Environmental Information Document
Relevant to Australia

POLYPROPYLENE (PP)

5
PP

Revision 1: September 2009

Introduction

This Environmental Information Document (EID) describes the current situation in Australia regarding end of life and recycling options. Also detailed is information based upon life cycle inventory (LCI) data from Plastics*Europe*'s Eco-profile programme which relates to European Polypropylene (PP) manufacturing facilities. Environmental performance data is detailed within, there is no information on the economic or social aspects which would be necessary for a complete sustainability assessment. Further more, it does not imply a value judgment between environmental criteria.

This guide describes the production, use and end of life situation of PP polymer in Australia. The LCI data quoted is indicative of European made PP and will vary with PP made in Australia. It is important to recognise that comparisons by weight of materials should not be made. 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 EID is intended as a source of general information to support product-orientated environmental management by users of plastics as a first look or preliminary life cycle assessment (LCA) overview and by other interested parties, as a source of life cycle information. This document is not suited for use in detailed LCA studies, where the use of full LCI data is required; such data is available within Eco Profile documents and within material inventory libraries commonly included in industry recognised LCA software packages.

LCA is the preferred tool to analyse the environmental efficiency of the complete cradle to grave life cycle of most systems or products. It can be instrumental in the design of systems, in product design optimisation, material selection and end of life considerations.

Description of the Product and the Production Process

Product

Polypropylene (PP) is a resin of the polyolefin family and is one of the most widely used plastics in the world today, with a density of only 0.9 g/cm3, it is also the lightest of the widely used thermoplastics. The low density characteristic of PP is a key factor enabling lighter weighting of many end applications relative to using higher density materials. Light weighting and reduced material usages that result are often important drivers of LCA environmental impact results.

PP has outstanding chemical resistance - the best of all thermoplastics to organic chemicals, in fact there is no solvent for polypropylene at room temperature, although it may swell in some cases. It is basically flammable and ignites at a temperature of about 350°C. Although its burning rate is slow when tested to ASTM D635, it can be made flame-retardant by incorporating suitable additives. When used in applications involving extended UV and outdoor exposure, PP will require the addition of UV stabilising additives.

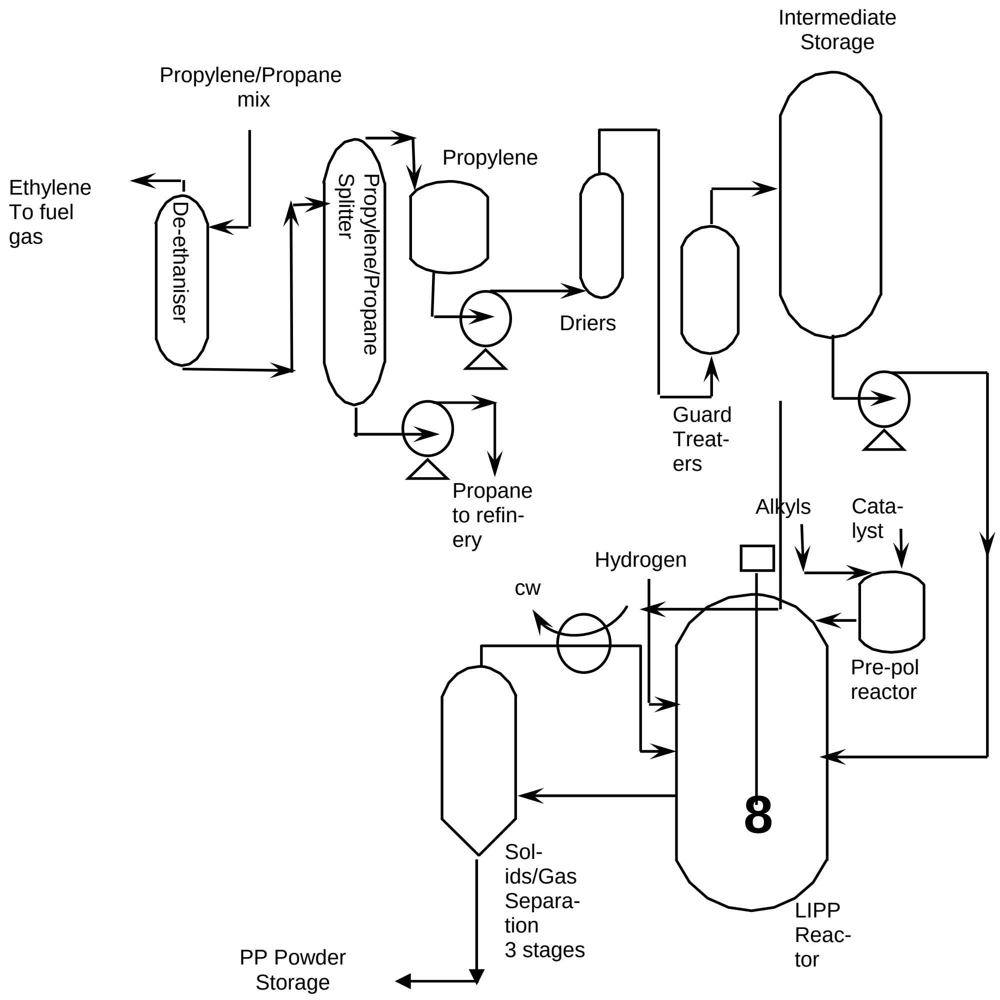
PP is a versatile material that can be easily processed via injection molding, blow moulding, extrusion and thermoforming techniques into a diverse range of industrial and consumer applications.

The functional unit, to which all data given in this EID refers to is 1kg of PP polymer granules.

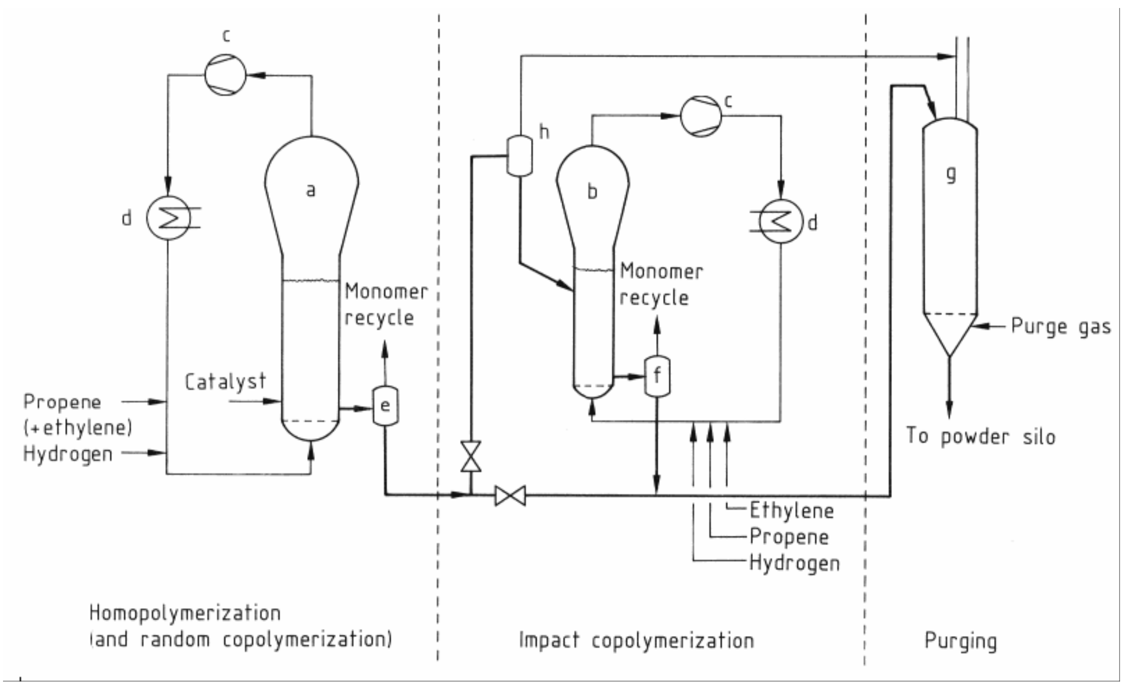
Production process

PP is produced commercially from olefin (alkene) monomers which contain a reactive carbon to carbon double bond. The starting material, propylene, is called the monomer and the final product consisting of many thousands of bound propylene units is called the polymer. Co-monomers (ethylene, butene) are used to improve toughness, impact resistance and transparency (random co-polymers). Two techniques are used for the production of polypropylene within Australia: **Liquid Propylene Pool Process (LIPP)** : The polymer is produced in a liquid pool of propylene by the inclusion of a Ziegler Natta catalyst which forces the molecules of the monomer to align and join in a certain manner to enable long chain formation, or polymerisation, into polypropylene. When long chain formation is sufficient, growth of the molecule is stopped via hydrogen, following this the catalyst is deactivated and resultant polymer separated from the liquid propylene. **Gas phase polymerisation**: A gas phase reactor is essentially a fluidised bed of dry polymer particles maintained either by stirring or by passing the propylene monomer gas at high speeds through it. As with the LIPP process, high activity speciality catalysts are used in the polymerisation of the gaseous monomer into polypropylene. Pressures are usually relatively low at ~2MPa and temperatures are usually in the range 60 - 80°C.

In both processes, the polypropylene leaving the reactor is in a fine powder form. This powder is then mixed with various chemical stabilising and performance additives, fed to an extrusion compounding machine which melt mixes the materials and forces the melt through dies where the resin is cut into pellets, cooled using water then packaged for sale.



Flow Diagram of the Liquid Propylene Pool (LiPP) process used at Geelong.
Source: LyondellBasell Australia 2009



Flow diagram of the fluidized bed gas phase process as used at Clyde
Source: IPPC Reference Document on Best Available Techniques in the Production of Polymers- October 2006

Use Phase and End-of-Life Management

Use Phase

Polypropylene is one of the most commonly used and versatile plastics today and is used in both short and long life applications, in Australia we consumed an average of 11.5kg/person during 2007[1]. It is likely you will come into daily contact with an article made from PP, be it your shampoo container, food containers for products such as margarine, yoghurt, fruit and breakfast spreads, protective films keeping food stuffs fresh, household carpets, in light weighted interior and exterior trim components of your car, to the banknotes used to pay for these. There are also a myriad of applications we seldom see yet benefit from, be it medical fabrics and items, materials handling items to soil erosion control grids.

The responsible use and disposal of PP will continue to be important issues. Within the plastics industry there are ongoing efforts to reduce the environmental impact that products impart along their life cycle. This is being accomplished through a variety of ways spanning innovations in the technologies used for manufacture, through to aspects of product and system design, recycling infrastructure development, grade development benefits and consumer education. Some of the program initiatives are detailed in the *"Environmental Performance"* section.

Recycling

PP is readily able to be mechanically recycled several times using conventional equipment. Within Australia there is currently only one route available for the recovery of embedded energy within end of life PP articles, that being mechanical recycling. Other options involving Energy from Waste (EfW) and Chemical recycling as used in parts of Europe, Asia and NA, are currently not available in Australia. In 2007 a total of 37,980 tonnes of PP articles were recovered by the Australian recycling industry, of this amount 27,193tonnes was reprocessed in Australia with 10,787 tonnes exported for recycling[1].

Mechanical recycling conducted in Australia involves collection, sorting grinding and re-pelletising for re-use. Established recycling schemes are in place for post industrial articles and, more recently, for post consumer packaging waste. PP (type 5) plastic packaging articles are now accepted by local councils servicing over 73% of Australia's population[1]. Studies conducted into the properties of recycled polypropylene show it to have reduced, yet still useful, properties that enable it to be reused into an existing and established myriad of applications[2].

In Australia, there are some 32[1] companies collecting (and competing for) available Polypropylene scrap from industry, and, more recently from Municipal Recovery Facilities (MRFs) that collect and sort PP post consumer waste from council kerb side collection schemes. The process involves collection, sorting, baling then size reduction into flake (film and sheet) or granules which may then need washing and drying. This is then re-compounded with additives and/or more virgin raw material, extruded and chopped into pellets ready for reuse. An industry study funded by the NPC into the recovery and recycling of PP articles confirmed that it was both technically and commercially viable[2].

Examples of PP recycling include:-

- Automotive battery cases where the batteries are collected at the end of their life, the lead and acid recovered, and the PP battery case material is recycled. This recycled material typically goes back into new automotive battery cases and can also be used in other applications.

- Australian banknotes are made from PP and upon their withdrawal from use are collected from Banking Institutions then granulated into small pieces. These pieces are then re-melted and formed into pellets ready to be used as a raw material for a range of new products.

- Municipal Kerbside Collected packaging items such as used ice cream, yoghurt and margarine containers, spreads/dip containers, cordial bottles, personal care containers, laundry product containers and more.

- Materials handling applications such as pallets, crates, containers and tote boxes. These multi use durable applications are sought after by the recycling industry as a source of feedstock for recycled PP. Recycling companies will typically form collection deals with major sources of such items.

Although PP like other thermoplastics is capable of being recycled, for a multitude of reasons some of it will end up in landfill. Landfill is the least preferred end result for a variety of reasons, however, in isolated areas or where the costs and energies required to transport and recycle waste outweigh the benefits, this may be a better option than existing recycling methods. PP is inert under landfill conditions; it does not contribute to leaching in landfill sites, does not generate methane gas and is stable within the landfill.

There is a variety of safe ways to handle end of life PP articles, depending on the circumstances. If large and relatively clean streams are available and can be collected in an economically viable way, recycling is the preferred option. Alternatively, the high calorific content of the material offers potential for use as a valuable feedstock in possible future energy recovery facilities.

Environmental Performance

The production of 1 kg of polypropylene is associated with environmental impacts as represented by the following performance indicators[3].

Input Parameters

Indicator	Unit	Value
Non-renewable materials		
• Minerals	g	1.8
• Fossil fuels	g	1,564.5
• Uranium	g	0.005
Renewable materials (biomass)	g	0.005
Water use[1)]	g	4,788
Non-renewable energy resources[2)]		
• for energy	MJ	20.4
• for feedstock	MJ	52.6
Renewable energy resources (biomass)[2)]		
• for energy	MJ	0.4
• for feedstock	MJ	0
[1)] This indicator comprises only process water. Cooling water is not included. [2)] Calculated as upper heating value (UHV).		

Output Parameters

Indicator	Unit	Value
GWP	kg CO_2	2.00
ODP	g CFC-11	n/a[3)]
AP	g SO_2	6.13
POCP (CML 2002)	g Ethene	0.92
NP (CML 2002)	g PO_4	0.74
Dust/particulate matter	g PM10	0.59
Total particulate matter	G	0.60
Waste		
• Non-hazardous	Kg	0.024
• Hazardous	Kg	0.005
[3)] Relevant LCI entries are below quantification limit.		

Data Sources and Allocation

All data in the above input and output tables refers to a European industry average (reference year 2005); all calculations were updated in 2006. Plastics*Europe*'s member companies supplied information on the production of hydrocarbon precursors. 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. Data will differ for the Australian made product which is not available at this point. For the underlying LCI data (eco profile) and for additional information please refer to http://www.plasticseurope.org

Additional Environmental and Health Information

Sustainability Covenant

LBA has signed the covenant with partners of EPA Victoria and PACIA. The key tenants of this agreement are to enhance sustainability via:-

- Increasing the efficiency with which we use resources to produce products and services.
- Reduce the ecological impact of those products & services throughout the life cycle.

EPA Victoria - Sustainability covenants

ISO14001

Our manufacturing sites are accredited to this international environmental management standard and are regularly audited by a third party external agency to ensure ongoing accreditation.

National Packaging Covenant

As an active signatory LBA is committed to the principals of the covenant and its goal of increasing the recovery rate of plastics packaging materials. | The National Packaging Covenant | - Home

Responsible Care®

The Responsible Care program initiated by the chemical industry provides a structured commitment to enhanced HSE performance. Responsible Care has been adopted by LBA manufacturing, research & development and marketing activities. http://www.responsiblecare.org

Additional Technical Information

PP is readily able to be mechanically recycled several times. Studies conducted into the properties of recycled polypropylene show a slight loss in physical properties which each recovery cycle. The retained properties are adequate to enable reuse into an existing and established myriad of applications.

A separate study funded by the National Packaging Covenant confirmed the mechanical recycling of consumer waste PP to be economically viable. [2]

Information

Company/Association

LyondellBasell Australia Pty Ltd
Level 5, 627 Chapel Street
South Yarra Vic 3141
Telephone: (03) 9829 9400, Fax: (03) 9541 3025.
www.lyondellbasell.com

This Environmental Information Document has been reviewed against the *Green Marketing and Trade Practices Act* of the Australian Competition and Consumer Commission (ACCC)[4].

References

1. *PACIA:* National Plastics Recycling Survey 2008. Plastics and Chemicals Industries Association
2. *National Packaging Covenant:* A Study into the Economic Viability of recycling post consumer PP waste. | The National Packaging Covenant | - Home
3. Plastics*Europe*: Polypropylene (PP). Eco-profiles of the European Plastics Industry. Brussels, March 2005.http://www.plasticseurope.org
4. Green marketing and Trade Practices Act*. Published by the ACCC 02/08*http://www.accc.gov.au

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 Protection Authority, EPA – A statutory authority established under the Environmental Protection Act of 1970. Purpose is to protect, care for and improve the environment.

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.

Polypropylene (PP) — A thermoplastics polyolefin with a density around 900 kg/m³. Thermoplastic consisting of bound propylene units. (C_3H_7)

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.

Life Cycle Inventory, LCI – A standardised set of data relating to the environmental inputs, outputs and impacts involved in the production of a given amount of a product or service. Collected in accordance with ISO14040-44 standards. Used as base data in LCAs.

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.

Plastics & Chemical Industry Association, PACIA – The peak representative body of the Plastics industry.

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.