



Technical Information, November 2018

Makrolon[®], Vivak[®], Axp[®] Environmental aspects

LCA (life cycle assessment)

LCA is a method that provides objective information about the consumption of resources and the quantity of waste during the life cycle of a product.

This information enables comparison with competitive products based on environmental aspects (energy requirement, waste quantity, emissions etc.).

When drawing up an ecological balance sheet for a product, all process steps relevant to manufacture and the resources employed, as well as their utilization, must be taken into consideration.

It makes sense to start with a higher upgrading step, in this case PC pellets, when drawing up such a balance sheet.

The energy balance sheet for manufacturing polycarbonate pellets can be seen in table 1, for polyester pellets in table 2: energy in MJ required to manufacture 1 kg of polycarbonate resin. (Owing to rounded figures, the total is not exactly 100).

Table 1: Energy balance sheet polycarbonate (Makrolon[®])

| Type of energy | Energy for producing the type of energy (MJ) | Energy content of type used (MJ) | Energy for transportation (MJ) | Energy content of raw material (MJ) | Total energy (MJ) |
|--------------------|--|----------------------------------|--------------------------------|-------------------------------------|-------------------|
| Electricity | 10.24 | 4.53 | 0.09 | <0.01 | 14.86 |
| Oil fuel | 0.60 | 9.05 | 0.14 | 10.62 | 20.42 |
| Other type of fuel | 2.57 | 51.55 | 0.05 | 27.37 | 81.53 |
| Total | 13.41 | 65.13 | 0.28 | 37.99 | 116.81 |

Source: I Boustead. Ecoprofiles of plastics and related intermediates
Published by APME, Brussels, 1999

N.B.: Please bear in mind compilation method before using the data.

Utilization

The properties of Makrolon[®], Vivak[®], Axp[®] class them as materials that are used for high-quality, durable items, not classical consumer or disposable articles. Their resistance to ageing and weathering ensures that they remain fully functional even after several years of use, so that they do not need to be prematurely replaced or exchanged.

At the end of their life cycle, Makrolon[®], Vivak[®], Axp[®] can be incinerated or recycled after being carefully separated from other materials.

The heat generated during incineration is either used directly or employed to generate energy. In Germany, a product may only be incinerated if its calorific value without the addition of other substances is at least 11 MJ/kg. Makrolon[®] exceeds this value by far and has an even greater calorific value than coal or wood (Table 4).

Since PC and polyester only contain carbon, hydrogen and oxygen, they burn very cleanly.

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Table 2: Energy balance sheet polyester (Vivak[®]/ Axp[®])

| Type of energy | Energy for producing the type of energy (MJ) | Energy content of type used (MJ) | Energy for transportation (MJ) | Energy content of raw material (MJ) | Total energy (MJ) |
|--------------------|--|----------------------------------|--------------------------------|-------------------------------------|-------------------|
| Electricity | 5.32 | 2.39 | 0.03 | <0.01 | 7.74 |
| Oil fuel | 1.45 | 11.38 | 0.28 | 32.53 | 45.64 |
| Other type of fuel | 3.22 | 13.37 | 0.05 | 6.16 | 22.79 |
| Total | 9.99 | 27.13 | 0.36 | 38.69 | 76.17 |

Source: I Boustead. Ecoprofiles of plastics and related intermediates
Published by APME, Brussels, 1999

N. B : please bear in mind compilation method before using the data.

Table 3 serves to illustrate this fact. It compares the toxicity potential of wool, wood and PC. Makrolon[®] shows much better behavior than fossil fuels.



Recycling means that, after careful separation from other materials, Makrolon[®] is regranulated and can then be reintroduced into the extrusion process. The quality of the products manufactured there from depends on the purity (cleanliness) of the starting material.

Levels of recycling

With primary recycling, the sections made from our product that have not yet left the factory are separated, reground and used in special products. This has been our practice for many years and leads to no loss of quality. So-called secondary recycling involves the reutilization (if carefully separated) or incineration of scrap produced at our customers' premises, e.g. according to the German recycling law. Covestro commissions recycling companies with the corresponding licenses, and the recycling conditions are also clarified with these companies.

The final stage is reached when parts made from Makrolon[®], Vivak[®], Axp[®] are disposed of at the end of their life cycle. The most efficient method in this case is incineration, which takes advantage of the high calorific value to generate energy.

Certified recycling companies also handle this process.

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The licensed recycling company Krall handles disposal in almost all European countries. Please contact Krall directly:

Krall Kunststoff-Recycling GmbH
Glanzstoffstraße 21
D - 63820 Elsenfeld a. Main, Germany
Phone: +49 (0) 60 22 70 99-0
Fax: +49 (0) 60 22 70 99-20
www.kunststoff-recycling.de
info@krall.de

Calorific Values

Table 4 compares the heat of combustion Q_{net} according to ISO 1928:1995 for certain plastics and fossil fuels.

| Material | Calorific value (in MJ/kg) |
|-----------------|-------------------------------|
| PC | 31 |
| SAN | 39 |
| Polystyrene | 46 |
| Polyethene | 46 |
| APET/ PETG | 25 |
| Polypropene | 44 |
| PMMA | 27 |
| PVC | 18.9 |
| Oil fuel | 44 |
| Natural gas | 34 |
| Coal | 29 |
| Brown coal | 20 |
| Wood | 16 |
| ABS | 40 |
| PA6 | 31 |
| Paper | 16.8 |
| Household waste | 8 |

Halogens

Compounds of PVC, chlorinated and brominated flame retardants have not been intentionally added for the production of our

Makrolon[®] GP clear 099
Makrolon[®]UV clear 2099
Makrolon[®]AR clear 8099
Vivak[®] clear 099
Vivak[®] UV clear 2099
Axp[®] clear 099
Axp[®] UV 2099

sheets and therefore these substances are not expected to be present.

The presence of analytically detectable traces of the above mentioned compounds, which have possibly been introduced into our product via raw materials, auxiliaries and additives, cannot be excluded.

The manner in which you use and the purpose to which you put and utilize our products, technical assistance and information (whether verbal, written or by way of production evaluations), including any suggested formulations and recommendations, are beyond our control. Therefore, it is imperative that you test our products, technical assistance, information and recommendations to determine to your own satisfaction whether our products, technical assistance and information are suitable for your intended uses and applications. This application-specific analysis must at least include testing to determine suitability from a technical as well as health, safety, and environmental standpoint. Such testing has not necessarily been done by Covestro. Unless we otherwise agree in writing, all products are sold strictly pursuant to the terms of our standard conditions of sale which are available upon request. All information and technical assistance is given without warranty or guarantee and is subject to change without notice. It is expressly understood and agreed that you assume and hereby expressly release us from all liability, in tort, contract or otherwise, incurred in connection with the use of our products, technical assistance, and information. Any statement or recommendation not contained herein is unauthorized and shall not bind us. Nothing herein shall be construed as a recommendation to use any product in conflict with any claim of any patent relative to any material or its use. No license is implied or in fact granted under the claims of any patent.

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Ozone depleting substances (ODS)

ODS = ozone depleting substances, i.e. chlorofluorocarbons (HCFC, CFC), partially halogenated chlorofluorocarbons (HFC), halons or carbon tetrachloride have not been intentionally added for the production of our

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Silicones

Silicone bases release agents and corresponding composites have not been intentionally added for the production of our

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sheets and therefore these substances are not expected to be present.

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