Poly methyl methacrylate (PMMA)

Eco-profiles and Environmental Product Declarations of the European Plastics Manufacturers

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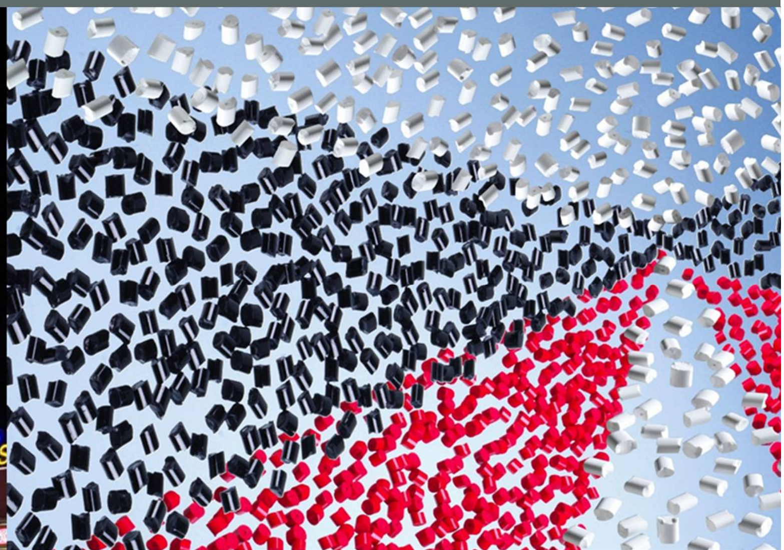


Environmental Product Declaration

Introduction

This Environmental Product Declaration (EPD) is based upon life cycle inventory (LCI) data from PlasticsEurope's Eco-profile programme. It has been prepared according to **PlasticsEurope's Eco-profiles and Environmental Declarations – LCI Methodology and PCR for Uncompounded Polymer Resins and Reactive Polymer Precursors** (PCR version 2.0, April 2011). EPDs provide environmental performance data, but no information on the economic and social aspects which would be necessary for a complete sustainability assessment. Further, they do not imply a value judgment between environmental criteria.

This EPD describes the production of poly methyl methacrylate (PMMA) from cradle to gate (from crude oil extraction to polymer at plant). **Please keep in mind that comparisons cannot be made on the level of the material alone**: it is necessary to consider the full life cycle of an application in order to compare the performance of different materials and the effects of relevant life cycle parameters. This EPD is intended to be used by member companies, to support product-orientated environmental management; by users of plastics, as a building block of life cycle assessment (LCA) studies of individual products; and by other interested parties, as a source of life cycle information.

Meta Data

Data Owner	Cefic, MSG
LCA Practitioner	BIO Intelligence Service
Programme Owner	PlasticsEurope aisbl
Programme Manager, Reviewer	DEKRA Assurance Services GmbH
Number of plants included in data collection	12
Representativeness	European and Israeli production >85%
Reference year	MMA: 2010 – 2011 PMMA: 2011 – 2013
Year of data collection and calculation	MMA: 2012 – 2013 PMMA: 2013 – 2014
Expected temporal validity	2017
Cut-offs	No significant cut-offs
Data Quality	Good
Allocation method	Price allocation and 50/50 allocation (functional approach) for MMA production No significant allocation made for PMMA production (polymerisation, casting or extrusion process)

Description of the Product and the Production Process

This Eco-profile represents the European and Israeli average production of poly methyl methacrylate (PMMA) from cradle to gate.

PMMA is a thermoplastic with the formula $(C_5H_8O_2)_n$.

3 types of products are studied: PMMA resin, PMMA cast sheets and PMMA extruded sheets. These products correspond to the main PMMA products marketed in Europe.

Production Process

PMMA resin, PMMA cast sheets and PMMA extruded sheets are produced according to a succession of different processes, the first one being the production of MMA.

PMMA resin is then produced via the polymerisation of MMA. Two main processes can be used: the mass process or the suspension process.

The mass process is carried out by adding a soluble initiator to MMA monomers and by heating. As the reaction proceeds the mixture becomes more viscous and a wide range of molecular masses are produced. The polymer is then pelletised into granules.

The suspension process is a heterogeneous radical polymerisation process. MMA is dispersed in water under controlled agitation. After centrifugation and drying, the process gives beads of polymer.

PMMA cast sheets are produced from MMA via a bulk polymerisation process. The process consists of casting liquid monomer in a flat mould (between two sealed glass sheets) and to heat it (in hot water baths or in ovens) in order for the MMA to polymerise. The PMMA sheet is then withdrawn from the mould.

PMMA extruded sheets are produced from PMMA resin, that is to say after a previous step of polymerisation of MMA. PMMA resin is fed into an extruder that melts and pressurises the polymer. The molten polymer then goes through a die and takes the form of a thin and flat planar flow. The polymer is finally cooled with cooling rolls in order to obtain the PMMA sheet.

Data Sources

This Eco-profile is based on 5 individual LCA studies performed independently by the 5 main European and Israeli producers of PMMA: Altuglas, Evonik, Lucite, Plazit Polygal and Polycasa.

The primary data used in these 5 studies and then in this Eco-profile comes from 12 plants located in 9 different countries and is site-specific gate-to-gate production data.

The 5 producers participating in this Eco-profile cover >85% of the European and Israeli PMMA production in 2012.

Regarding MMA production, the company specific LCIs of MMA were used after a harmonisation process covering several aspects such as system boundaries or allocations rules. For PMMA producers which do not produce MMA, the MMA Eco-profile [PLASTICSEUROPE 2014], which is representative of the European average production of MMA, was used. Regarding background data (such as energy and auxiliary materials), the ecoinvent database 2.2 was used.

Allocation

Several co-products are produced at the MMA production step. In order to share the inputs and outputs of the system between the co-products, economic allocation and functional allocation (50/50 split based on the functions fulfilled by an intermediate reagent) were applied.

Regarding the following steps of the production process of PMMA products, no significant allocation rule was applied, as each individual process is mono-functional (i.e. generates only one type of output).

Use Phase and End-of-Life Management

The disposal of waste from production processes is considered within the system boundaries of this Eco-profile. The use phase and end-of-life processes are outside the system boundaries of this cradle-to-gate system.

Environmental Performance

The tables below show the environmental performance indicators associated with the production of 1 kg of each PMMA product.

Input Parameters

Indicator	Unit	PMMA resin	PMMA cast sheet	PMMA extruded sheet
Non-renewable energy resources[1)]	MJ	104	130	116
• Fuel energy	MJ	69	95	80
• Feedstock energy	MJ	36	36	36
Renewable energy resources (biomass)[1)]	MJ	0,9	1,5	1,4
• Fuel energy	MJ	0,9	1,5	1,4
• Feedstock energy	MJ	-	-	-
Abiotic Depletion Potential				
• Elements	kg Sb eq	2,3E-06	7,0E-06	2,3E-06
• Fossil fuels	MJ	97	119	106
Renewable materials (biomass)	kg	-	-	-
Water use (including cooling water)[2)]	kg	498	614	506
[1)] Calculated as upper heating value (UHV) [2)] Considering available data, it was not possible to calculate the following indicators : Water use without cooling water or Net freshwater consumption				

Output Parameters

Indicator	Unit	PMMA resin	PMMA cast sheet	PMMA extruded sheet
GWP	kg CO_2 eq	3,75	4,77	4,38
ODP	g CFC-11 eq	4,2E-04	4,6E-04	4,1E-04
AP	g SO_2 eq	17,4	26,3	18,3
POCP	g Ethene eq	0,94	1,48	0,96
EP	g PO_4^{3-} eq	2,16	2,99	3,04
Dust/particulate matter	g PM10	0,46	0,71	0,55
Waste sent to landfill[1)]				
• Non-hazardous	kg	0,16	0,32	0,23
• Hazardous	kg	4,8E-03	4,9E-03	4,4E-03
[1)] Considering available data, it was not possible to assess the amount of waste sent to incineration.				

Additional Environmental and Health Information

PMMA products can be easily machined and processed by standard mechanical and thermal techniques. PMMA is insoluble in water and resistant to salty water. Acrylic sheets and their polyethylene protective layers are fully recyclable. Some grades are approved for food contact. Acrylic sheets do not contain any toxic materials or heavy metals, which may cause environmental damage or health risks. When acrylic burns, it does not produce toxic or corrosive gases which is compliant with international standards. Given correct fabrication, PMMA releases no pollutant substances to the environment. At the end of its product life and after careful separation from other materials, PMMA can be used for energy recovery and chemical or mechanical recycling. PMMA scrap is not classed as hazardous waste. Small quantities can therefore be disposed of as household refuse. However, large quantities should be disposed to recycling.

Additional Technical and Economic Information

PMMA is widely used in various applications for its many advantageous properties. Perhaps the most well-known of these properties is light transmission. Typical PMMA grades allow 92% of light to pass through it, which is more than glass or other plastics. This outstanding clarity enables the use of PMMA in many different optical and related applications. Because it is inherently stable to UV-light, PMMA is used for many outdoor applications, in which it maintains its original colour and finishes for many years. PMMA also has excellent scratch resistance and is able to be processed to a very high gloss finish. These properties, combined with PMMA's dimensional stability, enables its use in many different applications where lasting beautiful appearances are important, such as on furniture or kitchen or bath walls or cabinet facades. PMMA can be further modified by incorporating different additives. These modifications are typically performed to improve specific properties of the polymer, usually targeted toward specific applications. Examples of properties that can be adjusted in this way are impact resistance, chemical resistance, flame retardancy, light diffusion, UV light filtering, or optical effects.

Optical properties: Since cast PMMA is manufactured by cell casting between two sheets of mirror-like glass, it has excellent surface quality. Extruded PMMA is manufactured in a special extrusion process and therefore cannot always match the high optical quality of cast PMMA.

Machining: Cast PMMA offers greater scope for fabrication, which means the machining conditions do not have to be observed with such accuracy. Less scope is available with extruded PMMA, and care must be taken to ensure the correct tools are used in order to obtain clean cuts and drill holes, if necessary using cooling lubricants.

Thermoforming: Extruded PMMA allows more economical solutions during thermoforming because the forming cycles are shorter and contours can be more accurately reproduced.

Information

Data Owner

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Programme Manager & Reviewer
DEKRA Assurance Services GmbH

This Environmental Product Declaration has been reviewed by DEKRA Assurance Services GmbH.
It was approved according to the Product Category Rules PCR version 2.0 (2011-04) and ISO 14025:2006.
Registration number: PlasticsEurope 2015-01 validation expires on 31 December 2017 (date of next revalidation review).

Programme Owner

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For copies of this EPD, for the underlying LCI data (Eco-profile); and for additional information, please refer to www.plasticseurope.org.

References

PlasticsEurope: Eco-profiles and environmental declarations – LCI methodology and PCR for uncompounded polymer resins and reactive polymer precursor (version 2.0, April 2011) [PLASTICSEUROPE 2011].