



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

Polyamide 6.6 (PA6.6)

PlasticsEurope
February 2014

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 Polyamide 6.6 (PA6.6) polymer from cradle to gate (from crude oil extraction to granules or resin at plant). **Please keep in mind that comparisons cannot be made on the level of the polymer 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	PlasticsEurope, Product Group, Product Group Engineering Polymers
LCA Practitioner	PricewaterhouseCoopers
Programme Owner	PlasticsEurope aisbl
Programme Manager, Reviewer	DEKRA Consulting GmbH
Number of plants included in data collection	5
Representativeness	79%
Reference year	2011–2012
Year of data collection and calculation	2013
Expected temporal validity	2018
Cut-offs	No significant cut-offs
Data Quality	Very good
Allocation method	No allocation

Description of the Product and the Production Process

Polyamides are a group of polymers characterised by a carbon chain with $-C=O-NH-$ groups interspersed at regular intervals along it. They are commonly referred to by the generic name Nylon and are usually identified by a numbering system that indicates the number of carbon atoms between successive nitrogen atoms in the main chain. This EPD is for Polyamide 6.6 (PA6.6). Both adipic acid and HMD have 6-atom carbon chains, hence the name of PA6.6. Polycondensation occurs when a salt solution of adipic acid and HMD is heated.

Production Process

PA6.6 is formed by polycondensation of adipic acid with the aqueous salt of hexamethylene diamine (HMDA). Adipic acid is formed through the oxidation by nitric acid of a mixture of cyclohexanol and cyclohexanone (both derived from benzene), called "olone" or ketone/alcohol oil (KA oil). The oxidation of KA oil by nitric acid renders adipic acid. KA oil is produced via two main routes: The first route is the hydrogenation of benzene to produce cyclohexane, which is then oxygenated to give cyclohexanone and cyclohexanol. The alternative route uses the reaction of benzene with propylene. This gives cumene that can be further oxygenated to phenol, giving acetone as by-product. Phenol can then be hydrogenated to form cyclohexanone and cyclohexanol. HMDA is produced either via hydrogenation of adiponitrile, itself produced through catalytic hydrocyanation of butadiene; or from propylene (via acrylonitrile). The reference flow, to which all data given in this EPD refer, is 1 kg of PA6.6 in pellet form.

Data Sources and Allocation

The main data source was a data collection from European producers of PA6.6. Primary data on gate-to-gate production is derived from site-specific information for processes under operational control supplied by the participating companies of this study. Four different producers with plants in five European countries were participating in the primary data collection. They cover 79 % of PA6.6 production

volume in Europe (EU27) in 2011/2012. The data for the upstream supply chain until the precursors as well as relevant background data, such as energy and auxiliary material, are from the *DEAM*, *GaBi*, *PlasticsEurope* and *Ecoinvent* databases.

Use Phase and End-of-Life Management

PA6.6 can be processed via extrusion, injection moulding and blow moulding. The main uses include fibers and engineering plastics; PA6.6 is generally not used in film applications as it cannot be bi-axially orientated. Applications range from automotive to electrical/electronic and textile uses. It should be noted that PA6 (polycaprolactam or Nylon 6) and PA6.6 are used for similar purposes. PA6.6 can be recycled mechanically or for feedstock.

Environmental Performance

The tables below show the environmental performance indicators associated with the production of 1 kg of PA6.6.

Input Parameters

Indicator	Unit	Value
Non-renewable energy resources ¹⁾	MJ	138.6
• Fuel energy	MJ	107.6
• Feedstock energy	MJ	31
Renewable energy resources (biomass) ¹⁾	MJ	0.91
• Fuel energy	MJ	0.86
• Feedstock energy	MJ	0.05
Abiotic Depletion Potential		
• Elements	kg Sb eq	3.2E-06
• Fossil fuels	MJ	126.9
Renewable materials (biomass)	kg	1.3E-02
Water use	kg	2724
• for process	kg	52
• for cooling	kg	2672
¹⁾ Calculated as upper heating value (UHV)		

Output Parameters

Indicator	Unit	Value
GWP	kg CO ₂ eq	6.4
ODP	g CFC-11 eq	8.3E-05
AP	g SO ₂ eq	12.9
POCP	g Ethene eq	1.0
EP	g PO ₄ eq	3.7
Dust/particulate matter ²⁾	g PM10	0.8
Total particulate matter ²⁾	g	0.8
Waste		
• Non-hazardous	kg	0.24
• Hazardous	kg	0.45
²⁾ Including secondary PM10		

Additional Environmental and Health Information

PA6.6 is not classified as dangerous according to CLP legislation (EC 1272/2008). It does not require a hazard label in accordance with EC Directives. Under certain circumstances (temperature >300°C), thermal degradation can give rise to toxicologically relevant HCN and CO emissions. The manufacturers of polyamides are working through PlasticsEurope, the American Chemistry Council (ACC) and other industry groups to foster product safety and to actively engage with stakeholders.

Additional Technical Information

High tensile strength, excellent abrasion resistance, elasticity, and durability are the main characteristics of PA6.6. It is resistant to acid and alkali chemicals. It is also resistant to hydrocarbons, solvents, fuels, waxes, and oils. In addition, PA6.6 is an electrical isolator.

Additional Economic Information

Weight reduction in automobiles is one example where PA6.6 applications contribute to reduction of carbon footprint and costs in the use phase compared with standard solutions.

Information

Data Owner

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Programme Manager & Reviewer

DEKRA Consulting GmbH

This Environmental Product Declaration has been reviewed by DEKRA Consulting GmbH. It was approved according to the Product Category Rules PCR version 1.2 (2010-06) and ISO 14025:2006.

Registration number: PlasticsEurope 2013-004, validation expires on 31 December 2016 (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 <http://www.plasticseurope.org/>.

References

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