Q9

Issue 9

Design for Sustainability with Plastics

quickstart

Innovations for sustainability

This is the ninth in a series of Quickstarts on Design for Sustainability (D4S) with Plastics. It provides examples of innovation in the design, manufacture, use or recovery of plastics that will deliver more sustainable solutions.

In this Quickstart:

- Sustainability challenges and the plastics life cycle
- Polymers from renewable feedstocks
- Innovative plastics manufacturing
- Products to support sustainability
- Improved recovery technologies

A potential application for flexible plastic solar cells (digitally created image supplied by CSIRO)

Sustainability challenges and the plastics life cycle

The global population is expected to increase from 6 billion people in 2000 to around 9 billion in 2050[1]. This will put more pressure on the natural environment by increasing demand for the products and services essential for human survival and quality of life. All products and services consume raw materials, energy and water, and also generate wastes and emissions that can degrade the environment unless managed effectively.

The plastics industry continues to help address these problems by adapting or developing new materials, technologies, products and services in conjunction with its supply chain, customers, governments, research organisations and designers. Responsive and innovative design can harness the benefits of plastics to provide products and services to a growing population seeking a higher standard of living with a smaller ecological footprint. Early introduction of viable materials can improve sustainability and add business value.

In striving to achieve these outcomes the plastics industry also recognises the contribution made by reducing its sole reliance on traditional feedstock materials such as oil and gas. While there are still vast untapped reserves of gas, oil supplies are expected to peak some time between 2010 and 2030 and the price of oil is rising[2]. The solutions to managing finite feedstock and meeting growing demand include using plastics more efficiently, developing new plastics from renewable sources (including by-products[3]) and recovering a greater proportion of plastic products at the end of their life. All of these strategies will reduce the draw on finite resources.

Maize grown with and without coverage at planting with a photodegradable film which traps moisture and promotes early growth (image supplied by the CRC for Polymers)

The aim of the Quickstart series is to promote the design of products and services that are sustainable—that is, products and services that contribute to social progress and economic growth, as well as providing ecological benefit, throughout their life cycle. The sustainability of a product is largely locked in at the design phase, which is why D4S is so important. The Quickstarts are written for practitioners at every stage of the plastics product chain, including designers, polymer suppliers, product manufacturers, brand owners, specifiers and recyclers. The series also supports the implementation of PACIA's Sustainability Leadership Framework (2008), which promotes a whole-of-life approach to product innovation and stewardship and the need for step-change 'transformations' in material and resource use.

New materials and technologies

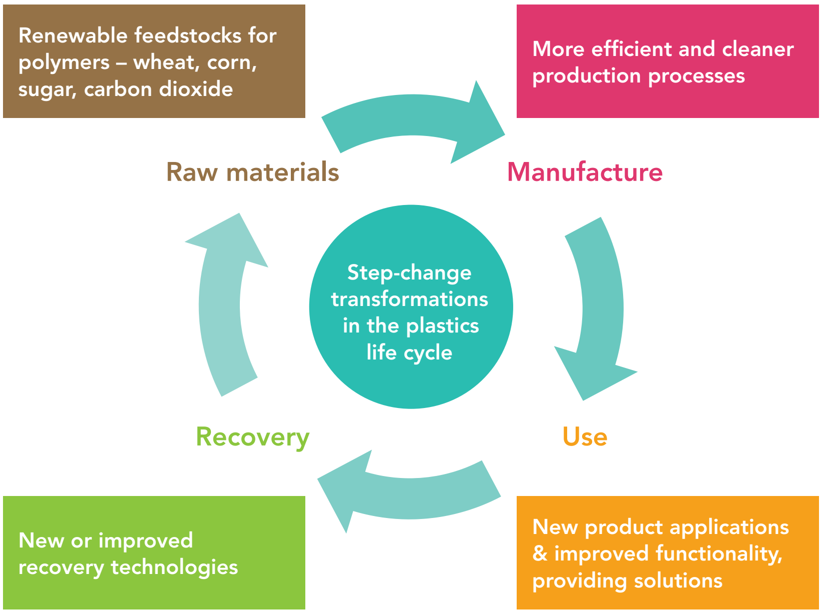
Decision making about new materials and technologies must be based on life cycle thinking and a good understanding of the impacts and benefits of alternatives.

The plastics industry has already made significant progress towards sustainability, for example by improving its energy and water efficiency. Further, for every tonne of greenhouse gas emitted by the global plastics and chemicals industry, 2-3 tonnes are saved by the products and technologies provided to other industries and users[4].

The industry is continuing to develop new materials, processing technologies and products to reduce the environmental impacts of production and consumption at every stage of the life cycle (Figure 1).

These innovations provide opportunities for the design or use of more sustainable plastic products. They will either reduce the environmental impacts of plastics or help to address urgent sustainability challenges, such as global warming and food security. In evaluating the potential for new materials or technologies, designers need to ensure that they meet essential requirements such as functionality and cost effectiveness. It is also important to ensure that these solutions are environmentally beneficial and don't simply transfer impacts from one part of the life cycle, or from one impact category, to another. For example, there are concerns that conventional silicon-based photovoltaic cells may consume more energy to manufacture than the energy they generate over their life cycle[5].

Figure 1: Innovations delivering sustainable solutions across the product life cycle



Some examples of initiatives that support the more sustainable manufacture, use or recovery of plastics are provided in the following sections.

Nanotechnology and conducting polymers can be used to produce flexible electronic products (image supplied by CSIRO)

Polymers from renewable feedstocks

New polymers are being developed using renewable feedstocks. In future many of these are likely to be manufactured from the by-products of large-scale 'bio-refineries' which will produce plastics and chemicals from biomass sources such as corn, sugar cane and soybeans, or from industrial by-products such as bagasse from sugar cane (Figure 2).

Designers need to monitor these developments and evaluate the value of new materials as they become commercially available. Consultation with manufacturers and reprocessors will assist whole-of-life management.

Figure 2: New polymers from renewable feedstocks

Initiative	Details	Further information
Polyurethanes from soybean oil	Renewable feedstock. Small scale commercial plant in Chicago.	Cargill, www.cargill.com/products/industrial/foam/index.jsp
Polycarbonate from carbon dioxide (CO_2)	CO_2 would be recovered from industrial emissions. Starting to be commercialised (Novomer).	American Chemical Society, www.eurekalert.org/pub_releases/2008-04/acs-dac031108.php Novomer, www.novomer.com/novomer_news_news.php?article_id=10
Polyethylene from ethanol (sugar cane)	Renewable feedstock. Manufacturing plants under construction in Brazil.	Braskem, www.braskem.com.br/upload/portal_braskem/pt/sala_de_imprensa/Press_release_verde_eng_21-06-07.pdf Dow Chemical Company, http://news.dow.com/dow_news/prodbus/2007/20070719a.htm
Polymers from safflower oil	Renewable feedstock. Research stage.	CSIRO, www.csiro.au/news GreenPlasticsFromPlants.html
Polymers and chemicals from bagasse (a by-product of sugar processing)	Renewable feedstock and recovery of an industrial by-product. Furfural from bagasse can be used to make polymers such as nylon, lycra, and polyurethane. Small scale commercial plant in Queensland.	Prosperpine Co-operative Sugar Mill, www.prosugar.com.au
Polymers from corn starch	Renewable feedstock and biodegradable. Commercial plant in Victoria.	Plantic Technologies, www.plantic.com.au

Innovative plastics manufacturing

New processing technologies are being developed to reduce the amount of polymer required in manufacturing or to reduce the environmental impacts of production or use (Figure 3).

Designers are encouraged to talk to manufacturers about the availability and potential benefits of these technologies for particular applications.

Figure 3: New developments in plastics processing

Initiative	Details	Further information
Microcellular expansion technology	Reduces the cost and weight of plastic products. Undergoing commercial trials.	MicroGREEN, www.microgreeninc.com
Non-halogenated flame-retardant polyurethane	Does not produce toxic gases during combustion (environmental and health benefits). Commercial product.	Clariant, www.clariant.com/corporate/internet.nsf/vwWebPagesByID/5FD0765949501C01C12575D1004B014C
Self-healing polymers	Use nanotechnology to identify and repair cracks in plastic products, extending their life. Research stage.	University of Illinois, http://autonomic.beckman.illinois.edu/index.html
UV-activated self-healing polyurethane	An additive allows scratches to heal themselves at ambient temperatures. Research stage.	Toensmeier, P. 'Polyurethane heals itself via UV-activated process', Plastics Engineering, June 2009, pp. 6,8
Engineering polymer (polybutylene terephthalate) –Ultradur® High Speed	Modified with organic nano-particles to reduce cycle times and improve energy and material efficiency. Commercial product.	BASF, www.plasticsportalasia.net/wa/plasticsAP~en_GB/function/conversions:/publish/common/upload/engineering_plastics/ultradur_high_speed.pdf
Fire-safe polymer (Ultrason) for fire helmets	Lightweight and fire resistant without the use of flame retardants, which improves safety for fire fighters and makes it more recyclable. Commercial product.	'Firefighters protected by plastics for our security', Driving Innovation, 7 February 2009, www.plastics-themag.com/22/actualite.html

Products to support sustainability

Innovative plastic materials and products are being developed to reduce the environmental and social impacts of increasing global populations, drought, climate change and land degradation (Figure 4).

These demonstrate the potential for innovatively designed plastics to facilitate step change transformations in production and consumption.

Figure 4: Innovative plastic products with sustainability benefits

Initiative	Details	Further information
Flexible plastic solar cells	Solar cells are 'printed' on to polymer films, with potential to cover any surface, e.g. buildings and cars. Expected to decrease cost and environmental impact of manufacture, and enable effective mass production. Research stage.	CRC for Polymers, www.crcp.com.au CSIRO, www.csiro.au/news/Trials-for-printable-plastic-solar-cells.html UCLA, http://newsroom.ucla.edu/portal/ucla/ucla-researchers-create-polymer-72064.aspx
Plastic electronics	Use nanotechnology and conducting polymers to produce light weight flexible electronic products. Research stage.	CSIRO, www.csiro.au/science/Flexible-Electronics.html
Degradable films for agricultural production	Will conserve water and increase crop yields. Research stage.	CRC for Polymers, www.crcp.com.au
Ultra-thin films to cover reservoirs and dams	Will reduce water evaporation. Research stage.	CRC for Polymers, www.crcp.com.au
Plastic membrane that mimics the pores in plants	A wide range of potential applications including more efficient purification of water or methane from landfill. Research stage.	CSIRO, www.csiro.au/news/FantasticPlastic.html

Improved recovery technologies for plastic products

The recovery of plastics in Australia is primarily through manual sorting of polymer types and mechanical recycling back into plastic products (see Quickstart 5). New technologies, or processes adapted from other sectors, are being used to make recycling more efficient and to find new applications for recovered plastics (Figure 5).

In future it is expected that plastics will be recovered through an integrated approach which involves both material and energy recovery[6].

Figure 5: New technologies to sort or recover plastics

Initiative	Details	Further information
'Active disassembly' to separate plastic components for recycling	Uses shape memory to allow parts to be separated at a certain temperature. Research stage.	Active Disassembly Research, www.activedisassembly.com/index3.html
Cyclonic media separators	Could be used to sort individual plastic types from shredded electronic products and cars. Research stage.	Gent, R. et al 2009, 'Recycling of plastic waste by density separation: prospects for optimisation', Waste Management & Research, 2009: 27, pp. 175-87
Post-consumer plastics used as a secondary fuel in steel making	Plastics replace coal or coke as a reducing agent. Reduces waste to landfill and the greenhouse gas emissions associated with the steel industry. Research stage.	University of NSW, www.materials.unsw.edu.au/school/articles/wasteplastics.html
Recyclable thermoset polymer	Heals itself when heated and can be recycled many times. Provides advantages over traditional thermosets which are difficult to recycle because they decompose when heated. Research stage.	University of Groningen, Netherlands, www.iom3.org/news/recycling-thermosetting-plastics

Researchers apply an ultra-thin film to a trial site to observe the reduction in evaporation (image supplied by the CRC for Irrigation Futures)

The Quickstart series is part of the 'Design for Sustainability with Plastics' program managed by a collaborative partnership between Sustainability Victoria and PACIA. The Quickstart series can be downloaded from www.pacia.org.au.

Further information

Centre for Green Chemistry, Monash University (for research updates): www.chem.monash.edu.au/green-chem/

CRC for Polymers (for research updates): www.crcp.com.au

CSIRO Plastics and Polymers (for research updates): www.csiro.au/science/Plastics.html

Driving Innovation – The Magazine about Plastics: www.plastics-themag.com

PACIA (for information on D4S, plastics recycling and sustainability): www.pacia.org.au

Plastics Europe (for information on plastics): www.plasticseurope.org

Sustainability Victoria (for a range of D4S resources): www.sustainability.vic.gov.au

Footnotes

1 United Nations 2009, *World Population prospects: 2008 revision,* New York, www.un.org/esa/population/publications/wpp2008/wpp2008_highlights.pdf.

2 Marshall, J. 2007, 'Who needs oil?', *New Scientist*, 7 July, pp. 28-31.

3 The use of waste products from manufacturing as raw materials for another process is often referred to as 'industrial ecology'. A good example is the use of waste biomass from sugar processing to make furfural, which is then used in the manufacture of chemicals and plastics.

4 International Council of Chemical Associations (ICCA), 2009, *Innovations for greenhouse gas emission reductions,* www.pacia.org.au/Content/media-6.07.2009-1.aspx.

5 Gosline, A., 2006, 'Something to be proud of', *New Scientist,* 9 September, p. 54.

6 International Standards Organisation, 2008, ISO 15270: *Plastics—guidelines for the recovery and recycling of plastics waste*, ISO, Geneva.

Publication details

Quickstart: Design for Sustainability with Plastics was prepared by Helen Lewis Research for Sustainability Victoria and the Plastics and Chemicals Industries Association (PACIA) with input and advice from practitioners and others involved in the sector.

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