Environmental Product Declarations of the European Plastics Manufacturers

Polystyrene

General purpose (GPPS) and high impact (HIPS)
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 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 GPPS and HIPS polymers from cradle to gate (from crude oil extraction to pellets coming out the polystyrene manufacturing plant). Please keep in mind that comparisons cannot be made on the level of the polymer raw 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.

Description of the product and the production process

Polystyrene is a versatile polymer resin sold in three main forms: general purpose polystyrene also known as crystal polystyrene (GPPS), high impact polystyrene (HIPS) and expandable polystyrene (EPS). This EPD is for GPPS and HIPS. The functional unit, to which all data is given in this EPD refer, is 1 kg of the respective polystyrene polymer.

Polystyrene production

Styrene is the building block (monomer) of polystyrene and is obtained from crude oil. A range of processes such as distillation, steam-cracking and dehydrogenation are required to transform the crude oil into styrene. In practice, the production route from crude oil and natural gas is as shown in the scheme. Crude oil refining produces a fraction known as naphtha which contains a mixture of low molecular weight, saturated hydrocarbons of various compositions. This is converted into a smaller group of unsaturated hydrocarbons by cracking - a process in which the naphtha is heated to a high temperature in the absence of air. The resulting mixture is then separated into its constituent components by distillation producing principally ethylene, propylene and a number of other products, which find uses elsewhere in the petrochemical plant either as feedstocks or fuels. Natural gas is also converted into ethylene and other products by cracking. Ethylene and benzene are reacted to form ethylbenzene which is dehydrogenated into styrene. At the end polystyrene is produced by polymerising styrene. This is an exothermic reaction that can be initiated with organic peroxide or by heat. GPPS is manufactured by polymerisation of styrene alone. HIPS is obtained by adding polybutadiene rubber at the styrene polymerisation stage. The final product is available in the form of pellets. In order to get the final products, polystyrene pellets are extruded, thermoformed or injection moulded by plastic converters.

Environmental performance

The tables below show the environmental performance indicators associated with the production of 1 kg of GPPS and 1 kg of HIPS.
### Input parameters

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Unit</th>
<th>Value GPPS</th>
<th>Value HIPS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Non-renewable materials</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Minerals</td>
<td>g</td>
<td>5.9</td>
<td>6.2</td>
</tr>
<tr>
<td>• Fossil fuels</td>
<td>g</td>
<td>1,894.5</td>
<td>1,910.5</td>
</tr>
<tr>
<td>• Uranium</td>
<td>g</td>
<td>0.004</td>
<td>0.004</td>
</tr>
<tr>
<td><strong>Renewable materials (biomass)</strong></td>
<td>g</td>
<td>4.007</td>
<td>4.294</td>
</tr>
<tr>
<td><strong>Water use</strong></td>
<td>g</td>
<td>9,175</td>
<td>10,279</td>
</tr>
<tr>
<td><strong>Non-renewable energy resources</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• for energy</td>
<td>MJ</td>
<td>39.9</td>
<td>40.8</td>
</tr>
<tr>
<td>• for feedstock</td>
<td>MJ</td>
<td>46.3</td>
<td>46.4</td>
</tr>
<tr>
<td><strong>Renewable energy resources</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• for energy</td>
<td>MJ</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>• for feedstock</td>
<td>MJ</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

*This indicator comprises only process water. Cooling water is not included.

1) Calculated as upper heating value (UHV).

### Output parameters

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Unit</th>
<th>Value GPPS</th>
<th>Value HIPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>GWP</td>
<td>kg CO₂ eq</td>
<td>3.46</td>
<td>3.46</td>
</tr>
<tr>
<td>ODP</td>
<td>g CFC-11 eq</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>AP</td>
<td>g SO₂ eq</td>
<td>11.09</td>
<td>11.82</td>
</tr>
<tr>
<td>POCP</td>
<td>g Ethene eq</td>
<td>1.25</td>
<td>1.29</td>
</tr>
<tr>
<td>NP</td>
<td>g PO₂ eq</td>
<td>0.72</td>
<td>0.76</td>
</tr>
<tr>
<td>Dust/particulate matter</td>
<td>g PM₁₀</td>
<td>0.90</td>
<td>0.97</td>
</tr>
<tr>
<td>Total particulate matter</td>
<td>g</td>
<td>0.90</td>
<td>0.98</td>
</tr>
<tr>
<td>Waste</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Non-hazardous</td>
<td>kg</td>
<td>0.050</td>
<td>0.056</td>
</tr>
<tr>
<td>Hazardous</td>
<td>kg</td>
<td>0.029</td>
<td>0.028</td>
</tr>
</tbody>
</table>

*CO₂ emissions contribute 2.7 kg (78%) for GPPS respectively 2.8 kg (81%) for HIPS of GWP

### Additional technical and economic information

The main properties of polystyrenes are high stiffness, excellent optical clarity for GPPS, and good mechanical properties, such as toughness for HIPS. All polystyrenes have excellent processability and a low heat capacity value leading to process energy reduction. Thanks to high stiffness and low density, all articles made from polystyrene have excellent strength-to-weight ratio offering many environmental benefits, such as a reduction of weight, non-renewable resource savings, transportation costs and carbon footprint.

For example, a yoghurt pot made from polystyrene weighs about 15 times less than containers made from non-plastic material. Polystyrene foaming can reduce density by a factor of 35 that allows significant savings on resources and cost of packaging. Also building insulation using polystyrene insulation boards saves huge amounts of fossil energy and greenhouse gas emissions. The first year energy savings exceed the energy used to manufacture the insulation products.

### Additional environmental and health information

Polystyrene has been successfully used in food packaging for over 50 years and its food safety benefits are undisputed. Polystyrene can be safely used for food packaging applications.

### Additional information on end-of-life management

Polystyrene is identified by the resin identification code n°6. It can be recycled mechanically into new products, such as flower pots, desk trays and office products, wood-alternative mouldings and profiles utilized by the building industry. Polystyrene can be recycled several times without any damage to its physical properties. Another method of recovery is to take benefit of the valuable energy content of polystyrene. Polystyrene contains twice the energy of coal and as much energy as crude oil per kg. Several municipalities are incinerating waste containing polystyrene and providing heat and light for neighbouring communities.
Information

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

References

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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.

General purpose polystyrene, GPPS — A crystal clear polystyrene, very stiff; i.a. used for food packaging, clear disposable cups, petri dishes, pens, boxes, insulation boards...

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.

High impact polystyrene, HIPS — Due to addition of polybutadiene, a highly impact resistant polystyrene, ductile, stiff, and hazy; for example used for food packaging, disposables, consumer electronics, fridges, and consumer goods.

Life cycle assessment, LCA — A standardised management tool (ISO 14040-44) for appraising and quantifying the total environmental 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.

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 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 to the substance in question in relation to the emission of 1 kg of ethene as a reference substance.

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).

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