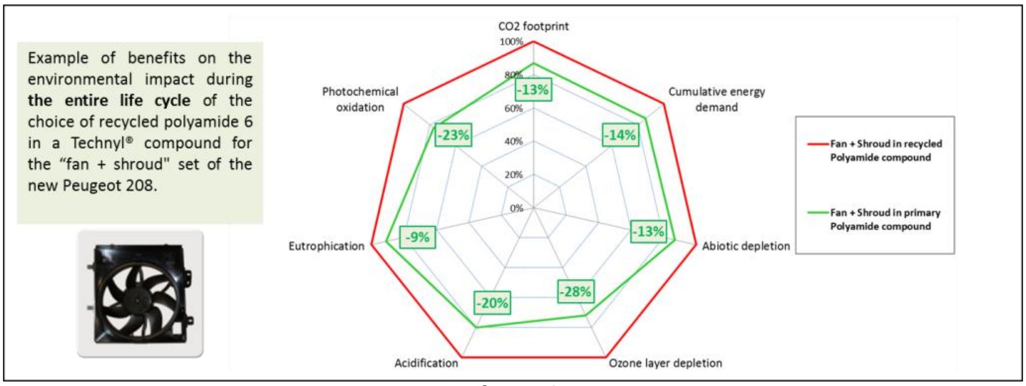

Figure 3

That study was made possible by the LCA program implemented within Rhodia and focusing on "cradle-to-gate" LCA describing the environmental impact of our Technyl® compounds, polymers and intermediates production.

Such LCA are building blocks for full "cradle-to-grave" LCAs of specific applications.

Our LCA studies are conducted internally, using SIMAPRO as software and Ecoinvent as main database; within an ongoing continuous improvement process :

- from a simplified model of the involved processes, based on actual data for raw material and energy consumption as well as main effluents and emissions ; at this step, only our most significant stream for each polymer and only the major compounds are described ; also, databases are widely used for describing raw materials as well as energy production ; this simplified approach is also applied to innovation and development projects in order to orientate our research towards more sustainable solutions ;
- to a detailed description of all the flows in all our plants and for an ever larger part of our product portfolio, taking into account each site and plant specificities in energy recovery, emission abatement, electricity production mix and aiming at more relevant descriptions of raw materials and additives, involving our suppliers in the process ; at this step, we can have a full mapping of our operations, intermediates, polymers and compound core range (that represents about 80% of our total sales of Technyl® compounds)

1 – "Cradle-to-gate" LCA of Polyamide matrices

Our LCA program covers all our polyamide range. It will be illustrated here by examples from Polyamide 6-6, which is the core polymer of Technyl® range.

In early steps, polyamide process is schematically represented by the flowchart proposed at figure 4. Such a model shows a quality of data similar to a significant number of process descriptions in databases and allows a relevant multi-criteria environmental impact evaluation.

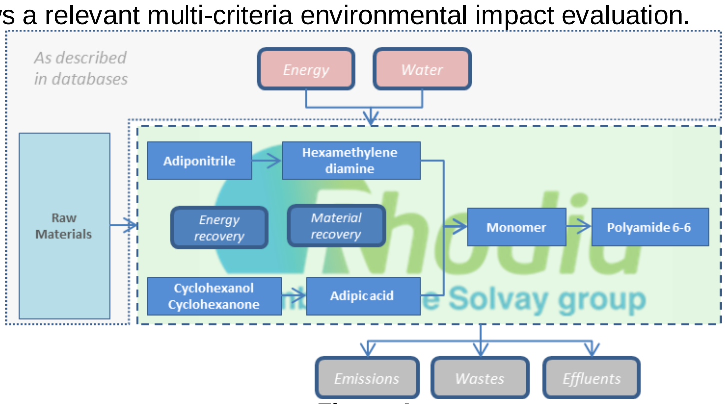

Figure 4

In a more advanced step of our LCA program, a detailed inventory of product flows inside each of our production sites and between sites gives a complete mapping of the environmental impact of each of our intermediates and polyamides. Figure 6 gives an example for CO_2 footprint and non-renewable resources consumption for polyamide 6-6 production at each of our production plants, and compared to both our simplified model as described above and Ecoinvent model (derived from Plastics Europe Ecoprofiles).

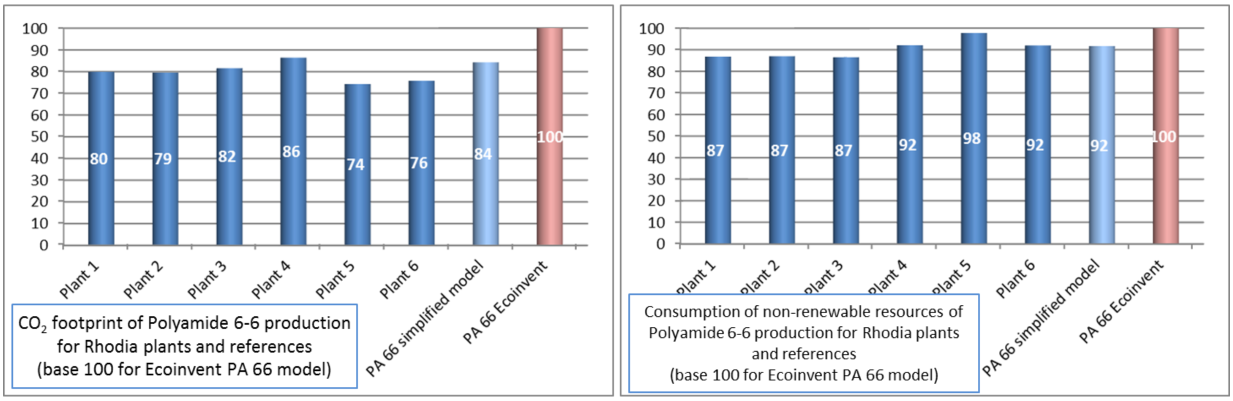

Figure 5

Such results reveal the consistency of our simplified model, even though variations can be observed between our plants, mainly due to specificities in energy management. It also has to be noted that our results always show lower impacts than Ecoinvent model, which is based on data collected several years ago.

In addition, such studies are now updated each year for taking process improvement into account. Figure 7 gives the example of CO_2 footprint reduction over several years for Polyamide 6-6 produced in one of our facilities. This reduction is majorly due to a significant improvement consisting in N_2O destruction at Adipic Acid synthesis step. N_2O is a gaseous by-product of Adipic Acid synthesis. It is a strong greenhouse gas, with a GWP of about 300 kg CO_2 eq./kg. Its abatement was a major stake in reducing our contribution to climate change.

Figure 6 highlights both the huge benefits of this abatement as well as the continuing improvement gained by increasing the equipment efficiency. In 2011, the abatement efficiency was as high as 98,8% over the year.

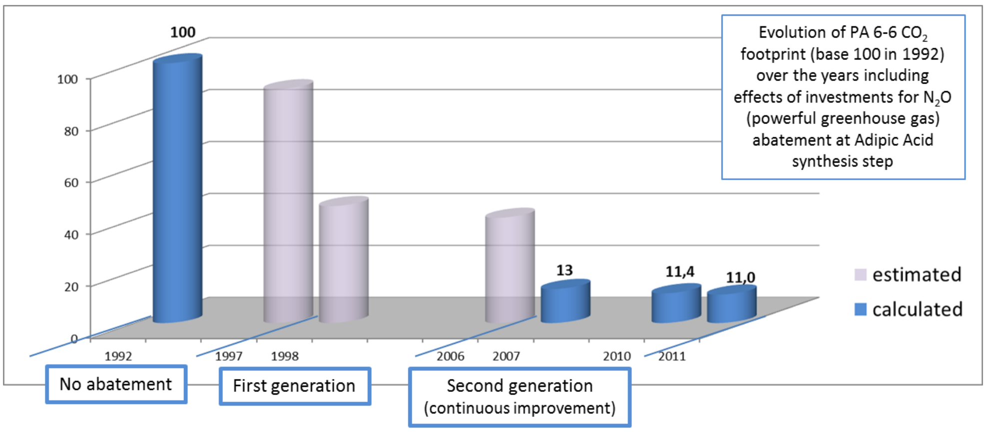

Figure 6

Aside Polyamide 6-6, Polyamide 6-10 is now proposed. It is a partially bio-sourced polyamide, based on sebacic acid, instead of adipic acid. Sebacic acid is synthesized from castor oil. Due to the vegetable origin of this intermediate, and in particular its consecutive bio-sourced carbon content, Polyamide 6-10 presents a lower environmental footprint as compared, for example to polyamide 6-6 as shown in Figure 7 for CO_2 footprint and non-renewable resource consumption.

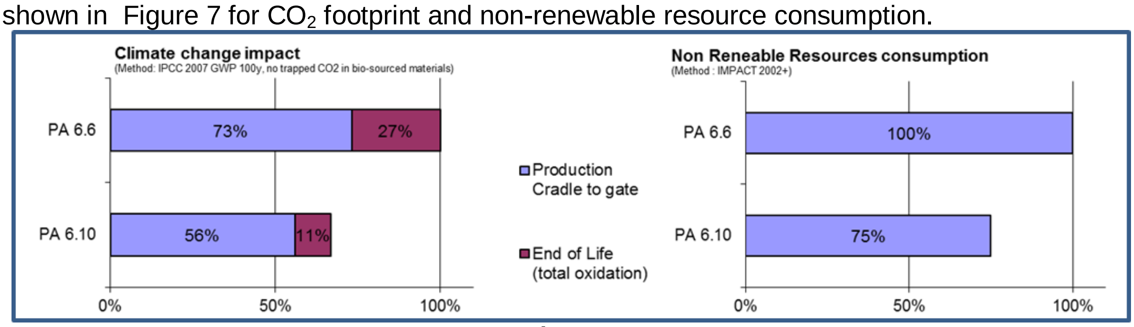

Figure 7

This comparison highlights the environmental benefits potential brought by the use of bio-sourced materials.

2 – "Cradle-to-gate" LCA of Technyl® compounds

Once polyamide production has thoroughly been described, it is possible to assess Technyl® production by adding the compounding step into the scope of the study. Aside from energy consumption assessment, a model of the additives has to be built, either using databases or – if not available in databases – assembling a simplified model according to literature data for their production. Figure 8 shows that, for two types of Technyl® (one for mechanical performances and one for flame resistance), contributions of raw material and additive production account for more than 60% in – for example CO_2 footprint - of the compounds.

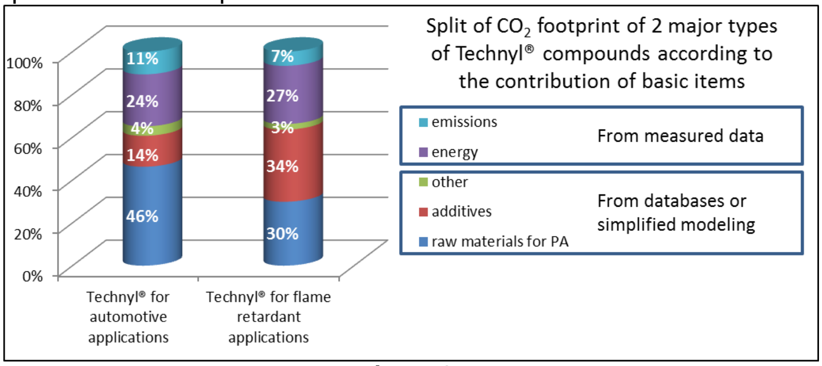

Figure 8

Relevance of databases thus appears to be a key issue in the quality of our LCA studies. We started a process of involving our suppliers in building and sharing LCA data for the products contributing to our polymers and compounds, in order to replace their generic descriptions provided by the database or our simplified models by real data. This participates to our program of continuous improvement in our LCA quality.

4 CONCLUSION

Resolutely committed to sustainable development, Rhodia Engineering Plastics - as a member of Solvay group - has included sustainability in the scope of performances of its products and thus developed several years ago an expertise in assessing the environmental impact of its operations and products over their life cycle, based on LCA methodology. A full program of continuous improvement in LCA quality has been built and is implemented.

Today, this program provided a complete mapping of the environmental impact of each of our intermediates and polyamides, whatever the site or plant they are produced.

Levers for producing still more sustainable products have been identified and quantified, as examples :

- process improvement (reduction of on-site emissions) ;
- use of recycled polymers ;
- introduction of bio-sourced intermediates.

An important result of our program is that relevance of databases appears to be a key issue in the quality of our LCA studies. It is necessary to involve industrial partners in collaborative programs aiming at building and sharing LCA data of industrial products in order to provide more reliable environmental footprint all along the value chains. That is what the community is expecting from us.