OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

This document has been produced without formal United Nations editing. The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Industrial Development Organization (UNIDO) concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries, or its economic system or degree of development. Designations such as “developed”, “industrialized” and “developing” are intended for statistical convenience and do not necessarily express a judgment about the stage reached by a particular country or area in the development process. Mention of firm names or commercial products does not constitute an endorsement by UNIDO.

FAIR USE POLICY

Any part of this publication may be quoted and referenced for educational and research purposes without additional permission from UNIDO. However, those who make use of quoting and referencing this publication are requested to follow the Fair Use Policy of giving due credit to UNIDO.

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org
First Brazilian Congress of the Plastics Industry
São Paulo, Brazil, 2 – 4 February 1983

PACKAGING AND PLASTICS*

by

Desmond A. Dean**

* The views expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO. This document has been reproduced without formal editing.

** Deputy Group Head, Pharmacy, Pisons Limited, Pharmaceutical Division, Loughborough, United Kingdom
Packaging may be defined as the economical means of providing protection, presentation, identification/information, convenience and containment of a PRODUCT during storage, carriage, display and use until such time as the product is removed or used. Fulfilling these functions in the broadest sense will inevitably produce a compromise as emphasis on each of these factors will vary according to the product being packed. The type of packaging material used will also affect this compromise and a subject such as plastics in packaging may be influenced by any of the following:

1. The type of product and the characteristics of the product which can benefit from the use of plastic.

2. The basic characteristics of plastic which can be exploited to the general benefit of packaging.

3. The plastic materials which are most economical to use. This normally covers polystyrene, polyethylene, polypropylene and polyvinylchloride.

4. The negative features of plastic, some of which may now be historical, but must at least be acknowledged and borne in mind if the more overwhelming positive features are to be optimised.

5. The conversion processes associated with containers, components, films and laminations by which the use of plastic can be extended. These may be related to trends in design, processing and decoration methods.

6. The cost advantages of plastics when compared with other alternative materials such as glass, metal or paper-based materials.
7. The pack characteristics. A technological study of the types of pack
and packaging systems available.

8. The environmental issues which may relate to reuse, recycling, the
general conservation of energy and problems arising from disposal and
possible pollution.

The steady growth of plastic packaging not only depends on a balance of all
the above points, but on on-going awareness how each may change, with time.
However, most of these factors interact one with the other, hence many of
the various examples of plastic in packaging which follow cannot be
necessarily isolated as typical of one group. Virtually all products now
benefit from the use of plastics and examples will be taken from food,
pharmaceutical, chemical, agricultural, household, hardware, toiletry and
cosmetic etc., products.

Plastics are found in primary packaging (those items which immediately
close the product), secondary packaging (those items which add to the
presentation and assist in the protection of the pack during warehousing and
distribution) and any ancillary items which add to the convenience of the
product. Indirect uses of plastics must also be included, e.g., hot melt
adhesives, self adhesive and heat seal labels, both of which are plastic
based, and adhesives which may be used in laminations.

However, before expanding on the broad usage of plastic and specific trends
it would be advisable to identify some of the negative features, of which a
few may be restrictive to the use of plastic.
Permeability - all plastics are to some degree permeable to gases and moisture - hence poorer barrier materials may be unsuitable for even lowly moisture or gas sensitive materials.

Limited light exclusion - plastics, unless thick and highly pigmented (carbon black is the most effective) tend to provide only limited screening to light. Note: the addition of U.V. absorbers may assist.

Environmental stress cracking - normally applies to certain grades of low density polyethylene which under stress (in-built or applied) and in contact with certain groups of chemical substances (wetting agents, detergents, some essential oils) may give rise to stress cracking.

Electrostatic attraction - usually of dirt, dust and fibres which in turn may increase the risk of microbiological contamination. Varies according to the nature of the plastic - normally reduced by antistatic additives, earthing, ionic discharge or avoiding handling under dry conditions.

Panelling or Cavitation - whereby a plastic container may partially collapse or indent. It may occur for a number of reasons, i.e.,

1. Hot fill leading to a partial vacuum after closing.

2. "Compression" during capping which leads to a partial vacuum (note this may occur momentarily and only be confirmed by a high speed camera).

3. Adsorption of gases from container headspace - usually related to oxygen.
4. Adsorption and absorption at the inner container wall - leading to swelling or expansion of the wall thus causing distortion.

Impact Resistance
The earlier belief that plastics are unbreakable only broadly applies to selected materials. Plastics such as polystyrene and PVC will crack on impact (say 1 metre drop) unless either modified in some way or produced by a process which improves impact strength (e.g., orientation).

Clarity or Transparency
Only a few plastics have high clarity (like glass). Many tend to be translucent and therefore may not display the product to advantage.

Key of the Print - Pretreatments
Some plastics are difficult to print unless the surface is 'oxidised' to improve the key. This treatment can be achieved by:

(i) Flaming.
(ii) High voltage corona discharge.
(iii) Chemically, e.g., hydrogen peroxide.

Compression and Distortion
As a light-weight material many plastic based materials may become distorted by top pressure as found under conditions of stacking. It may therefore be necessary to increase the compression strength of the outer packaging. Designing a pack with strengthening features (rings/ribs) may overcome such problems.
Adsorption, Absorption and Migration

A two-way exchange can occur between a plastic material and a product, i.e., constituent from the product is lost onto, into or through a plastic or a constituent from the plastic is removed into the product. This may be relevant to foods, toiletries and cosmetics and in particular pharmaceuticals. In the latter case loss of part or all a preservative system may render a product microbiologically ineffective. Migration of constituents from a plastic into a product must be checked for safety (toxicity/irritancy) changes, to flavour or odour, or product changes due to chemical interaction. Some plastics (e.g., LDPE) are particularly permeable to organic odours, hence internal flavourings, perfumes may be lost and external contact with odourous material may be conveyed to the product.

Low Density

This may lead to problems on production lines which are not properly designed to handle plastics, i.e., instability, mushrooming, etc.

Poor Design

Weakness in plastics related to breakage, distortion, indentation, paneling due to compression during capping, compression during stacking etc., may all be related to poor design which in turn may give rise to uneven wall distribution. Angular, square sections will inevitably cause weaknesses and therefore well radiused shapes, radiused angles plus special strengthening features may need consideration. Design features may vary according to the conversion process chosen.
Examples of how some of these adverse affects can be overcome include:

1. A hygroscopic pharmaceutical in a moisture permeable PVC blister pack-
foil sachet overwrap provides five year shelf life until product is
removed when PVC remains adequate even against a high RH.

2. A veterinary product in a collapsible multidose LDPE flask which allows
pack to collapse as doses are withdrawn via a special syringe - again
in a foil sachet. This prevents loss of preservative, moisture and the
ingress of oxygen which could cause product deterioration.

3. A pharmaceutical product which if packed in a squeeze (LDPE) bottle
would suffer loss from the preservative system. A blister overwrap
with peelable backing retained the preservative system, reduced
moisture loss and acted as a pilfer-proof system.

The writer considers it important that problem areas in plastic packaging
are clearly identified, as a problem recognised is usually half way to
having a problem solved. The above therefore provides a check-list of what
could occur. It is equally important to have a check-list on the advantages
of plastic since many of these features are so 'obvious' that they can
readily be overlooked.

**POSITIVE FEATURES OF PLASTIC**

**Light Weight**

The fact that the majority of plastics lie within a density of 0.8 - 2.0
(glass 2.25 - 2.5) and can be moulded in relatively thin sections can
significantly reduce distribution costs for the delivery of raw materials,
supply of packaging 'material' and the distribution of the packed item.

**Lower Volume**

A plastic container will occupy less volume than the equivalent glass bottle (a glass bottle and a PVC bottle of the same external dimensions will hold approximately 75 ml and 100 ml liquid respectively. This advantage may be less with metal but largely depends on the processes used to produce the metal container.

Lower volumes can significantly reduce the space required to store and distribute both the empty and filled container.

This can be even more improved where plastic materials are delivered as reels (form, fill, seal, i.e., blister packaging) or as granules for manufacture into containers immediately prior to a production line operation (selected example - Rommelag Bottlepack equipment that forms, fills and seals a liquid into a container on one machine).

**Flexibility**

Many plastics (thermoplastics) exhibit degrees of flexibility which can be exploited, i.e., squeezing to aid product expulsion, to reduce or adsorb impact or shock, collapsibility (to avoid air being drawn in during use, e.g., bag in box for wine, plasticised PVC bags for blood or IV solutions).

Many other areas can be quoted when flexibility adds to the presentation, e.g., overwraps or bags for vegetables, clothing, confectionary etc., many of which have become so accepted that they virtually go unnoticed. Plastic liners for drums are another useful example.
**Water Resistance - low water permeability**

Since most plastics are water repellent, plastics can be used for external storage (sacks of fertiliser) or as a protective overwrap to pallets (shrink, stretch or prestretched wraps). Such systems will also increase the stacking strength of fibreboard (protected from moisture extremes from the atmosphere) and further restrict moisture loss or gain between the product and the outside atmosphere. Internal plastic coatings or loose linings in fibreboard, metal containers etc., does enable wet goods, such as frozen fish, to be handled more economically without interaction with the external material. For metallisation of films - see under 'Appearance'.

**Low Toxicity/Irritancy Risks**

Although much has been written on the migratory nature of certain constituents in plastics (plasticisers from PVC) there are few reported cases where migratory constituents have caused difficulties. For example, the vinyl chloride monomer saga whilst clearly establishing the dangers of high monomer concentrations at the plant, risks from any packaging usage have remained extremely low. Today Europe and the USA work at a VCM limit of less than 1 ppm for any packaging usage. Many constituents in plastic tend to be non migratory unless a specific solvent is the contact material. Constituents such as antistatic additives, lubricants and slip additives etc., which are only effective if they are present at the surface of the plastic although removable by abrasion as well as extraction are normally only present at low levels. Provided plastic formulations are chosen with recognised food grade substances, risks associated with toxicity/irritancy are usually minimal. Special clearance procedures are obviously advised for plastics containing blood or I.V. solutions since these products are administered directly into the blood stream. Extra test procedures are also
advised for eye preparations. Pigments likely to be toxic, based on for example lead, cadmium, arsenic etc., are now avoided for foods, pharmaceuticals, cosmetics, toiletries and toys. Moulding processes may dictate the presence of certain processing aids.

**Versatile Moulding and Design Capabilities**

The fact that plastics can be fabricated and moulded by a wide range of processes (injection, reaction injection moulding (RIM), injection blow, extrusion blow, extrusion rotational moulding, thermoforming, cold forming etc.,) gives flexibility in both design, output and quality capabilities. It is also frequently possible to make shapes and configurations in one piece whereas a similar design in metal could involve several fabrication processes plus assembly.

**Versatility in Decoration**

Decorative appeal can be added to plastic by many means, i.e., labelling (paper, plastic and shrink labels), offset lithography, dry offset letterpress, hot die stamping, (silk) screen, therimage and lettraset, cliché or tampon, gravure, flexography, jet and laser printing and embossing and debossing. Each process may have some limitations - for example gravure, flexography, offset litho and silk screen can be used on film or sheet based materials printed in the flat or from a reel. The fact that the cliché or tampon process can actually print in three dimensions has seen a substantial expansion to this process. Pretreatment or applying a surface wash or lacquer-type coating prior to printing has also given rise to fewer problems from poor ink key. Such protective coatings may also be used after printing to improve resistance to abrasion, product resistance and reduce moisture/gas permeation.
Improved Moisture Vapour and Gas Barrier Properties

As indicated earlier all plastics are to some degree permeable to moisture and gases (note permeability of gases is usually of the ratio 1:4:20 for nitrogen:oxygen:carbon dioxide (i.e., carbon dioxide shows the highest permeability.) Improved control of wall thickness and the more selective use of materials and processes has meant that more products can be packed in plastic provided the turnover/shelf-life is acceptable to the product. It should be noted that a good moisture barrier material may not necessarily be a good gas barrier material. Moisture barrier properties for some plastics are given comparative figures below.

Aclar* (polymonochlorotrifluoroethylene) 0.01
$ 20,000 per tonne
(*trade name Allied Chemical Company)

PVdc (polyvinylidene chloride) 0.1
copolymer $2,500 per tonne

HDPE (high density polyethylene) 1.0
$ 900 - $ 1,250 per tonne

PP (polypropylene - copolymer) 1.5
$ 900 - 1,250 per tonne

LDPE (low density polyethylene) 3.0
$ 900 - 1,250 per tonne
PVC (polyvinyl chloride unplasticised) 8.0
$ 900 - $ 1,250 per tonne

PS (polystyrene) 72.0
$ 900 - $ 1,250 per tonne

Adar, PVdc, PVC and HDPE have good oxygen barrier properties whilst LDPE, PP and PS are considerably inferior.

Adar (Allied Chemical Co) although the most inert and impermeable plastic is also the most expensive. Other than a coating for pharmaceutical blister packs it has few commercially viable packaging applications. The total economics recommending the use of any one plastic are dependent on many additional factors, i.e., density, moulding cycle, (temperature/cooling), moulding process, design, capital expenditure etc., as no decision should be taken on polymer price alone.

Versatility in Appearance - colour, clarity, opacity, texture etc.

Plastics can be produced which are clear, completely opaque, have metal finishes (metallised), opalescent, marbled etc., with a whole range of textures from high gloss, matt, artificial leather etc. Light penetration can be restricted by pigmentation (carbon black being the most effective), dyes and the use of UV absorbers. Metallisation may be used for decorative effect or to reduce permeability to moisture. Metallisation can be a relatively variable process hence the barrier properties achieved have to be critically evaluated. A metallised PET coated with LDPE to give scuff resistance can offer barrier properties approaching that of 9 μm foil. Scuff resistance can however be poor if a protective layer is not included. (PET = polyester) Metallised materials are finding success in bag-in-the-box applications (e.g., wines).
Opaque materials are available in a wide range of colours. White opaque may be obtained by the use of fillers such as chalk or talc, whiteners (titanium dioxide 1 - 3% level) and modified by optical brighteners (e.g., ultramarine). Colouring can be carried by precompounding, dry colouring, liquid and solid master batching and concentrates or high let-down master batching.

Fillers, depending on their affinity for moisture can either increase or reduce moisture permeation. This applies to other constituents; for example plasticisation of PVC can cause a significant increase in moisture permeation.

**Versatility in Material Modification to Assist Certain Properties**

**Examples:**

Stackability and stability (will not slide so readily) can be improved with plastic sacks if an anti-slip additive is incorporated into the material.

Reel fed form fill seal operations can be improved if friction and drag (possibly leading to stretch) is reduced by the addition of a slip additive.

Circumstances could however be envisaged where the above two features are in conflict with each other.

The incorporation of lubricants into the polymer can assist a moulding operation and lead to less rejects or generally improve the overall quality of the item being moulded.
Reuse of Clean Scrap i.e., regrind

Scrap for moulding processes (tops and tails from extrusion blown bottles, sprue and runners from injection mouldings) if handled cleanly can be recycled provided it is permitted and has not been subjected to excessive (e.g., overheating) conditions. Regrind up to a defined level, e.g., 20% is frequently allowed.

Product Resistance

Although plastics cannot be described as inert and lack the high level of compatibility enjoyed by glass, plastics exist which can be used for a majority of products (for example plastic petrol tanks are currently becoming a distinct trend). Few problems exist with many aqueous-based products provided they are not strongly acid or alkaline. Greater selection has to be exercised with organic-type solvents, volatile oils and synthetics generally. Vegetable oils, for example, which are widely sold in PVC would not be suitable for storage in LDPE where both oxidation and penetration of the oil through the container could occur.

Easily altered so that Specific Properties can be more readily exploited

This can occur by both physical and chemical means. Physically, plastics can have their molecular structure orientated in a machine and/or cross direction by a process of stretching at a temperature below the material melting point. Orientation in films provides a shrink wrap material unless the film is held and heated to 'set' the in-built stretch. Newer processes known as injection stretched blow and extrusion stretch blow involve a stage where the parison is cooled and stretched (orientated) prior to the final blowing operation.
Orientated materials show improvement in both physical and chemical properties, i.e., improved clarity, impact (drop) resistance and lower moisture and gas permeability. The highest success (USA and Europe) is found in PET (polyester) stretch blown bottles in the 1 - 2 litre size for carbonated drinks. PVC and PP are also being used. Bottles shapes currently have some restriction with the base which may either be 'petalled' or rounded. In the latter case a base cup has to be added to give stability.

Stretch blown PVC bottles are usually cheaper and more resistant to drop (impact) than a conventionally blown impact modified grade. The addition of an impact modifier to PVC (normally up to 15% of vinyl acetate) is a further example of how the properties of a plastic can be changed. Straight PVC is likely to shatter if dropped together with product at a 1 metre drop height. The addition of the modifier overcomes this problem. Impact modified PVC will also thermoform faster, at lower temperatures, and give better distribution than an unmodified material. However, the addition of vinyl acetate will increase permeability to moisture.

Although additives are the group of substances used to modify a plastic, it should be recorded that plastics, in terms of total constituents may also contain residues and processing aids. Since terminology in the industry tends to be rather loose it may be necessary to ask questions on additives, residues and processing aids from the polymer supplier, compound/master batch supplier and convertor, if the detail on the total constituents is to be obtained.
The more commonly found constituents include:

- monomer residues
- catalyst
- accelerators
- solvents
- anti-oxidants
- emulsifiers
- mould release agents, lubricants
- fillers
- colourants - pigment and dyes
- stabilisers (PVC)
- plasticisers - modifiers
- extenders
- slip additives
- antislip additives
- antistatic agents
- whiteners and opacifiers
- UV absorbers
- flame retardants
- antiblock agents
- release agents

Reference to many of the above are found throughout the text.
Undue publicity and emphasis on plasticisers has frequently lead to misuse of this word, particularly as many less informed people see plasticisers as being migratory, possibly toxic and found in most plastics. Relatively few plastics (the main ones are plasticised PVC and the cellulose group (acetate, butyrate, propionate etc.) contain plasticisers. However, the question, 'does the plastic contain plasticisers', should frequently be addressed to the word 'additive'.

Most Plastics Can be 'Welded' by One Means or Another

More important with engineering applications but may occasionally be used in a packaging context. Methods of welding include hot gas, hot plate, high (or radio) frequency, adhesives, 'spin' and friction, and ultrasonic.

Coextrusion and Lamination

For film and sheet material the properties of two or more plastics can be combined by multiple extrusion or lamination. These materials, depending on their thickness, can be used for sachets, strips, blisters, tubes, solid phase pressure forming (SPPF), scrapless forming process (SFP), conventional thermoforming or directly coextruded and blown into a container.

The above list, although not complete, clearly established both the flexibility and versatility of plastics and the processes associated with them. Many of these plus features can be combined to the general benefit of plastic packaging. Since packaging is inevitably a compromise of many factors, the earlier listed negative factors can either be overcome by selecting the plastic (e.g., a LDPE with a low melt flow index will
normally eliminate a stress cracking risk), by preventative measures (e.g., using additional protective packaging to reduce risks associated with permeation of moisture, oxygen etc.), process controls or by simply accepting that the positive features outweigh any disadvantages.

A number of examples of specific package or pack component usages are identified below to emphasise the effective utilisation of plastic.

**Closure Systems**

1. **Wadless Closures**
   A range of wadless closures are now widely used on metal, plastic and glass containers for solid and liquid products. The materials used include LDPZ, HDPE and PP. The seal part of the closure can be achieved by a plug, an internal skirting, sealing rings or a curled-over feature.

2. **Pilfer Resistant Closures**
   Again, a similar range of plastics are used. Designs include lock-on bead with tear-off skirt, ratchet bottles with interlocking tear-off skirt, or heat shaped under lock with screw-off perforated tear caps (e.g., Obrist closure) or caps with perforated extensions which lock on bottle with lugs etc. Heat shrinkable (PVC) seals provide an alternative means of pilfer resistance.

3. **Child Resistant Packs and Closures**
   Virtually all reclosable child resistant packs are based on plastic, with squeeze, press down, line-up features being widely utilised to achieve release.
In the case of blisters and strips child resistant is achieved by hidden access features, in between unit perforation or by the strength of the material used. Opaque or deep tinted materials are essential to make the contents less attractive to children.

4. Overwrapping, Collation, Pallet Stabilising
Shrink, stretch, prestretch stretch wraps are being increasingly used to stabilise pallets, overwrap packs and items (either for purpose of collation or to reduce general spillage, or simply to make the product self-identifiable (recognition) or to encourage more responsible handling of semi-fragile goods.

5. Closures - General
An increasing proportion of plastic closures are moving from thermosets (UF and PF) to thermoplastics (PS, PP, HDPE). Whereas years ago a wide range of waddings and facings were used these are gradually reducing in number. Composition cork is largely being replaced by pulpboard, expanded polyethylene and flowed-in compounds. The most widely used facings include PVdC, polyester, vinyls (reducing) and polyethylene (reducing).

Sprinkler top closures (widely used for powders and at one time all in metal) have gradually been replaced by plastic.
Dispensing fitments for spirits, pouring aids for medicines and difficult to control products, and general dropper systems for food colourants, sweetening liquids etc., are further extending the use of plastics.
Plastic toggle caps are an extension of dispensing aids in that the caps contain spouts or tubes for controlling the flow of a product from a squeezable plastic container.

Container Trends
To overcome the poor size impression of single walled plastic jars when compared with the thick walled glass jars then available, double shell plastic jars became the vogue in the late 50's, early 60's. A recent ruling in the UK argued on the deceptive nature of double walled jars, has made the single walled smaller jar virtually acceptable overnight. Single walled jars are now widely available in HDPE, PP, PS although the latter material may be suspect for creams where moisture losses can be problematical.

The plastic can - 1/4 litre bottles in polyester (PET) and PVC with a wide neck have recently been introduced as a further competitor to the metal can and glass bottle beverage containers.

Plastic Drums
Increasingly stringent safety regulations for the carriage of dangerous goods and chemical substances generally are encouraging the use of fairly thick walled plastic drums with high molecular weight, high density polyethylene being the preferred material. Drums of this nature have good impact resistance (including drop strength) good stacking strength, good chemical resistance and although some degree of chemical absorption may occur this is usually extremely small. However, if drums are reused it is always advisable to refill with the same material.
Films, Foils and Laminates

The use of plastic films and coatings is showing continuous growth with a predictable expansion in the future due to the more recent success of retort pouches. As a laminant ply plastic can play a variety of roles covering heat sealing and cold sealing, protective plies giving product, climatic and biological protection and as a decorative ply to aid presentation.

Collapsible tubes made from laminates are now showing a fairly rapid growth.

The more widely used heat sealing plies include LDPE, ethylene vinyl acetate (EVA), polymers modified with EVA, PVdC. Surlyn (ionomer DuPont) and a range of heat seal coatings. Surlyn in spite of its higher cost has seen considerable success in Europe and the USA as it shows advantages on lower weight, caliper of ply, lower sealing temperatures, a wider temperature sealing range, sealability in contact with product contamination in seal (both powders and liquids) all of which lead to fewer rejects and higher output speeds.

For clarity, polyester, cellulose acetate (poor in dimensional stability) certain gauges and grades of polypropylene and for a protective over laquer (against rub and permeation) PVdC provides a useful coating base.

Coextrusion can provide higher barrier properties by the selection of the correct material provided relatively long runs are involved. Coextrusions materials can be used to make bottles, thermoformings etc. Typical coextruded materials include:-
PS/PE, PS/PP, PS/PE/PS (medium barrier materials), and

HIPS/PS/PVdC/PS
HIPS/PS/PVdC/PE
PS/Eval/Pe
PP/PVdC/PP
PP/Eval/PP

**Films**

Polypropylene film is still finding increasing usage as a laminate ply, as an overwrap material replacing cellulose films, and as a form fill seal material for bags, sachets etc. The brittle nature of PP at lower temperature is overcome by copolymerisation usually with ethylene. This addition improves its heat sealability. Coated PP using either a PVdC or PE coating also gives a good heatsealing and protective lamination. LLDPE - linear low density polyethylene, which is a combination of ethylene with either butene-1, octene-1, is a relatively new family of polymers which according to all accounts will largely replace LDPE as a film material in the near future. LLDPE also shows certain advantages over LDPE for other applications involving injection and extrusion moulding. Although the initial cost of LLDPE may be slightly higher than LDPE, the fact that it can be made in thinner gauges with good impact, tensile and tear resistance makes it economically viable for stretch wraps, bin liners, bags etc. Large usage is already being seen in the USA, Canada, Japan and Europe.

Bubble film (film containing bubbles of air) is being increasingly used for product protection. Polyester, nylon and polypropylene strapping is widely replacing metal strapping.
Form Fill Seal

Reel fed processes which then pass through a series of stages whereby a material is formed into a container which is subsequently filled and sealed are on the increase. As well as the better known thermoforming processes (vacuum, pressure forming with and without plug assistance) forming at lower temperatures (to give orientation) and cold forming are now finding specific applications. Both the food and pharmaceutical industries are using a cold forming process for such material as nylon/foil/PE, polypropylene/foil/PVC and nylon/foil/PVC. These materials enable a fairly thick gauge (40 μm) of foil to be stretched without perforation provided the form is well radiused and not too deep and angular. The formings give virtually 100% protection against moisture and gases and can be used for a retortable tray pack with the correct material combination.

From a pharmaceutical point of view cold formed blisters are not only competitive with foil strip packs but occupy less space, are easier to handle and provide a similar high level of moisture protection.

Conventional pharmaceutical blister and strip packs for solid dosage forms vary considerably in their usage throughout the world, i.e., less than 5% in the USA, approximately 20% in the UK and approximately 80% in Germany.

Whilst the latter mainly use blister packs of the push-through type, the USA relies on peelable liddings. These conventional blisters use UPVC, and combinations of UPVC/PVdC, PVdC/PVC/PE, PP/PE, PVC/Aclar as the thermoforming ply with paper and foil heat seal for the peelable or push-through lidding.

However, none give a high level of moisture protection, hence the need for a foil bearing material (strips or cold formed blisters) if moisture sensitive products need to be packed in a unit dose form.
Expanded Plastics

The density of plastics can be further reduced by producing a cellular structure to give an expanded material. Expanded polystyrene is most used, usually to mechanically protect such delicate items as cameras, TV's, videos, either as set formed pieces or as small pieces as a filling. Expanded polystyrene sheets (sometimes laminated to polyethylene) is also used as a protective covering. Plastishield (trade name) coated glass is an excellent example of a marriage between glass and plastic which enables a light weighted glass bottle to withstand impacts on the production line and in transportation.

Expanded materials can also be used to give insulation for products which require specific storage conditions (e.g., vaccines).

Expanded polyethylene is now being widely used as a cap wadding, replacing naturally based composition cork.

OTHER COATINGS

Cold Sealing

A material based on a plastic coating which can be sealed by pressure offers faster throughput for a form fill seal process than one involving heat. Cold sealing materials have therefore been developed and are in use for confectionery sticks and bars.

Labels

Two label types are based on plastic coatings (a) self adhesive labels and, (b) heat seal labels. Both types are extending in use, frequently at the expense of plain paper labels which are applied by the addition of an adhesive (dextrin, starch, PVA etc). Coated labels present advantages in
cleanliness, less machine down time, improved tack and setting time and their ready application to a range of substrates. Both heat sealing and self adhesive labels are available in cut singles and reel fed form. Since the latter indicates a degree of security, reel fed labels now with an additional identity code have become widely used for pharmaceuticals and products where security is essential. In the USA heat seal labels are predominant whereas in Europe self adhesive labels are preferentially used. Application speeds up to 600 labels per minute are now practical with both.

Environmental Issues

The above examples emphasise the extensive usages of plastics in packaging. However, no paper would be complete without reference to certain environmental issues, which may occasionally take on an emotional aspect. Although many plastics are derived from petroleum, it should be noted that the main use of petroleum products are related to transportation and the manufacture of energy whereas conversion to plastics still remains a relatively small percentage. Plastics do suffer criticism when compared with other materials in both energy required to convert them into a packaging application and difficulties associated with reuse and recycling. The attached Table 1, ex Metal Box Company, indicates typical energy comparisons.

Reuse of plastic packaging other than for the larger containers as mentioned previously is not usually recommended, except where circumstances have clearly established that reuse (plastic milk bottles in polycarbonate) is practical. Recycling again is difficult as once a plastic has been used for a product, some degree of contamination may have occurred. There is also a significant difference to the recycling of glass as cullet where the material is reheated to around 1200°C, thus driving off virtually all likely contaminants (other than certain metals) as carbon, hydrogen etc. Plastic
scrap from the converting processes is suitable for recycling provided it is not contaminated by oil, dirt, dust during the conversion process. Whether a plastic is recycled or reground from the conversion scrap largely depends on the final usage - it may not be permitted or limited for food, pharmaceuticals etc.

Recycling is also difficult for a mass of products since individual plastics cannot usually be segregated. Usages for recycled materials therefore tend to look for opportunities where an admixture of plastics can be found, i.e., pallets, corrugated sheets for roofing, cavity wall insulation, etc.

CONCLUSION

The introduction indicated a number of ways plastic and packaging could be considered. These have only been covered on a very broad basis in this paper. Each of the many aspects touched upon could be expanded into a topic which, when discussed in detail, could form a conference in its own right.

It is perhaps reasonable to conclude that every packaging function is a compromise of many factors - whether the compromise reached is the best can only be judged by the functional and aesthetic success which in turn relates to both the initial sell-in and the follow-up sales. The role of plastics in packaging is already a success story and will continue to increasingly dominate the packaging scene. The environmental issues are being closely studied and will ultimately be solved by common sense and logic.

Two final points. First, the above paper places emphasis on the plastics which are already successful and economic. Although expansion tends to develop along such a path, usages for higher priced materials, like polyester, can occur, with a result that the larger volume applications can further reduce the price of the basic material. Many plastics which have not been mentioned, have and will have, packaging applications, particularly
where certain specialised properties are required. Their exclusion from this paper does not mean they have been forgotten, but that time and space has not permitted their inclusion. Secondly, any future developments in the extension to plastic packaging will largely depend on consumer trends and their purchasing power. Europe, the USA etc., have seen two virtually opposing trends, the need to have smaller portion packs to meet the demands of a growing elderly population and the need for larger pack sizes to meet the demands of the less frequent shopper, i.e., shopping done once a month instead of once a week. An acute awareness of such trends is essential to predict any packaging development with constant reference to the definition of packaging given in the introduction.
I am indebted to Fisons plc - Pharmaceutical Division for their support in the production of this paper. The opinions expressed are my own and do not necessarily constitute an indication of Company policy.
Table I: Energy Used in Container Production (Toe*/Tonne)

<table>
<thead>
<tr>
<th></th>
<th>Tinplate</th>
<th>Aluminium</th>
<th>Plastics</th>
<th>Board</th>
<th>Glass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conversion to</td>
<td>0.1</td>
<td>0.2</td>
<td>0.4</td>
<td>0.05</td>
<td>0.1</td>
</tr>
<tr>
<td>Containers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heating and</td>
<td>0.04</td>
<td>0.08</td>
<td>0.16</td>
<td>0.07</td>
<td>0.04</td>
</tr>
<tr>
<td>Lighting</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transport of</td>
<td>0.02</td>
<td>0.02</td>
<td>0.06</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Containers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raw Material</td>
<td>1.0</td>
<td>6.0</td>
<td>2.3</td>
<td>1.45</td>
<td>0.3</td>
</tr>
<tr>
<td>Production</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>1.2</td>
<td>6.3</td>
<td>2.9</td>
<td>1.6</td>
<td>0.5</td>
</tr>
</tbody>
</table>

*Toe = Tonne of oil equivalent

By kind permission of the Metal Box Co
PACKAGING
IS A WORLD-WIDE
GROWTH AREA
MEETING AND
CREATING DEMANDS OF
MARKETING (HOME/EXPORT) AND DISTRIBUTION.

IN THIS GROWTH
PLASTICS SHOULD
ACHIEVE THE GREATEST
BENEFIT.
A DEFINITION

PACKAGING
IS THE

ECONOMICAL MEANS OF PROVIDING

PROTECTION

PRESENTATION

IDENTIFICATION/INFORMATION

CONVENIENCE/CONTAINMENT

DURING

STORAGE

CARRIAGE

USE

DISPLAY

UNTIL SUCH TIME AS THE PRODUCT IS

REMOVED OR USED.
CREATING AWARENESS

PACKAGING AND PLASTICS

1. The type of product and the characteristics of the product which can benefit from the use of plastic.

2. The basic characteristics of plastic which can be exploited to the general benefit of packaging.

3. The plastic materials which are most economical to use. This normally covers polystyrene, polyethylene, polypropylene and polyvinylchloride.

4. The negative features of plastics, some of which may now be historical, but must at least be acknowledged and borne in mind if the more overwhelming positive features are to be optimised.

5. The conversion processes associated with containers, components, films and laminations by which the use of plastic can be extended. These may be related to trends in design, processing and decoration methods.

6. The cost advantages of plastics when compared with other alternative materials such as glass, metal or paper-based materials.

7. The pack characteristics. A technological study of the types of pack and packaging systems available.
8. The environmental issues which may relate to reuse, recycling, the general conservation of energy and problems arising from disposal and possible pollution.
SUCCESS
OF
PLASTICS
DEPENDS
ON
EXCHANGE
BETWEEN
PACKAGING TECHNOLOGY
AND
PLASTICS TECHNOLOGY
-
EXPLOITING TECHNOLOGY
A PROBLEM IDENTIFIED IS
PARTWAY TO A PROBLEM SOLVED

POSSIBLE NEGATIVE FEATURES

PERMEABILITY
LIMITED LIGHT EXCLUSION
ENVIRONMENTAL STRESS CRACKING

ELECTROSTATIC ATTRACTION
PANNELLING OR CAVITION
IMPACT RESISTANCE
CLARITY OR TRANSPARENCY

KEY OF THE PRINT - PRETREATMENTS

COMPRESSION AND DISTORTION

ADSORPTION, ABSORPTION AND MIGRATION

LOW DENSITY
POOR DESIGN
BENEFICIAL USE OF
POSITIVE FEATURES

POSITIVE FEATURES OF PLASTIC

Light Weight
Lower Volume
Flexibility
Water Resistance
Low Toxicity/Irritancy Risks
Versatile Moulding and Design Capabilities
Versatility in Decoration
Improved Moisture Vapour and Gas Barrier Properties
Versatility in Appearance
Versatility in Material Modification to Assist Certain Properties
Reuse of Clean Scrap
Product Resistance
Easily altered so that specific properties can be more readily exploited
KNOW YOUR MATERIALS

CONSTITUENTS IN PLASTICS

ADDITIVES

RESIDUES

PROCESSING AIDS
A REMINDER

CONSTITUENTS

<table>
<thead>
<tr>
<th>Monomer Residues</th>
<th>Antistatic Agents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catalysts</td>
<td>Whiteners and Opacifiers</td>
</tr>
<tr>
<td>Accelerators</td>
<td>UV Absorbers</td>
</tr>
<tr>
<td>Solvents</td>
<td>Flame Retardants</td>
</tr>
<tr>
<td>Anti-oxidants</td>
<td>Antiblock Agents</td>
</tr>
<tr>
<td>Emulsifiers</td>
<td>Release Agents</td>
</tr>
<tr>
<td>Mould release agents, lubricants</td>
<td></td>
</tr>
<tr>
<td>Fillers</td>
<td></td>
</tr>
<tr>
<td>Colourants - pigment and dyes</td>
<td></td>
</tr>
<tr>
<td>Stabilisers (PVC)</td>
<td></td>
</tr>
<tr>
<td>Plasticisers - modifiers</td>
<td></td>
</tr>
<tr>
<td>Extenders</td>
<td></td>
</tr>
<tr>
<td>Slip Additives</td>
<td></td>
</tr>
<tr>
<td>Antislip Additives</td>
<td></td>
</tr>
</tbody>
</table>
OTHER FACTORS/INFORMATION

Most Plastics can be "welded" by one means or another

Coextrusion and Lamination

Closure Systems

Wadless Closures

Pilfer Resistant Closures

Child Resistant Packs and Closures

Overwrapping, Collation, Pallet Stabilising

Closures - General

Container Trends

Plastic Drums - Pails

Films, Foils and Laminates

Films

Form Fill Seal

Expanded Plastics

Composites
FOOD TRENDS

1. ASEPTIC PROCESSING
   REEL FED
   GRANULE FED

2. RETORTABLE PACKS
   TRAYS
   POUCHES

3. MICROWAVE COOKING
   POLYESTER TRAYS
   OVENABLE BOARD
   (BOARD POLYESTER)
SOME NEWER PLASTIC PROCESSES

1. STRETCH AND BLOW

2. SFP
   SCRAPLESS FORMING PROCESS

3. SPPF
   SOLID PHASE PRESSURE FORMING

4. COEXTRUSION
OTHER COATINGS

COLD SEALING

LABELS

ENVIRONMENTAL ISSUES
ENERGY USED IN CONTAINER PRODUCTION (TOE*/TONNE)

<table>
<thead>
<tr>
<th></th>
<th>Tinplate</th>
<th>Aluminium</th>
<th>Plastic</th>
<th>Borex</th>
<th>Glass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conversion to</td>
<td>0.1</td>
<td>0.2</td>
<td>0.4</td>
<td>0.05</td>
<td>0.1</td>
</tr>
<tr>
<td>containers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heating &amp; lighting</td>
<td>0.04</td>
<td>0.08</td>
<td>0.16</td>
<td>0.07</td>
<td>0.04</td>
</tr>
<tr>
<td>Transport of</td>
<td>0.02</td>
<td>0.02</td>
<td>0.06</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>containers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raw material</td>
<td>1.0</td>
<td>6.0</td>
<td>2.3</td>
<td>1.45</td>
<td>0.2</td>
</tr>
<tr>
<td>production</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1.2</td>
<td>6.8</td>
<td>2.9</td>
<td>1.6</td>
<td>0.5</td>
</tr>
</tbody>
</table>

*TOE = Tonne of Oil Equivalent.

by permission of Metal Box Co.
FINALLY REMEMBER THE NEED FOR:

1. INFORMATION EXCHANGE

2. USE OF INFORMATION TO SELECT FUTURE UTILIZATION OF MATERIALS, PROCESSES, DESIGNS, ETC.

3. COOPERATION BETWEEN MARKETING AND PACKAGING TECHNOLOGIES PLASTIC