Environmental Product Declarations
of the European Plastics Industry

POLYVINYLCHLORIDE (PVC)

(EMULSION POLYMERISATION)

European Council of Vinyl Manufacturers (ECVM)
& Plastics*Europe*

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Introduction

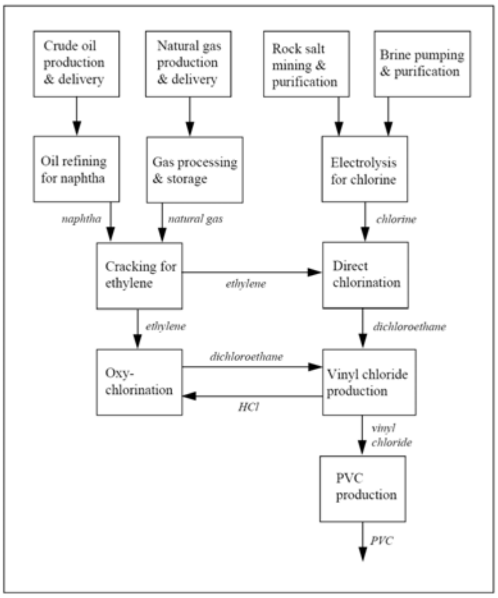
This Environmental Product Declaration (EPD) is based upon life cycle inventory (LCI) data from Plastics*Europe*'s Eco-profile programme. It has been prepared according to Plastics*Europe*'s **Product Category Rules (PCR) for Uncompounded Polymer Resins and Reactive Polymer Precursors** (June 2006). 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 PVC polymer. Please keep in mind that comparisons cannot be made on the level of polymers: 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.

Description of the Product and the Production Process

This EPD is for emulsion polyvinyl chloride (E-PVC). E-PVC accounts for 10–15% of the EU PVC market. The functional unit, to which all data given in this EPD refer, is **1 kg of E-PVC polymer** (without additives).

Emulsion Polymerisation



E-PVC is produced through either batch emulsion, continuous emulsion, or micro-suspension polymerisation. All three routes produce an aqueous latex, i.e. a very fine suspension of PVC polymer with mean particle sizes between 0.1 and 3 µm and thus much smaller than those produced by suspension polymerisation. Liquid vinyl chloride is insoluble in water and disperses to fine droplets when mechanically agitated in presence of an emulsifier. The reaction takes place in pressurised vessels under the influence of heat, initiators and/or catalysts. In the batch process, the polymerisation takes place at the VCM–water interface with a water-soluble initiator. In the continuous process, VCM, emulsifiers and initiator are fed into the reactor and PVC latex is withdrawn continuously. Alternatively, micro-suspension produces latex with a wider particle size distribution: here, polymerisation takes place within the dispersed VCM droplets, with an initiator highly soluble in VCM, but not in water. In each case, the reaction is exothermic and heat is removed in order to keep temperatures constant. Latex is transferred to a blow-down vessel; unreacted monomer is extracted, recovered and recycled back to the polymerisation reactor. The polymer particles are then dried.

Data Sources and Allocation

All data refer to a European industry average (reference year 2005); all calculations were updated in 2006. ECVM's and Plastics*Europe*'s member companies supplied information on the production of hydrocarbon precursors, on chlorine and the relevant intermediates EDC and VCM. Information on the production of fuels, energy and the main hydrocarbon resources was derived from the reports of the *International Energy Agency*. Data for ancillary operations and transport were obtained from other manufacturers and operators as well as publicly available LCI databases. Mass allocation was used for multi-output processes. Vertical averaging was performed to take into account company- and site-specific production routes and to protect confidentiality.

Use Phase and End-of-life Management

By choosing suitable stabilisers and plasticisers, PVC can be converted into a wide variety of different products. E-PVC can be extruded in rigid profiles when high surface gloss and smoothness are required. But mainly, E-PVC is dispersed in plasticiser to produce a mix known as plastisol. Plastisol is spread or sprayed, then heat-cured. Typical applications are cushion flooring, wall coverings, coated fabrics, gloves, rotational and slush mouldings, such as interior car parts, steel coatings and automotive under-body sealants.

For responsible end-of-life management, ECVM recommends recycling, as far as economically feasible and ecologically sensible. Alternatively, feedstock recycling or energy recovery can be conducted in specialized plants equipped for recycling hydrochloric acid. In LCA studies, credits for recovered products may be awarded on the basis of substituted virgin materials, if functionally equivalent.

Environmental Performance

The production of 1 kg of emulsion PVC polymer (E-PVC, without additives) is associated with environmental impacts as represented by the following performance indicators.

Input Parameters

Indicator	Unit	Value
Non-renewable materials		
• Minerals	g	796
• Fossil fuels	g	1,490
• Uranium	g	0.014
Renewable materials (biomass)	g	0.626
Water use[1)]	g	11,000
Non-renewable energy resources[2)]		
• for energy	MJ	36.68
• for feedstock	MJ	27.70
Renewable energy resources (biomass)[2)]		
• for energy	MJ	1.52
• for feedstock	MJ	0

[1)] Only process water, cooling water not included.
[2)] Calculated as upper heating value (UHV).

Output Parameters

Indicator	Unit	Value
GWP	kg CO_2	2.500
ODP	g CFC-11	n/a[3)]
AP	g SO_2	7.000
POCP (CML 2002)[4)]	g Ethene	0.450
NP (CML 2002)	g PO_4	0.800
Dust/particulate matter	g PM10	0.750
Total particulate matter	g	0.827
Waste		
• Non-hazardous	kg	0.225
• Hazardous	kg	0.005

[3)] Relevant LCI entries are below quantification limit.
[4)] See note in glossary.

Additional Environmental and Health Information

The methodology for assessing toxicity impacts on humans and the environment within LCA is still subject to scientific debate and cannot support business decisions yet. Additionally, emissions potentially contributing to toxicity impacts originate essentially from the combustion of fuels for energy production and from oil refinery, not from specific PVC processes.

ECVM has issued Industry Charters for the production of VCM in 1994 and for E-PVC in 1998. These Charters set tight limits on VCM emissions and on the maximum amount of residual VCM present in PVC resin. The inter-governmental *Oslo and Paris Commissions for the Protection of the North Sea (OSPAR)* later issued two decisions on emissions from VCM and S-PVC plants and a recommendation for emissions from E-PVC plants: limits imposed by *OSPAR* for VCM emissions are broadly in line with the limits specified in the Charter. The companies that signed the charters undergo an independent third-party verification of compliance. The levels of monomer and other volatile organic compounds in PVC resin are very low and do not present any health or environmental risk.

The 'Voluntary Commitment of the PVC Industry' (including additive producers and converters), signed in March 2000 and revised in 2005, is an integrated approach to deliver responsible cradle-to-grave management. This Commitment is now known under the name *Vinyl 2010*: it addresses key issues across the PVC lifecycle. *Vinyl 2010* contains quantifiable targets. Progress reports show that European PVC industry has been forging ahead with continuous environmental improvement and resource efficiency through a 'learning by doing' approach, strengthening the partnership within their supply chain. More information is available on: www.vinyl2010.org.

Additional Technical Information

PVC is easy to recycle mechanically several times in conventional equipment. Large quantities of pre-consumer PVC are already being recycled, and the recycling of post-consumer PVC is increasing steadily. Other options are mechanical recycling by dissolution processes (extracting PVC from products), or feedstock recycling (recovery of a basic chemical substance). The main difficulty for the recycling of post-consumer PVC is in collecting suitable waste at an acceptable cost. This is the case for all plastics as well as many other materials.

PVC, like other thermoplastics, has intrinsic energy, which can be utilized through energy recovery operations. The chlorine part ends up in the form of hydrochloric acid, which can also be recovered, purified and re-used. Flexible PVC will generally contribute a higher energy content than rigid PVC, although even rigid PVC has a calorific value similar to paper. Recovering both hydrochloric acid and energy significantly increases the eco-efficiency of incineration or other recovery options.

Landfilling is the least sustainable waste treatment option for all plastics. A study carried out in 2002–2003 in order to compare different end-of-life treatment options for PVC-rich waste concluded that all recovery/recycling options are preferable to landfill.

Additional Economic Information

ECVM's member companies undertake further efforts to reduce climate impacts, e.g. by introducing energy-saving technologies such as membrane electrolysis. PVC is among the polymers with the lowest releases of greenhouse gases per kg. The remaining greenhouse gas emissions related to PVC production can be addressed, e.g. through offsetting, as offered by a number of non-profit organisations. For typical PVC applications the cost of offsetting these remaining emissions amounts to less than 1 % of the product price. This demonstrates how economic and environmental aspects can be combined to achieve the fastest possible progress towards a sustainability objective.

Information

Company/Association

European Council of Vinyl Manufacturers (ECVM)
Contact person: Arjen Sevenster
Avenue E van Nieuwenhuyse 4, Box 3, B–1160 Brussels, Belgium
Telephone: +32 (2) 6753297, Fax: +32 (2) 6753935,
E-mail: info@plasticseurope.org.

Programme Manager

Five Winds International
Contact person: Dr. Ivo Mersiowsky
Gölzstraße 12, D–72072 Tübingen, Germany
Telephone: +49 (7071) 68873–0,
E-mail: info@fivewinds.com.

This Environmental Product Declaration has been reviewed by *Five Winds International*. It is approved according to the Product Category Rules PCR 2006-06 for Uncompounded Polymer Resins and Reactive Polymer Precursors and ISO FDIS 14025.
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Programme Owner

Plastics*Europe*
Contact person: Riccardo Fabiani
Avenue E van Nieuwenhuyse 4, Box 3, B–1160 Brussels, Belgium
Telephone: +32 (2) 6753297, Fax: +32 (2) 6753935,
E-mail: info@plasticseurope.org.

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

References

- Product photographs on cover with kind permission of *Hydro Polymers*.
- Plastics*Europe*: Polyvinylchloride PVC (Emulsion Polymerisation). Eco-profiles of the European Plastics Industry. Brussels, April 2006.
- Plastics*Europe*: Product Category Rules (PCR) for Uncompounded Polymer Resins and Reactive Polymer Precursors. Brussels, June 2006.
- ISO FDIS 14025 : Environmental Labels and Declarations – Type III Environmental Declarations. Geneva, 2005.

Glossary

Acidification potential, AP — An environmental impact category (“acid rain”). Emissions (e.g. sulphur oxides, nitrous oxides, ammonia) from transport, energy generation, combustion processes, and agriculture cause acidity of rainwater and thus damage to woodlands, lakes and buildings. Reference substance: sulphur dioxide.

Environmental Product Declaration, EPD — A standardised method (ISO 14025) of communicating the environmental performance of a product or service based on LCA data.

Ethylene dichloride, EDC — A precursor of the vinyl chloride monomer (VCM).

Global warming potential, GWP — An environmental impact category (“greenhouse effect”). Energy from the sun drives the earth’s weather and climate, and heats the earth’s surface. In turn, the earth radiates energy back into space. Atmospheric greenhouse gases (water vapour, carbon dioxide, and other gases) are influencing the energy balance in a way that leads to an increased average temperature on earth’s surface. Problems arise when the atmospheric concentration of greenhouse gases increases due to the “man-made” (or anthropogenic) greenhouse effect: this additional greenhouse effect caused by human activities may further increase the average global temperature. The index GWP is calculated as a multiple equivalent of the absorption due to the substance in question in relation to the emission of 1 kg of carbon dioxide, the reference substance, over 100 years.

Life Cycle Assessment, LCA — A standardised management tool (ISO 14040–44) for appraising and quantifying the total environment impact of products or activities over their entire life cycle of particular materials, processes, products, technologies, services or activities.

Nutrification potential, NP — An environmental impact category (“over-fertilisation”). Emissions such as phosphate, nitrate, nitrous oxides, and ammonia from transport, energy generation, agriculture (fertilisers) and wastewater increase the growth of aquatic plants and can produce algae blooms that consume the oxygen in water and thus smother other aquatic life. This is called eutrophication and causes damages to rivers, lakes, plants, and fish. Reference substance: phosphate.

Offsetting — Financing activities which compensate the climate effect (and often at the same time also the use of non-renewable resources) resulting from the production.

Ozone depletion potential, ODP — An environmental impact category (“ozone hole”). The index ODP is calculated as the contribution to the breakdown of the ozone layer that would result from the emission of 1 kg of the substance in question in relation to the emission of 1 kg of CFC-11 (a freon) as a reference substance.

Photochemical ozone creation potential, POCP — An environmental impact category (“summer smog”). The index used to translate the level of emissions of various gases into a common measure to compare their contributions to the change of ground-level ozone concentration. The index POCP is calculated as the contribution to ozone formation close to the ground due the substance in question in relation to the emission of 1 kg of ethene as a reference substance. *NOTE: Due to recent methodology developments, nitrous oxides and carbon monoxide are now taken into account for POCP calculation; accordingly, figures cannot be compared anymore with previous POCP results.*

Polyvinyl chloride, PVC — A halogenated polymer based on the raw materials petrochemicals (oil and gas) and salt (sodium chloride).

Vinyl chloride monomer, VCM — A precursor of polyvinyl chloride (PVC).

Product Category Rules, PCR — A set of rules for the preparation of LCA and EPD within a functionally defined class of products. A PCR document is a necessary component of any Type III Environmental Declaration programme (ISO 14025).