Evaluating the interest of making a road safety device with recycled plastics by LCA

C. L. Simões*, S. M. Xará**, C. A. Bernardo***

**PIEP, Innovation in Polymer Engineering, 4800-058 Guimarães, Portugal*
***College of Biotechnology, Portuguese Catholic University, 4200-072 Porto, Portugal*
****Polymer Engineering Dept., Minho University, 4800-058 Guimarães, Portugal*

1. Framework

The present work aims at evaluating the potential environmental impact of using recycled High Density Polyethylene (HDPE) in the production of an Anti-Glare Device (AGD), a road safety device currently manufactured from virgin (not recycled) polymer. First, a technological feasibility study of producing this alternative AGD was performed. Then, the potential environmental impact was evaluated using the Life Cycle Assessment (LCA) technique.

2. Methodology and systems characterization

The LCA methodology, which involves all stages of a product life, was used to compare the environmental aspects and potential impacts of two systems:

(1) current AGD: manufactured from virgin HDPE

(2) optional AGD: manufactured from recycled HDPE obtained from post-consumer packages (waste voluntarily deposited by citizens, in containers placed in the streets, the so-called yellow "ecopontos")

The AGDs studied are safety devices used in highways to prevent drivers to be dazzled by the headlights of vehicles circulating in the opposite lane.

The LCA procedure used was in accordance with the standards from ISO 14040 series.

As the functional feature of the AGD is equivalent for both the current and optional devices, a single AGD was used as reference flow in the present study.

Figure 1 - Anti-Glare Device

The system boundaries include all stages of the AGD life cycle, from the production of HDPE (made from oil or HDPE recyclate, respectively for current and optional AGD) and masterbatch, to its manufacture by injection blow-molding, distribution, use, and end-of-life (EoL).

The systems have been modeled using commercial databases and also data collected from industries, which were ultimately summarized in the Life Cycle Inventory (LCI) that was performed in SimaPro 7.

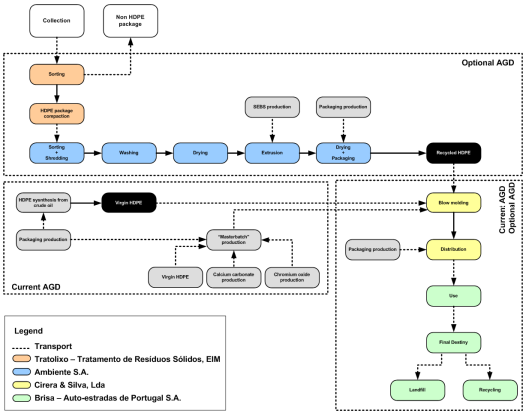

Figure 2 - Products systems (current and optional AGD) and corresponding system boundaries and information sources

The environmental impacts were estimated up to the end-point impacts with the Eco-indicator 99.

Table 1 - Impact assessment categories and normalization and weighting factors

Impact categories	Damage categories	Normalization factors	Weighting factors
Carcinogens (DALY) Respiratory organics (DALY) Respiratory inorganics (DALY) Climate change (DALY) Radiation (DALY) Ozone layer (DALY)	Human Health (DALY)	65.1	400
Ecotoxicity (PAF*m^{2}yr) Acidification/ Eutrophication (PDF*m^{2}yr) Land use (PDF*m^{2}yr)	Ecosystem Quality (PDF*m^{2}yr)	0.000195	400
Minerals (MJ surplus) Fossil fuels (MJ surplus)	Resources (MJ surplus)	0.000119	200

DALY: Disability Adjusted Life Years (Years of disabled living or years of life lost due to the impacts)
PAF: Potentially Affected Fraction (Animals affected by the impacts)
PDF: Potentially Disappeared Fraction (Plant species disappeared as result of the impacts)
MJ surplus: Surplus Energy (Extra energy that future generations must use to extract scarce resources)

3. Results

Current AGD

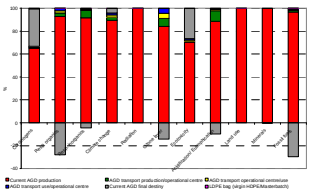

Figure 3 - Characterization results of the main life cycle phases of the current AGD

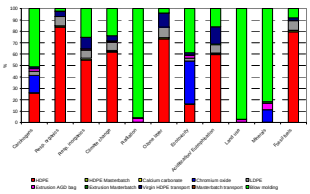

Figure 4 - Characterization results of the production phase of the current AGD

Optional AGD

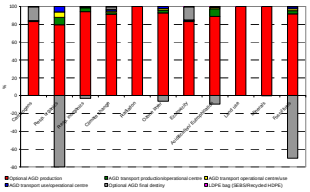

Figure 5 - Characterization results of the main life cycle phases of the optional AGD

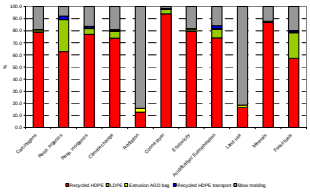

Figure 6 - Characterization results of the production phase of the optional AGD

Comparative assessment of the current and optional AGD

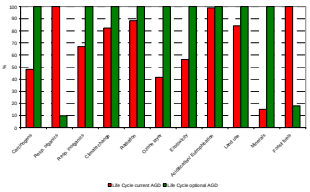

Figure 7 - Characterization results of the two AGD systems

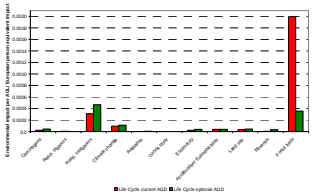

Figure 8 - Normalization results of the two AGD systems

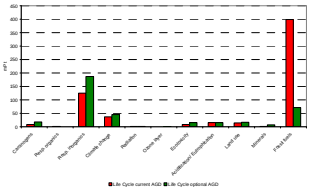

Figure 9 - Weighting results of the two AGD systems

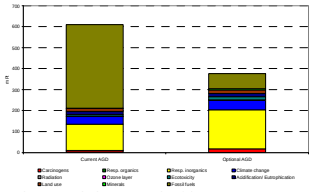

Figure 10 - Single score results of the two AGD systems

- The LCA study performed allowed the identification of the manufacturing stage as the main responsible for most of the impacts occurring in both systems.
- In the manufacturing stage, for both systems, raw-material production (virgin or recycled HDPE) is the largest contributor to the *Fossil fuels*, *Respiratory problems (inorganic substances)* and *Climate change* impact categories.
- The end-of-life stage helps to improve the environmental impact in all cases, this effect being more significant in the *Fossil fuels* and *Respiratory problems (organic substances)* categories. This reflects the avoided emissions due to the EoL processes, namely recycling.
- In percentage terms, the optional AGD is the more relevant system in practically all environmental impact categories, excepting the *Respiratory problems (organic substances)* and *Fossil fuels* categories.
- From the single score results, it is possible to confirm that the optional AGD is environmentally more advantageous than the current one. In fact, the former presents an 82% reduction in the *Fossil fuels* category, and increases of 33% and 18% in the *Respiratory problems (inorganic substances)* and *Climate change* categories, respectively. These differences are due to the fact that the optional AGD is made from recycled HDPE, thus avoiding the use of the oil necessary to produce the raw material. Conversely, more electric energy is used in the recycling process, thus enhancing gaseous emissions that contribute to the *Respiratory problems (inorganic substances)* and *Climate change* categories.

4. Conclusions

- With the present LCA study it was possible to assess the environmental impact associated with using recycled HDPE to manufacture a road safety device traditionally made with virgin polymer.
- It was concluded that, within the limitations of this type of studies, the use of recycled HDPE has environmental advantages.
- The present work also allowed understanding the interest of using the LCA methodology, as a decision supporting tool, during the development process of a new product.

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