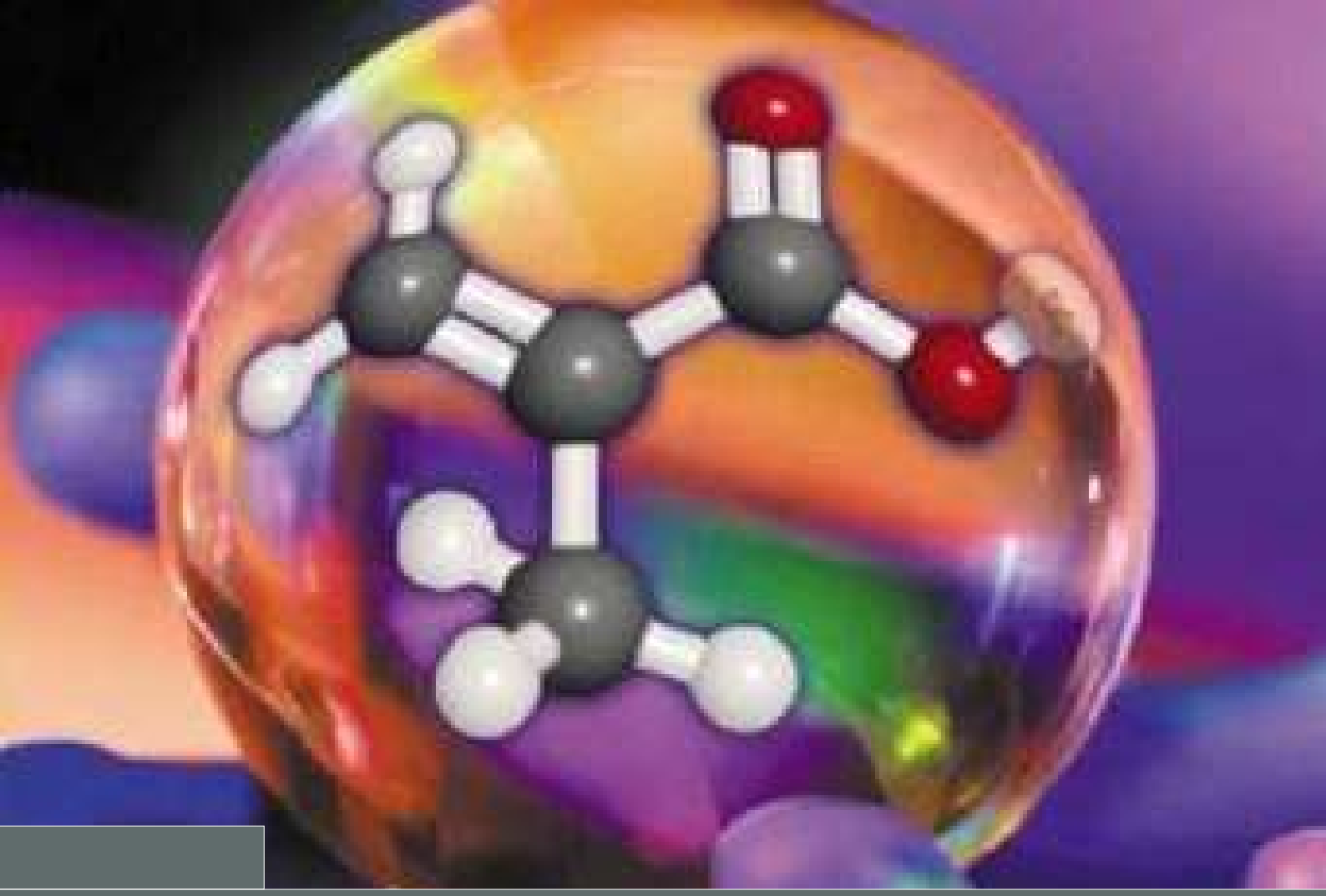

Methyl methacrylate (MMA)

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

March 2014

cefic

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 the methyl methacrylate (MMA) monomer from cradle to gate (from crude oil extraction to monomer 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 Consulting GmbH
Number of plants included in data collection	5
Representativeness	European production (92%)
Reference year	2010 – 2011
Year of data collection and calculation	2012 – 2013
Expected temporal validity	2016
Cut-offs	No significant cut-offs
Data Quality	Good
Allocation method	Price allocation or 50/50 allocation (functional approach)

Description of the Product and the Production Process

This Eco-profile represents the European average production of methyl methacrylate (MMA) monomer from cradle to gate. MMA is an organic compound with the formula $C_5H_8O_2$. It is a key intermediate chemical, due to its ability to undergo polymerization and copolymerization. MMA is mainly used for the production of polymethyl methacrylate (PMMA).

Production Process

Several methods exist for the production of MMA. The main route, which is used by the European producers participating in this Eco-profile, is the "acetone cyanohydrin route".

This route is based on three steps.

The first step of the process is intended to produce hydrogen cyanide (HCN). Hydrogen cyanide is usually produced from methane and ammonia according to the Andrussow process or the Degussa process. These processes produce ammonium sulfate as a co-product. Hydrogen cyanide may also be obtained as a co-product from the acrylonitrile production process (Sohio process).

In the second step, hydrogen cyanide and acetone are used as reagents for the production of Acetone cyanohydrin (ACH).

In the third step, MMA is produced from acetone cyanohydrin, sulfuric acid and methanol. Firstly, acetone cyanohydrin undergoes sulfuric acid assisted hydrolysis and is converted into a sulfate ester of methacrylamide. Secondly, an esterification with methanol gives MMA. During the third step, sulfuric acid is used as an intermediate reagent. After the reactions, the spent sulfuric acid may be recycled and reused for the MMA production or may be neutralised with ammonia, producing ammonium sulfate as a co-product.

Data Sources and Allocation

This Eco-profile is based on 3 individual LCA studies performed independently by the 3 main European producers of MMA: Altuglas, Evonik and Lucite. The primary data used in these 3 studies and then in this Eco-profile comes from 5 plants located in 3 different European countries and is site-specific gate-to-gate production data.

The 3 producers participating to this Eco-profile cover 92 % of the European MMA production capacity in 2012.

Data for the upstream supply chain until the precursors and all relevant background data (such as energy and auxiliary materials) are taken from the ecoivent 2.2 database, except for acetone which is taken from the GaBi 5 database.

In this Eco-profile, allocation was applied in the first step and in the third step of the MMA production process. In the first step of the process, when it was possible, the process was subdivided into sub-processes and only a few flows intrinsically shared by the co-products were allocated. In this case, these specific flows were fully allocated to the most valuable co-product. Otherwise, when the available data did not allow any subdivision, economic allocation was applied in order to partition all the input and output flows of the process between hydrogen cyanide and its co-product (ammonium sulfate or acrylonitrile). In the third step of the process, where the spent sulfuric is used to produce ammonium sulfate as a co-product, the amount of sulfuric acid consumed in the process is equally allocated between MMA and ammonium sulfate (50/50 by mass). This approach is based on the functions fulfilled by sulfuric acid, which is required for the production of the two co-products.

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 MMA.

Input Parameters

Indicator	Unit	Value
Non-renewable energy resources[1)]	MJ	100.3
• Fuel energy	MJ	64.8
• Feedstock energy	MJ	35.5
Renewable energy resources (biomass)[1)]	MJ	0.66
• Fuel energy	MJ	0.66
• Feedstock energy	MJ	—
Abiotic Depletion Potential		
• Elements	kg Sb eq	2.58E-06
• Fossil fuels	MJ	93.8
Renewable materials (biomass)	kg	—
Water use (including cooling water)[2)]	kg	500

[1)] Calculated as upper heating value (UHV)
[2)] With available data, it was not possible to calculate the water use without cooling water and net freshwater consumption.

Output Parameters

Indicator	Unit	Value
GWP	kg CO_2 eq	3.47
ODP	g CFC-11 eq	3.24E-04
AP	g SO_2 eq	19
POCP	g Ethene eq	1.07
EP	g PO_4 eq	1.97
Dust, particulate matter	g PM10	4.54E-01
Waste sent to landfill[1)]		
• Non-hazardous	kg	1.55E-01
• Hazardous	kg	1.30E-03

[1)] With available data, it was not possible to assess the amount of waste sent to incineration.

Additional Environmental and Health Information

Methacrylate monomers are reactive products which must be handled in appropriate ways. In order to manage hazards please refer to the Safe Handling Manuals MSG and MPA. These documents provide product stewardship advice for the safe storage, handling and use of these products. Along with the Safety Datasheets provided by each supplier, they should be read and understood before ordering, storing and using methacrylates. Because methacrylate esters are contact allergens, the use of unreacted liquid monomers in mixtures which are intended to come into contact with skin or nails, e.g. nail sculpting, is not recommended. More information on methacrylates and human health can be found on the MPA website.

Additional Technical Information

The polymer PMMA, made from monomer MMA, is characterized by its robust properties and by the fact that it is easy to process. Thanks to its properties (light reflexion and transmission, mechanical resistance, low-density, capacity to be thermoformed etc.), PMMA can be used for a wide range of fields and applications (automobile industry, medical technologies, decoration, anti-noise walls, bathtubs and showers, advertising signs etc.).

Additional Economic Information

MMA is produced for use as monomer for production of polymers and as intermediate for synthesis of other methacrylate esters. The substance is manufactured in industrial settings in closed systems and used by industry for manufacture of polymers in closed and semi-closed systems. Downstream use of MMA is almost exclusively in the form of polymer although some products used by professionals and hobbyists may contain significant quantities of the liquid monomer.