PLASTICS AND THE ENVIRONMENT

RECYCLING HANDBOOK

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Malaysian Plastics Manufacturers Association

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Foreword

Disposal is the final stage in a product's life cycle and the beginning of the waste management process. Plastics being used in everything from medical products to beverage containers make up a part of all waste generated in Malaysia.

There are only two options when a consumer disposes of a plastic product: 1) proper plastic disposal that results in it being placed in a landfill or 2) improper disposal, otherwise known as littering.

Throughout many parts of the country, communities are grappling with the same problem: how to dispose of their waste in an efficient, economical and environmentally sound manner.

With available landfill capacity decreasing and public opposition making new facilities difficult to sight, existing municipal landfills are now becoming a "resource" well worth conserving. Many experts now agree that landfills should only be used for solid waste that cannot be managed in any other way. They also agree that no single technology or approach will resolve the waste problem.

It is important to understand that effective waste management is a process of resource management. When we recycle, reuse, and compost waste, we are giving valuable materials another life of usefulness. Reusing, Recycling, and especially Reducing the amount of household, yard, office, and business waste makes real sense. Waste reduction and recycling provide effective alternatives to the unhappy financial and environmental costs associated with waste disposal by incineration or burial.

This Handbook is in your hands because the Government, businesses and individuals who support local recycling want to provide the public with the latest recycling information. This easy-to-understand guide is designed for Malaysians of all ages.

This Handbook has been published because we realise that we are learning all the time and our actions or inactions may have unforeseen consequences in the health of our environment, our country and our planet.

They say that it takes a tiny drop of water that leads to a river. We hope that this Handbook will lead to a better and cleaner environment.

Committee
Malaysian Plastics Forum

CHAPTER

1

Introducing Plastics

The word plastic is derived from the words plasticus (Latin for "capable of moulding") and plastikos (Greek for "to mould," or "fit for moulding").

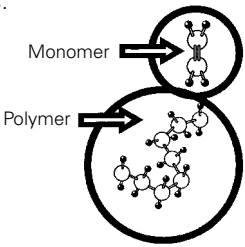
The first man-made plastic was unveiled by Alexander Parkes at the 1862 Great International Exhibition in London. This material, which the public dubbed Parkesine, was an organic material derived from cellulose that once heated could be moulded but that retained its shape when cooled.

At more or less the same time, but independently, an American, John Wesley Hyatt, experimented with cellulose nitrate as a substitute for ivory in the manufacture of billard balls and laid the foundation of the technology of celluloid. In spite of its flammability, availability of alternative materials, its use declined.

In 1907, chemist Leo Hendrik Baekland, while striving to produce a synthetic varnish, stumbled upon the formula for a new synthetic polymer originating from coal tar. He subsequently named the new substance "bakelite". Because of its properties as an electrical insulator, bakelite was used in the production of high-tech objects including cameras and telephones. It was also used in the production of ashtrays and as a substitute for jade, marble and amber. By 1909, Baekland had coined "plastics" as the term to describe this completely new category of materials.

How Plastics are Made

Plastics are polymers, that is, large molecules that consist of long repeating chains of smaller molecules known as monomers.



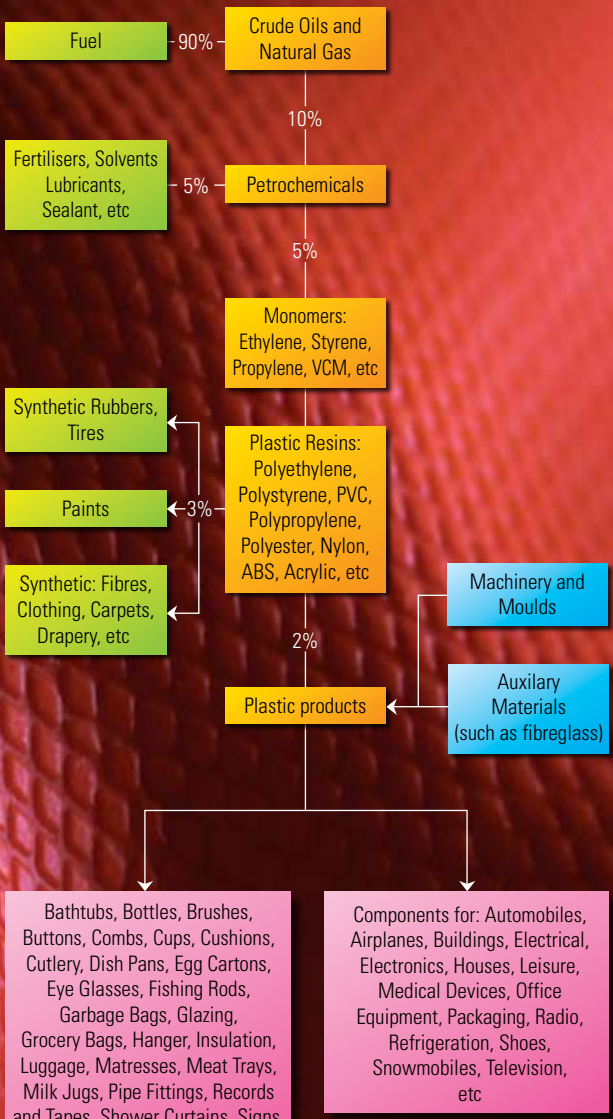
Structure of Monomer and Polymer Diagram

Oil and natural gas are the major raw materials used to produce plastics. Plastics production begins by heating components of crude oil or natural gas using a process called polymerisation, where many thousands of monomers are chemically joined to form a polymer chain. The different combinations of monomers yield plastics with a wide range of properties and characteristics.

The technological road from oil field to finished plastic product has numerous fascinating side trips. Here's the route taken in the petroleum-to-plastics process:

1. Petroleum is drilled and transported to a refinery.
2. Crude oil and natural gas are refined into ethane, propane, hundreds of other petrochemical products and of course, fuel for your car.
3. Ethane and propane are "cracked" into ethylene and propylene, using high-temperature furnaces.
4. Catalyst is combined with ethylene or propylene in a reactor, resulting in "fluff," a powdered material (polymer) resembling laundry detergent.
5. Fluff is combined with additives in a continuous blender.
6. Polymer is fed to an extruder where it is melted.
7. Melted plastic is cooled then fed to a pelletiser that cuts the product into small pellets.
8. Pellets are shipped to customers.
9. Customers manufacture plastic products by using processes such as extrusion, injection moulding, blow moulding, etc.

TYPICAL LIFE CYCLE OF THE PLASTIC MATERIAL



CHAPTER

3

Characteristics of Plastics

There are two main types of plastics; thermosets and thermoplastics.

Thermosets

Thermoplastics

- Permanent once moulded; they do not deform under heat.
- Valued for its durability and strength and are used primarily in the automotive and construction industry.
- Examples of product applications are: ski boots, toys, furniture, coating for electrical circuits, etc.

- Melt under heat and can be reformed repeatedly.
- Offer versatility and a wide range of applications. It is widely used for packaging because it can be rapidly and economically formed into any shape required to fulfill the packaging function.
- Examples include mineral water bottles, agricultural film, automotive bumpers, microwave containers, sheeting for electrical cables, credit cards, etc.

Each plastic has very distinct characteristics, but most plastics have the following general attributes:

1. **Plastics can be very resistant to chemicals.**

   Consider all the cleaning fluids in your home that are packaged in plastic. The warning labels describing what happens when the chemical comes into contact with skin or eyes or is ingested, emphasises the chemical resistance of these materials.

2. **Plastics can be both thermal and electrical insulators.**

   A walk through your house will reinforce this concept. Consider all the electrical appliances, cords, outlets and wiring that are made or covered with plastics. Thermal resistance is evident in the kitchen with plastic pot and pan handles, coffee pot handles, the foam core of refrigerators and freezers, insulated cups, coolers and microwave cookware. The thermal underwear that many skiers wear is made of polypropylene and the fiberfill in many winter jackets is acrylic.

3. **Generally, plastics are very light in weight with varying degrees of strength.**

   Consider the range of applications, from toys to the frame structure of space stations, or from delicate nylon fiber in pantyhose to Kevlar, which is used in bulletproof vests.

4. **Plastics can be processed in various ways to produce thin fibers or very intricate parts.**

   Plastics can be moulded into bottles or components of cars, such as dashboards and fenders. Some plastics stretch and are very flexible. Other plastics, such as polystyrene and polyurethane, can be foamed. Plastics are materials with a seemingly limitless range of characteristics and they have many inherent properties that can be further enhanced by a wide range of additives to broaden their uses and applications. The resulting plastics may be moulded or formed to produce many kinds of products with application in many major markets.

Types of Plastics

Polyethylene Terephthalate (PET) is clear, tough and has good gas and moisture barrier properties making it ideal for carbonated beverage applications and other food containers. The fact that it has high use temperature allows it to be used in applications such as heated pre-prepared food trays. Its heat resistance and microwave transparency make it an ideal heated film. It also finds applications in such diverse end uses as fibres for clothing and carpets, bottles, food containers, strapping, and engineering plastics for precision-moulded parts.

High Density Polyethylene (HDPE) is used for many packaging applications because it provides excellent moisture barrier properties and chemical resistance. However, HDPE, like all types of polyethylene, is limited to those food packaging applications that do not require an oxygen or CO_2 barrier. In film form, HDPE is used in snack food packages and cereal box liners; in blow-moulded bottle form, for milk and non-carbonated beverage bottles; and in injection-moulded tub form, for packaging margarine, whipped toppings and deli foods. Because HDPE has good chemical resistance, it is used for packaging many household as well as industrial chemicals such as detergents, bleach and acids. General uses of HDPE include injection-moulded beverage cases, bread trays as well as films for grocery sacks and bottles for beverages and household chemicals.

Unplasticised Polyvinyl Chloride (uPVC); Plasticised Polyvinyl Chloride (pPVC) has excellent transparency, chemical resistance, long term stability, good weatherability and stable electrical properties. Vinyl products can be broadly divided into rigid and flexible materials. Rigid applications are concentrated in construction markets, which include pipe and fittings, siding, carpet backing and windows. PVC's success in pipe and fittings can be attributed to its resistance to most chemicals, imperviousness to attack by bacteria or

micro-organisms, corrosion resistance and strength. Flexible vinyl is used in wire and cable sheathing, insulation, film and sheet, floor coverings, synthetic leather products, coatings, blood bags and medical tubing.

Low Density Polyethylene (LDPE); Linear Low Density Polyethylene (LLDPE) is predominantly used in film applications due to its toughness, flexibility and transparency. LDPE has a low melting point making it popular for use in applications where heat sealing is necessary. Typically, LDPE is used to manufacture flexible films such as those used for dry cleaned garment. LDPE is also used to manufacture some flexible lids and bottles, and it is widely used in wire and cable applications for its stable electrical properties and processing characteristics.

Polypropylene Copolymer (PP-CO); Polypropylene Homopolymer (PP-HO) has excellent chemical resistance and is commonly used in packaging. It has a high melting point, making it ideal for hot fill liquids. Polypropylene is found in everything from flexible and rigid packaging to fibres for fabrics and carpets and large moulded parts for automotive and consumer products. Like other plastics, polypropylene has excellent resistance to water and to salt and acid solutions that are destructive to metals. Typical applications include ketchup bottles, yogurt containers, medicine bottles, pancake syrup bottles and automobile battery casings.

General Purpose Polystyrene (GPPS); Expanded Polystyrene (EPS); High Impact Polystyrene (HIPS) is a versatile plastic that can be rigid or foamed. GPPS is clear, hard and brittle. Its clarity allows it to be used when see-throughability is important, as in medical and food packaging, in laboratory ware, and in certain electronic uses. EPS is commonly extruded into sheets for thermoforming into trays for meats, fish and cheese as well as into containers such as egg crates. EPS is also directly formed into cups and tubs for dry foods such as dehydrated soups. Both foamed sheet and moulded tubs are used extensively in take-out restaurants for their lightweight, stiffness and excellent thermal insulation.

Polymethyl Methacrylate (Acrylic) Acrylics are known for their crystal clarity and excellent weatherability. The "Acrylics" group of plastics includes several materials, but the most commercially important is Polymethyl Methacrylate (PMMA). PMMA has many general properties which include excellent weathering resistant particularly to UV light, impact resistant, thermal resistance, chemical resistance and flammability. Acrylics are used in a range of markets which include food handling trays, tail and indicator lamp lenses in automobiles, baths and basins, skylights and advertising displays, medical disposables, magnifying lenses, etc.

Acrylonitrile-butadienne-styrene (ABS) is an ideal material wherever superlative surface quality, colorfastness and luster are required. ABS is readily modified both by the addition of additives and by variation of the ratio of the three monomers Acrylonitrile, Butadiene and Styrene: hence grades available include high and medium impact, high resistance and electroplatable. Because of its good balance of properties, toughness/strength/temperature resistance coupled with its ease of moulding and high quality surface finish, ABS has a very wide range of applications. These include domestic appliances, telephone handsets, computer and other office equipment housings, lawn mower covers, safety helmets, luggage shells, pipes and fittings. Because of the ability to tailor grades to the property requirements of the application and the availability of electroplatable grades, ABS is often found as automotive interior and exterior trim components.

Polycarbonate (PC) is one of the most widely used engineering thermoplastics. Transparency, excellent toughness, thermal stability, good dimensional stability are some of the properties of PC. Compact discs, riot shields, vandal proof glazing, baby feeding bottles, electrical components, safety helmets and headlamp lenses are all typical applications for PC.

CHAPTER

5

Plastics Waste

This section will introduce the:

- Common types of plastics waste generated in Malaysia.
- Classification of plastics waste based on type or origin.
- Handling or treatment of plastics waste based on classification or origin.

The Malaysian plastics industry practise reuse of plastics waste as part of its efforts to minimise waste, therefore the various types and handling methods of plastics waste has a bearing on the eventual re-usage of these wastes.

Recycled plastics are developed into many household and industry products like tables, chairs and pails. Recycled plastics are not used in food contact applications.

CLASSIFICATION OF PLASTICS WASTES IN MALAYSIA

Plastics wastes in Malaysia are divided into two major groups – post-consumer (household waste) and post-industrial wastes (industry or factory waste), which are classified into five different groups. The following table showcases the various class of plastics waste, its source, reuse factors and post-application:

Classification of Waste	Source	Reuse Factors Application	Post-use
Primary Industrial Wastes	– Resin production of PS and PVC that supplies mainly reactor sludge and crusts discarded products. – Granulated and primary processing which supplies raw materials coming from processing machinery cleaning operations or from certain processing phases (such as resin or colour changes) as well as plastics that cannot be recycled during processing. – Secondary procreating: scraps from mouldings, lamination and thermoforming processors.	Medium to good quality and a relatively homogeneous composition making it economically viable.	Pipes and tubes.
Mixed Consumer Wastes	– Old and discarded consumer items such as houseware, appliances, toys, furniture, PVC sheets, diapers, packaging items, shoes, etc.	Contaminated, and in order to recover and reclaim them, it is necessary to use more complex recycling machines thus considered to be time-consuming and non-economical in terms of operation procedures, waste collection and separation problems.	

Classification of Waste	Source	Reuse Factors Application	Post-use
Well-Defined Industrial and Agricultural Waste	– **Industry** Sacks and drums from the chemical industry (mainly HDPE, PP and PVC), plastic containers and synthetic fibre scraps from the textile industry (polyamide and polyesters) packaging boxes for bottle handling and transport, shrink film from the industrial and food industry, PVC and PE cable insulation sheaths. – **Agriculture** Mulch film in plantations and farm areas, fertilisers, sacks, nets and boxes.	An important resource for recycling business.	Used for the processing of lower value-added products such as shoe soles, knee-tops, sandals, agriculture nursery and rubbish trash bags.
Long-Life Building and Automotive Waste	– Mainly water tanks (glass reinforced polyester resins), PVC pipes and fittings, electrical switches (thermosetting resins), PS/PP water cisterns, PS light diffuses and PVC wall papers.		
Short-Life Application Waste	– Plastic products classified under this category include consumer packaging and disposable items such as shopping bags, food wrappers, PVC/EPS bottles and containers, etc.		

DISPOSAL OF PLASTICS WASTE BASED ON CLASSIFICATION

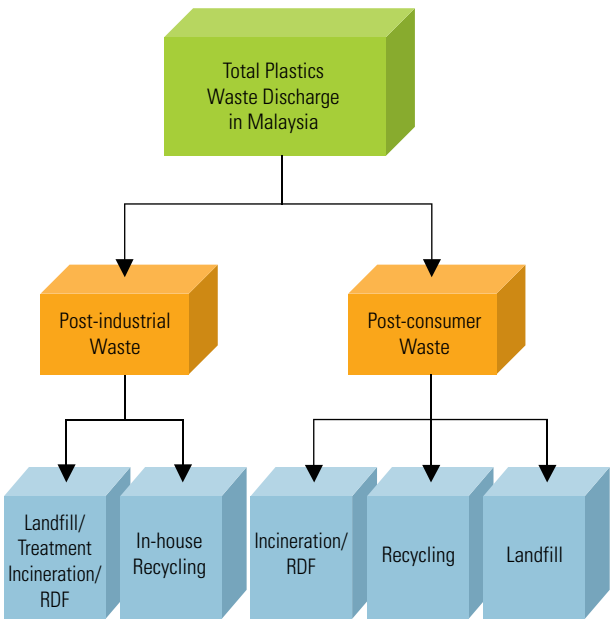
Post-industrial wastes originates from moulders, converters, packers and resin manufacturers. It is usually clean and easy to identify because it is from a single source.

In Malaysia, most injection moulding converters and film converters have in-house recycling and recycle their scraps by using granulators or mechanical recycling. The crushed materials are then used up immediately by mixing with virgin resin of the same type. Plastics manufacturers who don't have their own crusher and extruder facilities to recycle these wastes sell their scraps to recyclers for reprocessing.

Post-consumer wastes are referred to as wastes from discarded consumer items. It is a mixture of plastics and consists of a wide variety of resins which are usually contaminated in nature. These wastes are separated manually and then crushed into flakes before washing and drying. The flakes are then pelletised.

The following table highlights the various treatment of plastics waste:

FLOWCHART OF PLASTICS WASTE IN MALAYSIA



CHAPTER

6

Recycling

This section will introduce the various recycling activities currently practised in Malaysia.

RECYCLING AND RECOVERY ACTIVITIES IN MALAYSIA

Plastics recycling enable reuse and reproduction of other products that extends the life-cycle of the material resource. In Malaysia, mechanical or conventional recycling is widely practised by the industry and large volumes of plastics wastes or rejects are being reused by blending with virgin plastic material to produce new, useful and marketable products. Most plastics injection moulding moulders recycle their scraps by using granulators or mechanical recycling.

TYPES OF RECYCLING PRACTISED IN MALAYSIA

Conventional recycling (mechanical recycling) is successfully practised by recycling companies which collect industrial scrap and reprocess them through activities of sorting, cleaning and repelletising using an extruder to produce uniform pellets. It is then sold to the plastics industry for production of new products. But the plastics recycling industry is still experiencing limited success due to the limited domestic supply of post-consumer plastics. There is also the difficulty in segregating plastics waste as the use of labeling of plastics products is not widely practised. In addition to that, there is poor domestic demand and few economic incentives to encourage the growth of the recycled plastic market.

At present, there are three main methods in the management of plastic wastes, besides land filling:

1. Mechanical recycling
2. Feedstock recycling
3. Energy recovery

Other forms of recycling such as feedstock recycling and energy recovery is still lacking in Malaysia because of the high capital investment involved.

Feedstock recycling is a process that breaks down polymer molecule into petrol chemical feedstock or products that can be used to make new plastics of high quality, whereas energy recovery is a self-combustion of plastics waste to recover plastics-derived fuel as energy for electricity and power-generation.

Mechanical recycling is limited by the low purity of the wastes and the limited market for recycled products. Furthermore, recycled polymers have commercial applications only when the plastics waste have been subjected to a previous separation by resin; and recycled plastics wastes can only be used in undemanding applications.

CHAPTER

7

Profiles

MPMA

MPMA, established in 1967, is a progressive trade association providing leadership and quality service to its members and the plastics industry. MPMA is the official voice of the Malaysian plastics industry, representing its members and the industry in Government interaction, spearheading the plastics industry's growth and providing the platform to assist members to be globally competitive.

MPMA currently has about 900 members which represent about 60 percent of plastics manufacturers in the country and account for 80 percent of the country's total production of plastic products.

ExxonMobil

Headquartered in Kuala Lumpur City Center (KLCC), ExxonMobil is the largest US investor and an active participant in Malaysia's business sector and the local communities in which it operates.

As part of its corporate social responsibility, ExxonMobil is committed to maintaining the highest standards of safety, health and environmental care as it believes that a company's commitment and performance in the area of safety, health and environment is indicative of outstanding performance in other aspects of its operations.
ExxonMobil works collaboratively with government and non-government bodies and community leaders to identify areas of need and how best to meet them. Whilst education has been the main focus, ExxonMobil also supports projects in the areas of welfare, environment and the arts.

ExxonMobil's goal is to achieve excellent environmental performance in each of its businesses to *Protect Tomorrow. Today.* ExxonMobil further seeks to reach its objective to operate responsibly everywhere it does business by implementing scientifically sound and practical solutions that consider the social needs of the communities in which it operates. Accordingly, ExxonMobil seeks to communicate with the public on environmental matters and share its experience with others to facilitate improvements in industry performance.

On the aspects of safety and health, ExxonMobil's policy is to, amongst others, include identification and control of potentially adverse health and safety effects as priority considerations in the planning and development of products and identify and evaluate health risks related to its operations that potentially affect its employees, contractors or the public.

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