PLASTIC WASTE – TOXIC RUBBISH OR STRATEGIC RESOURCE?

MEETING OF THE PARLIAMENTARY AND SCIENTIFIC COMMITTEE ON MONDAY 11TH JULY 2005

Plastic waste can be recycled and re-used almost indefinitely or could be incinerated to provide up to 17% of our requirements for electrical power, thereby reducing damage to the environment and the need for landfill, which is much more stringently regulated and is filling up very rapidly. There is currently no alternative on the planners' horizon to a very greatly increased reliance on waste recycling if we are not going to be buried in rubbish.

Plastic Waste: Toxic Rubbish or Strategic Resource?

Peter Davis OBE,
Director General, The British Plastics Federation

This presentation demonstrates that used plastics are a strategic resource that has a life extending beyond their first use. This overview of our Federation shows how much plastic is produced and the very wide range of applications to which it can be put. A summary is also presented of the British Plastics Federation's views on the priorities for recycling and recovery of used plastics.

The British Plastics Federation (BPF) evolved from the British Plastics Moulding Trade Association (1929-33) and was founded on 21st December 1933, in the same year that an ICI scientist called Gibson discovered polyethylene. This was the starting point for the plastics industry in the UK as a commercial enterprise.

The BPF has a shared-cost approach to managing the national plastics industry. We have over 300 member companies with a wide range of commercial activities related to plastic manufacture, ranging from raw materials and additive producers to plastics processors and distributors and machinery suppliers and recyclers. We also have 20 Business Groups and four Market Sector Groups. A brief statistical overview (see page 12) shows the scope and range of the UK plastics industry, and demonstrates the importance of this sector to the national economy.

Resource Efficiency of Plastics

Plastics are extremely resource efficient and make very economical use of the world's oil production. For example, only 4% of this is used for plastics production, whereas 86% is used for transport and heating. Over the past 10 months plastic material prices have increased by 50-65% as they are directly affected by increases in oil prices. In May 2005 the London Metal Exchange opened a Futures Market in two plastic materials PP and LLDPE. Plastics confer major environmental benefits. They are both durable and lightweight, which minimises waste and helps to save energy in several different ways since the cost of energy used is less than 3% of the cost of a manufactured product and in making transport more energy efficient, for example. The use of 100kgs of plastic in a car to replace heavier materials saves 750 litres of oil over the lifetime of the vehicle. However, although plastics are taking weight out of cars and thereby providing the potential for more miles per gallon in fuel economies, car manufacturers are adding weight in the form of extras such as air conditioning, electric windows and MP3 players. Plastics packaging prevents wastage by keeping food fresh. Consumers are more upset by spoilt food than they are by over packaging.

Plastics Recovery: Waste Management options

Plastics can be recovered either as material or as energy with five possible options for their ultimate disposal: recover the energy as recycled materials; recover the energy as energy; recover the energy as material and energy; compost biodegradable waste – losing the energy to the environment; and landfill – burying (and losing) the resources.

Landfill is the worst possible option as used plastics are a valuable resource that should not be wasted in this manner. In the UK only 9.3% of recovered plastics are recycled, with only 7.7% used for recovering energy. The equivalent average figures for Western Europe are 16.5% and 22.5%. In 1985 only 84,500 tonnes of plastic packaging was recycled. Following implementation of the EU Packaging Wastes Directive, this rose to 344,243 tonnes in 2004. We still have a long way to go. The possible recycling methods available for plastics include the following: mechanical recycling; chemical recycling; feedstock recycling; organic recycling (composting); and energy recycling.

Several examples of important areas of plastics recycling are briefly summarised here.

Expanded Polystyrene Recycling

The BPF's Expanded Polystyrene Packaging (EPS) Group is working with Original Equipment Manufacturers (OEMs) such as Panasonic and Hitachi and retailers such as Comet and Dixons to take material back and reuse it. Recycling fish boxes is more challenging due to contamination. We are planning to work with major supermarkets in future. See www.eps.co.uk and www.bpf.co.uk for more information.

Bottle Recycling

There has been a 100% increase in the past two years with 10.5% of bottles (48,000 tonnes) collected from the household waste stream – 68% from the kerbside and 32% from return schemes. Collection facilities for plastic bottles are offered by 73% of all local authorities who also benefit financially.

Bio-plastics/Biodegradables

These are increasingly fashionable and some retailers have adopted them. They are not the correct solution for products such as pipes however. Claims made for the products need to be checked and bio-degradables can contaminate plastics recycling streams.

Farm Plastics

The Government is currently focusing on agricultural waste, including plastics waste such as silage film, in order to implement a European Directive. 162,000 farms generate one tonne of plastics waste a year. Currently this is stored, burned or buried. The BPF is involved with the Government in looking at a national mandatory scheme associated with local delivery, for the collection, recycling and recovery of farm plastics. This presents both logistical and economic challenges!

The Markets for recycled plastics in the UK

Some typical uses for recycled plastics material are: pallets; underground storage tanks; drains; film and bags; fabrics and fibres; garden furniture; office furniture, stationery; road barriers and cones; and street furniture. Many more applications are under development.

Energy Recovery – an urgent UK need

The BPF believes used plastics should not be landfilled as they are a valuable resource. When used plastics cannot be economically recycled with environmental benefits they can perform a valuable role as feedstock in mixed waste for energy from waste incineration. The UK lags far behind Western Europe in energy recovery capacity and in its attitude to energy recovery. The UK has only 19 Energy-from-Waste incinerators for a population of 60 million, whereas Denmark has 32 for a population of only 5 million. "Nimbyism" in Denmark is directed at landfill as it produces methane and can pollute groundwater. The City of Copenhagen landfills only 4% of its waste whereas London landfills over 80% and landfill tax is increasing. London faces a looming crisis since many of the landfill sites it currently uses for waste disposal, particularly in Essex, will close in 2007. The Mucking landfill alone takes 15% of London's waste, about 650,000 tonnes. Its closure will generate 100 extra lorry movements a day, taking the waste elsewhere.

The DTI Secretary of State has recently reopened the public inquiry into the Belvedere Energy-from-Waste Incinerator on the Thames, after the Inspector had given it the green light to proceed. This delay is frustrating when London urgently needs about eight more Energy-from-Waste incinerators in addition to the current two. The Mayor of London wants 80% of London's waste managed within its boundaries by 2020 rather than having to export it. This target is completely unattainable without major increases in both recycling and energy recovery.

Dispelling the myths on energy recovery

The European experience shows that increasing the energy recovery capacity does not prevent recycling rates also increasing, as waste is thereby diverted from landfill. UK plastics recyclers are much more threatened by the export of plastic waste to China. Energy recovery does not cause pollution or emit dangerous levels of dioxins. There is stringent Environment Agency control of energy recovery plants and dioxins have an air emission limit of 1 nanogram per cubic metre, equivalent to existing background dioxin levels in urban soils. The annual dioxin emissions for all UK incinerators are one tenth of the dioxins released from bonfires and fireworks on Guy Fawkes night.

Energy Recovery – growing support

The UK is now a net importer of energy with shortages predicted if we have a hard winter. The Institution of Civil Engineers and the Renewable Power Association in a joint report in April 2005 said that half of the 30 million tones of household rubbish sent to landfill in England could be incinerated and generate enough power to light 2 million homes each year. By 2020 17% of our electricity needs could be generated by energy recovery. Energy recovery provides clean, renewable power, and reduces demands on fossil fuels. Used plastics are "frozen fuel" with a higher calorific value than coal.

In conclusion, used plastics are a strategic resource and should not be landfilled but be recycled. However, if it is uneconomic or impossible to recycle for environmental reasons, the energy should be recovered by waste incineration.

Techniques to Identify, Sort and Recycle Mixed Plastics Waste

Graham Hearn,
Wolfson Electrostatics, University of Southampton

Introduction

The importance of effective, practical and economically viable recycling of consumer products and industrial materials is widely recognised. The proliferation in everyday life of plastics in their various forms, including mouldings, fabrics, packaging materials and films, presents a particular challenge in respect of recycling. In many products plastic often constitutes the largest single mass of material. A crucial stage in recycling plastics is identification and if possible the sorting of waste plastics into clean single polymer streams. This is important for the following reasons:

- Different polymer types are often incompatible in remould/re-extrusion
- Specific plastics are chosen for their mechanical/physical properties
- Toxic and banned additives may be present in some plastics eg BFR, Heavy metals
- Pure polymers command higher prices

If separation cannot be achieved prior to melt and reforming, the effective recycling of materials cannot be undertaken. In recent years the need to identify, sort and stream plastic waste has been given extra impetus by directives such as "End of Life Vehicles" (ELV) and "Waste Electrical and Electronic Equipment" (WEEE).

Two of the most successful techniques for plastics identification are spectroscopy and electrostatics. The spectroscopic system uses the fact that wavelengths in the infra-red region are absorbed differently by different polymers giving each plastic a unique fingerprint. The electrostatic technique measures the magnitude and polarity of charge generated by the plastic and how quickly it decays from the surface. These techniques complement each other: the system based on spectroscopy gives precise identification but is relatively complex and expensive whereas electrostatics provides a cheap and simple means of streaming basic polymer groups.

Waste packaging

During 2000-2002 the Onyx Environmental Trust sponsored a project at Southampton University to develop an automated pilot-scale system using electrostatic techniques to identify and separate different species of plastics from a mixed waste stream. The objectives were to:

- Separate plastics from non-plastics (cardboard etc)
- Segregate different polymer groups
- Identify presence of toxic and banned substances
- Simple reliable technique and suited to automated line
- Handle the required throughput
- Handle variations in size, differences in shape, contamination, moisture, labels etc.

The pilot rig features a conveyor belt which can be loaded with mixed packaging materials such as plastic bottles, food tubs etc. Plastics are first separated from non-plastics by measuring charge decay time (natural materials such as paper, cardboard and wood exhibit a much faster charge decay rate than plastic). The five main plastics found in packaging; polyethylene (HDPE), PET, polypropylene, PVC and polystyrene are then streamed using a phenomenon known as "triboelectrification" (derived from the Greek verb tribo: to rub).

Triboelectrification describes the electrical charge that is generated when two unlike surfaces are brought into contact and then separated, for example the sole of a shoe and nylon carpet. Positive (+) charge is generated on one surface with negative (-) charge on the other. Depending on their position in the triboelectric series (fig. 1), polymers have their own natural electrical characteristics with some tending to + and others -. When the unknown plastic packaging is brought into contact with a triboelectric probe then depending on the probe head material and the polarity of the static charge produced, the unknown plastic may be identified. A mixture of polyethylene (PE) and polypropylene (PP) for example, which are incompatible polymers in recycling, can be distinguished between using a probe with a PVC head because PE charges + and PP charges -.

Positive End

Polyamide (Nylon)
Polycarbonate

PMMA (acrylic)
ABS/PS.HIPS
Metals

PBT

Polypropylene
PVC
PVDF
Polyethylene
PTFE (Teflon)

Negative End

Figure 1. Triboelectric series containing some materials of interest in recycling. The materials in bold italics are metals and speciality plastics which have been investigated as probe head materials.

Waste electrical & electronic equipment (WEEE)

The European WEEE directive requires certain percentages by weight of all categories of domestic electrical equipment to be recycled. In many cases this involves dismantling of equipment followed by identification and segregation of plastic parts – primarily casings.

Wolfson Electrostatics latest project is in collaboration with the Hampshire Natural Resources Trust and others to produce the UK's first WEEE recycling plant in which plastics are fully characterised. In order for this to be successful, rapid identification of basic polymer types and the presence of brominated flame retardants and other contaminants and banned substances is essential. This is currently being achieved by a combination of the techniques described below.

Tribopen

The use of the electrical or electrostatic properties of a material as a basis for identification and sorting was pioneered at the University of Southampton some years ago. The Tribopen was originally developed at the University with the sponsorship of the Ford Motor Company and uses electrostatic techniques to divide materials into two streams. It is simple in operation, relatively inexpensive to produce and has a number of proven and potential applications. The Tribopen won a Millennium Products Award from the UK Government in 1999.

The Tribopen, which is currently commercially available, is essentially a small battery-operated hand-held device which, when rubbed across the surface, will distinguish between two different plastic types. It indicates the plastic type by illuminating a small red or green light. It has a single detachable sensor head that can be simply removed and replaced and choice of sensor will depend on the plastic materials to be identified. A typical application would be to separate a mixture of three unknown plastics, say polyethylene (PE), polypropylene (PP) and ABS into three individual streams. In this case, two pens would be required. The first pen could be used to pick out PE (PE giving a red light and PP and ABS giving green). A second pen (with a different sensor head to the first) would split PP and ABS. If there are four unknown plastics in the initial stream then three pens will be required, and so on. Obviously if a large number of unknown materials are present in the initial stream, the Tribopen application becomes impractical and a device such as the PolyAna (see below) may be more appropriate. Picking out a single material, such as PVC, from a variety of unknown plastic types would require just two single pens or a double-headed pen (a design for a double-headed pen is under consideration).

PolyAna

Like the Tribopen, the PolyAna plastics identification system was developed at the University of Southampton in a collaborative project funded by the Ford Motor Company some years ago and also won a Millennium Product Award from the UK Government in 1999.

The key to the PolyAna is an optical cell design and front-end software that enables a laboratory spectrometer to be used on an industrial recycling line by non-technical personnel. It can be used on large items (eg car panels) and small objects down to about 10mm. The 3-second measurement is non-destructive and does not usually require modification or treatment of the sample in any way. The optical cell design directs the IR beam to the sample by means of a series of mirrors. The computer then compares the spectrum of the reflected light with a database or "library" of pre-programmed spectra stored within the computer. Different libraries are available for different applications, and can be easily set up by the user in order to deal with specific materials of interest. This technique has also shown promise in the detection of brominated flame retardants in waste electrical and electronic equipment (WEEE) which are currently being phased out in the EU.

An important aspect of the PolyAna technology is that it enables the user to develop custom databases. This is critically important for the recycling industry because more often than not recycled materials are not pure polymers and a custom database is essential.

Sliding Spark

This instrument is essentially a more sophisticated derivative of the old-fashioned burn and sniff techniques used some years ago as a crude identifier of polymers. A high energy spark is used to burn the surface to be identified. This is done by means of a hand-held probe but may be used with an automated probe. The fumes from the burnt surface are then transferred by means of a vacuum line to a spectrometer chamber where they are analysed and the material under test identified. The primary use for this instrument on a WEEE recycling line is for detection of banned or potentially hazardous materials such as PVC, heavy metals and brominated flame retardants.

Further information on the activities of Wolfson Electrostatics can be found on the web at www.soton.ac.uk/~wolfson.
Email: wolfson@soton.ac.uk

Used plastic – resource for the future

Dr Roger Morton, Director, Axion Recycling Ltd

Axion Recycling Ltd (www.axionrecycling.com) was founded in 2001 to develop new projects in the waste recycling sector. Since then Axion has developed a process design for pyrolysis of mixed waste plastics to produce a hydrocarbon liquid fuel – "Plasoil" and has conducted a great deal of self-funded research and development of novel plastic separation techniques. The business has also carried out consultancy work in related sectors. Clients include:

- UK PVC Recycling Consortium - practical trials of novel recycling methods and implementation of the Recovinyl PVC recycling initiative for the UK PVC industry.
- Hampshire Natural Resources Trust – an ongoing, practical pilot project to test de-manufacturing and separation processes for small WEEE items.
- Stockport Council - kerbside collection trials for mixed plastics from 1800 homes and tests of advanced separation processes for mixed household waste plastic.
- WRAP – major project to develop a process to extract brominated flame retardants from WEEE polymers.
- Greenergy Fuels – practical trials and business planning for production of biodiesel from a range of waste and new feedstocks.

Axion is currently developing a plant of its own to process waste electrical equipment plastics in Sheffield.

This paper is based on Axion's practical experience of plastic recycling in the UK. It makes the political and environmental case for recycling a wide range of sources of waste plastic in the UK and provides pointers for how legislators can change the way they work to encourage investors in this sector.

People hate wasting plastic

Politicians are well aware that most people in the UK really dislike throwing away plastic.

Axion recently conducted large scale segregated kerbside plastic collection and separation trials in collaboration with WRAP (www.wrap.org.uk) and Stockport Council. As part of these trials we conducted a survey of the residents in the target collection areas. Participation in the survey was very high and the overwhelming response (99%) of residents was that they would be prepared to segregate their plastic for collection on a permanent basis.

Anecdotal evidence indicates that similar opinions prevail regarding other sources of waste plastic such as electrical equipment and construction.

There is plenty of it

There is a huge amount of valuable plastic going to landfill in the UK.

Axion's estimate of the recoverable quantity is:

Waste source	Recoverable plastic in the UK (te/yr)
Electrical equipment	300,000
Construction	200,000
Vehicle and related waste	200,000
Household waste	900,000
Total	**1,800,000**

Recycling plastics is complex

There are many different types of plastic and most are not compatible with each other. They contain a wide range of additives and colours. Some of the additives used in older products are no longer permitted in new items.

Complex separation processes are therefore required to separate plastic from other materials with which they are often combined such as metals, wood and paper and then to separate within the plastics by polymer type and additive content or colour.

These technologies are developing rapidly. It is now technically feasible to recover and separate most sources of waste plastic in their original form at reasonable cost without resorting to incineration or other thermal techniques.

Life cycle analysis

Mechanical recycling is separation and purification of plastic particles without changing their chemical form by incineration or other chemical transformation.

Life cycle analysis demonstrates that for the great majority of plastic products mechanical recycling is by far the best environmental option. An environmental impact comparison was completed recently for Axion and WRAP by Huisman Recycling Research in the Netherlands. Huisman compared the environmental impacts of a range of disposal and recycling options for plastics from waste electrical equipment that contain brominated flame retardants. These options included solvolysis, mechanical, feedstock, incineration and landfill and confirmed mechanical recycling as the best option.

Although recycling processes for plastic create some environmental impact themselves (unlike landfill where plastic is assumed to have minimal environmental impact because it does not degrade) the fact that they create useful material which can substitute new polymer saves all of the environmental impact of creating that new polymer.

People are doing it in the UK

There is already a vibrant plastic recycling sector in the UK. For example 40,000te/year of rigid PVC is recycled in the UK. However, with a few notable exceptions, the existing recyclers concentrate almost exclusively on scrap from industrial processes.

It would be a relatively small step for these recyclers to move into reprocessing dirtier, more co-mingled materials such as household plastic or waste electrical equipment. They are deterred by a combination of legislative factors which could easily be solved with a bit of political will.

Firm action needed from legislators

The basic legislative framework for encouraging plastic recycling in the UK is already in place. It is just not working effectively. The following legislation is most relevant:

- Landfill Directive
- Packaging Waste Directive
- End of Life Vehicle (ELV) Directive
- Waste Electrical and Electronic Equipment (WEEE) Directive

Legislators in the UK need to enforce this legislation much more boldly, consistently and firmly than they have to date. If they do, existing plastic recyclers will quickly develop the confidence to invest in the technologies required and the UK sector will quickly become the pride of Europe.

J F C Delleve Plastics Ltd

Lee Clayton, General Manager

I am the manager of the UK's only commercial scale plastic recycling plant. The company is primarily in business to make a profit for our shareholders from our expertise in processing plastic waste. However, in order to do so we have to be internationally competitive due to the flourishing offshore market for plastic waste with which we must be able to compete effectively.

I am also personally responsible for the following activities: management of the plant, development of new processes, material procurement, overview of Government legislation, product sales from the St Helens plant and polymer utilisation.

The present company was originally called Reprise Ltd and as a result of a recent development involving the relocation of the factory in St Helens costing £4 million, it became the first plant in the UK to recycle polyvinyl chloride (PVC), polyethylene terephthalate (PET) and high-density polyethylene (HDPE) bottles. However, the plant is still underfunded and underdeveloped with respect to the rest of Europe. In the UK 450,000 tons of bottles are produced annually but only 45,000 tons are collected, resulting in wastage of plastic raw materials. This is an indicator of the potential for expanding the business in the UK.

A new partnership project costing £3.5m over three years has therefore been developed with the Waste and Resources Action Programme (WRAP) with the objectives of improving the efficiency of sorting. This enables the plant to handle mixed waste streams derived from waste collections which are now changing to mixed plastics. The new sorting procedures are less labour intensive, are more accurate than and twice the speed of manual sorting and include a new bottle sorting and washing plant.

The capacity of the plant is 20,000 tons per annum and the primary feedstock is mixed bottles. The materials processed include segregated HDPE and mixed bottles. The plant produces feedstock such as PET flake and coloured HDPE flake, with products made from feedstock such as PET non-woven fibre and natural HPDE compound.

The demand for recycled plastics is 7000 tons per year for HDPE pipe and 2000 tons per year for HDPE compound, 6000 tons per year for clear PET flake and 2000 tons per year for multi-coloured PET flake. New recycled products for 2005 include bollards, decking and fencing.

So why do we recycle? The economic benefits are clear: cheaper feed stocks are obtained, competitive advantage is gained, and end-use manufacturers are not at the mercy of resin producers. In addition there is a legislative drive from Government on green procurement and businesses that fail to recognise this will lose out.

The public benefits of the St Helens plant can be briefly summarised as follows. The plant provides a convenient UK-based facility as a practical alternative to export for Local Authorities. It is the only plant in the UK equipped to process batches of mixed bottles thus reducing the need for prior segregation of waste streams. There is increased throughput of segregated materials, and for manufacturers a 50% saving on costs of primary raw materials. It also provides an alternative source of supply for other manufacturers of recycled products.

An outline specification of the St Helens plant provides some idea of the economic and social importance of this activity in helping to reach UK and EU eco-environmental targets at the same time as running a profitable business from a site with a relatively small footprint.

The annual throughput is now 20,000 tons of mixed bottles. Forty staff are employed to maintain the continuous operation of the plant for 24 hours a day, seven days a week, which is the target for 2005. The whole plant covers only 100,000 square ft. It is fully registered as a site for handling domestic waste. It is also certified to ship processed material to the Far East and is registered with the Environment Agency to issue Packaging Waste Recovery Notes (PRN'S). These are designed to ensure that industry takes full responsibility for packaging wastes generated as a result of their commercial activities.

The achievements of Delleve so far include the diversion of 1000 tons of bottles from export to the UK for processing here; 120 million bottles have been converted into products sold in the UK; 15.2 million bottles have been imported from Europe for processing here to compensate for the shortage of plastic waste resulting from export of UK bottles to the Far East. This is a successful business doing a valuable job in reducing waste delivered to landfill which is increasingly restrictive, and in helping to maximise the re-use of valuable and expensive raw materials.

In discussion the following points were made:

The UK has now become a net importer of energy for the first time, hence plastic waste could provide a source of high quality fuel to help fill the gap. Plastic waste can be mixed with lower grade waste to provide an effective fuel for incineration. Battersea Power Station could become London's incinerator. Dioxins generated from plastic incineration are only one tenth of the amount generated on Guy Fawkes night. This view was vigorously contested as a dreadful waste of a valuable resource. It might soon be economically desirable to commence mining landfill to recover polymers, methane and plastics. Plastic waste should be buried as remanufactured pipe having 100 years of useful life, not as rubbish. It is a finite resource and just takes some effort to process.

So what do we do now? More recycling should be encouraged, aided by identification of the plastic type used at the manufacturing stage to enable better separation of waste streams. The current practice of exporting most of this product overseas may solve the problem of disposal for local authorities, but may not be in the longer term national interest. Fraud has impacted negatively on the market for waste. Post-consumer plastic waste is a strategic resource with many valuable end uses.

UK Plastics Industry basic statistics			
Material processed	4.8 million tonnes		
Processing sales turnover	£13.6bn		
Value of direct exports	£3.6bn		
People employed	190,000		
Total number of firms	over 5,000, most very small		
UK Plastics Consumption by Market Sector			
Packaging	36%		
Building & Construction	23%		
Electrical & Electronic	11%		
Automotive and other transport	8%		
Furniture	5%		
Leisure	4%		
Housewares	3%		
Agriculture	3%		
Medical	2%		
Mechanical Engineering	2%		
Clothes & Footwear	1%		
Others	3%		
UK Plastics Consumption by Polymer Type			
ABS	235kt	PET	235kt
EPS	57kt	PP	764kt
HDPE	544kt	PS	260kt
LDPE	1002kt	PVC	777kt

Overview of UK Plastics Industry – the British Plastics Federation *(see page 6)*