Technical Information, January 2020

Makrolon®, Vivak®, Axpet®
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).

Utilization

The properties of Makrolon®, Vivak®, Axpet® 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®, Axpet® 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.

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

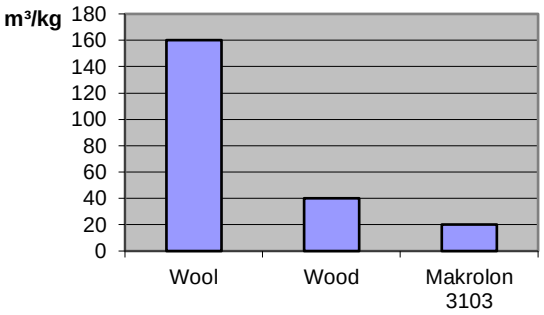
Source: I Boustead. Ecoprofiles of plastics and related intermediates
Published by APME, Brussels, 1999
N.B.: Please bear in mind compilation method before using the data.

Table 2: Energy balance sheet polyester (Vivak®/ Axpet®)

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®, Axpet® 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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Makrolon®, Vivak®, Axpet® Environmental aspects

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
Axpet® clear 099
Axpet® 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.

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Makrolon®, Vivak®, Axpet® Environmental aspects

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

Makrolon®
Vivak®
Axpet®

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.

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.

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.

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