120 million metric tons of plastic in packaging per year globally

60% of plastics found on beaches

Plastics Packaging

- product protection (performance)
- packaging cost
- usage benefits and
- environmental impact

Monolayer Film:
Plastic Wrap
Shopping Bags

Multi-layer Film:
Pouches and Sachets

- primary packaging—the material that first envelops the product and is in direct contact with the contents;
- secondary packaging—the material that is outside the primary packaging, often used to group primary packages together. Film wrappers around the primary packaging are examples of secondary packaging; and
- tertiary packaging—the material that is used for bulk handling, warehouse storage, and transport shipping. The most common form is a palletized unit that packs into containers.

Ideal Packaging:

Protect product from breakage, spoilage, contamination
Extend shelf-life/usage-life
Safeguard hygiene
Attractable appearance

Minimal material usage
Reduce package size
Reduce weight
Packability

Multiuse

Barrier properties tuned to product

Figure 2.1 Plastic films and bags found in the stomach of a whale stranded at Sotra, Bergen, in January 2017 (the University of Bergen Copyright) [97]. *Photo: Christoph Noever.*

Flexible Packaging:

Usually multilayer

- bulk layers (outer)
- barrier layers
- tie layers
- heat sealable layers

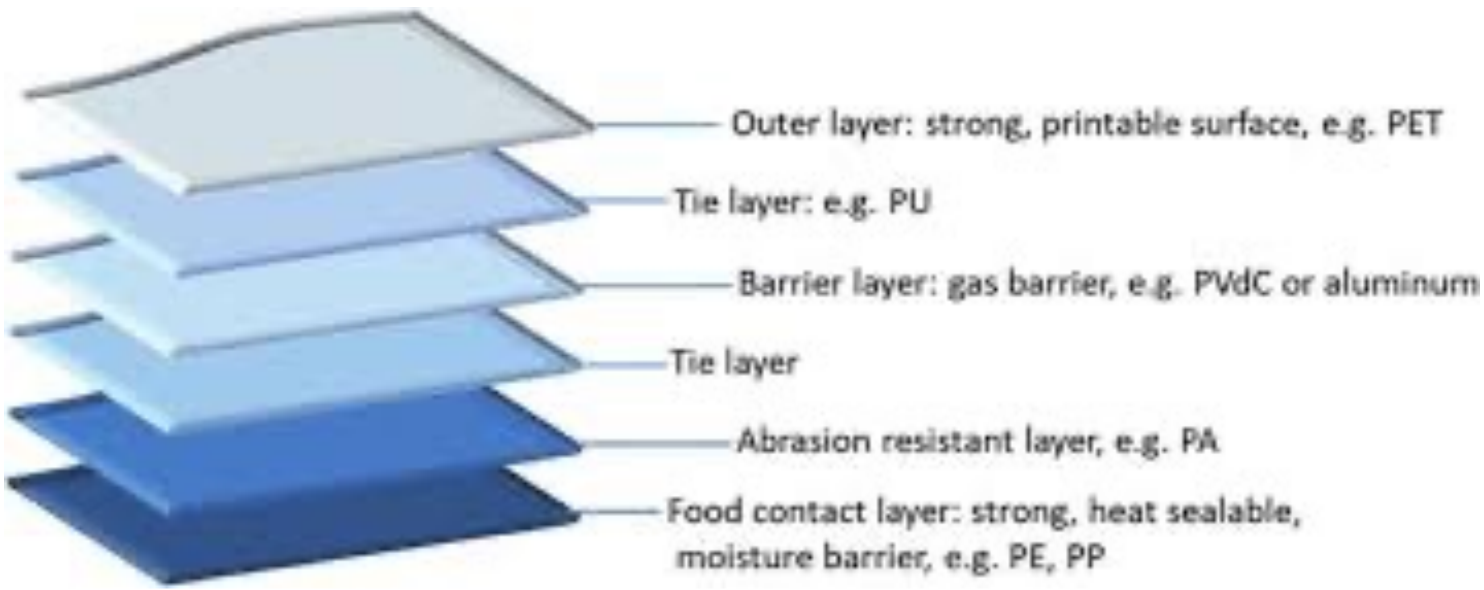


Table 4.1 Common Coextruded (Multilayer) Flexible Packaging Films

Multilayer	**Structure**	**Application**
LLDPE/HDPE/LLDPE	15/70/15	Grocery bags
HDPE/LLDPE/HDPE/EVA	30/30/30/10	Cereal liners
Paper-LDPE-Al-LDPE	Laminated packaging	Liquid/paste packaging (juice, milk cartons)
PET/Tie/LDPE/Al/LDPE	Laminated packaging	Liquid/paste packaging (juice, milk cartons)
LLDPE-Tie-EVOH-Tie-LLDPE		Fresh meat
LLDPE-Tie-PA-Tie-LLDPE	40/5/10/5/40	Fresh meat
LLDPE-Tie-PA-EVOH-PA-Tie-LLDPE	30/5/10/10/10/5/30	Fresh meat
LLDPE-HDPE-Tie-EVOH-Tie-HDPE-LLDPE	20/20/5/10/5/20/20	Processed meat

Al, aluminum; EVA, Ethylene vinyl acetate; EVOH, Ethylene vinyl alcohol; HDPE, High-density polyethylene; LDPE, Low-density polyethylene; LLDPE, Linear low-density polyethylene; PA, Polyamide; PET, Poly(ethylene terephthalate).

Table 4.2 Typical Tie Layer Resins

Tie Layer Resin	Adherent Layer
Ethylene vinyl acetate (EVA)	HDPE, LDPE, PP, PS, PVDC
Ethylene methyl acrylate (EMA)	HDPE, LDPE, PP, PS, PVDC
Ethylene acrylic acid (EAA)	PA, PET, ionomers, LDPE, EVA, EMA, Al
Ethylene-grafted maleic anhydride (AMP)	PA, Al, EVOH, cellulose

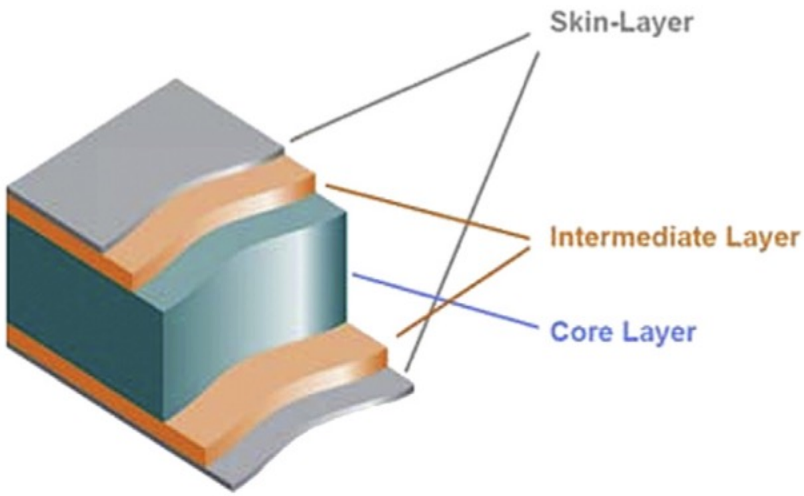


Fig. 16-1 A five-layer film structure.

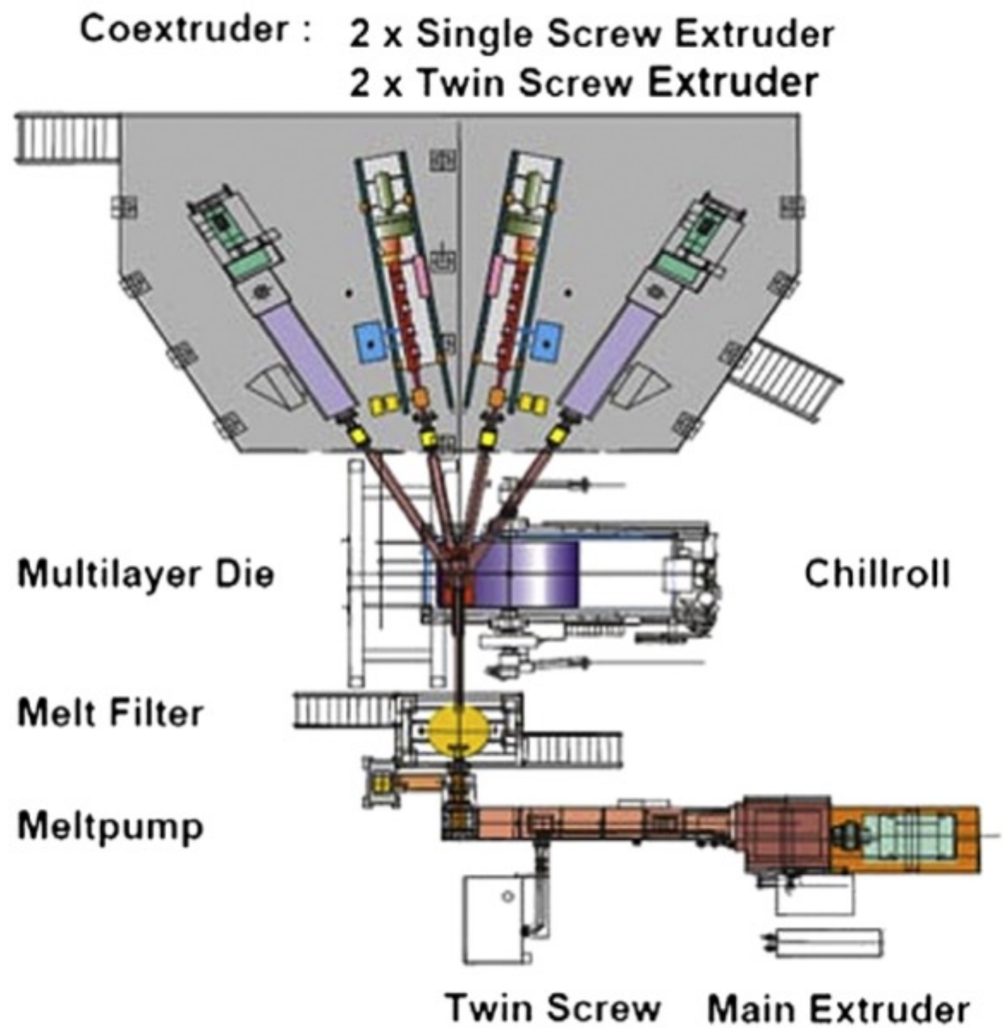


Fig. 16-3 A five-layer extruder configuration.

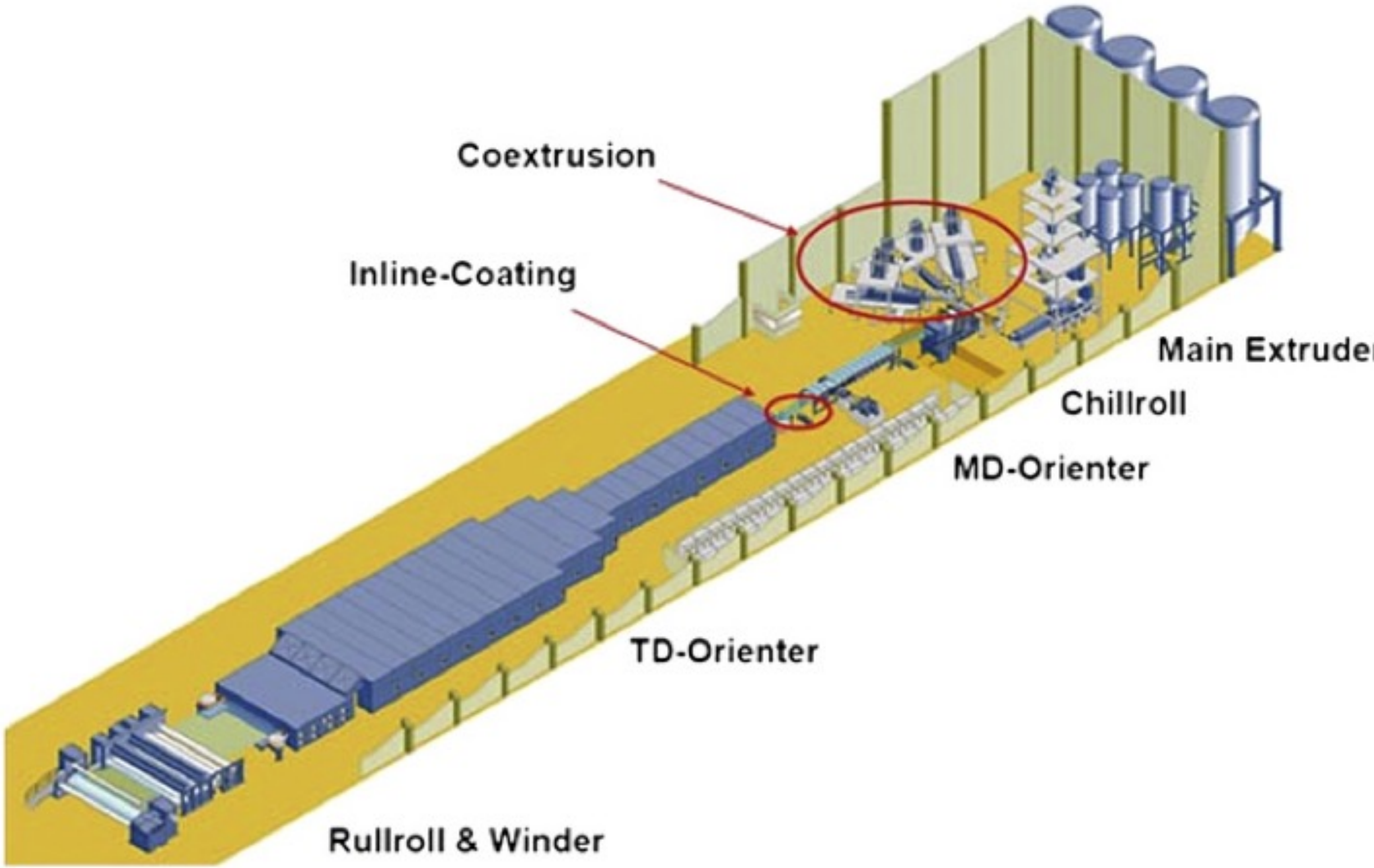


Fig. 16-2 Multilayer structures in Biaxially Orienting Lines.

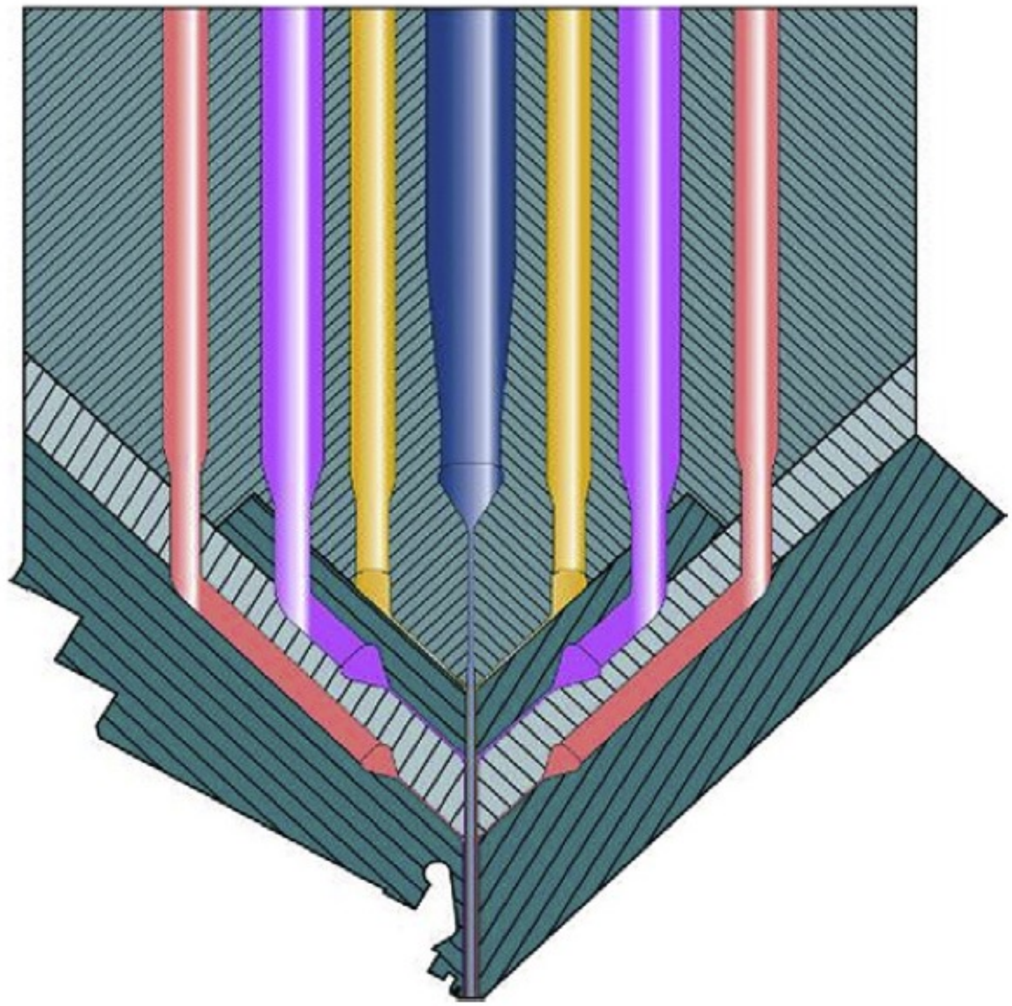


Fig. 16-5 Seven-layer coextrusion die.

Biaxially Oriented Polypropylene Film

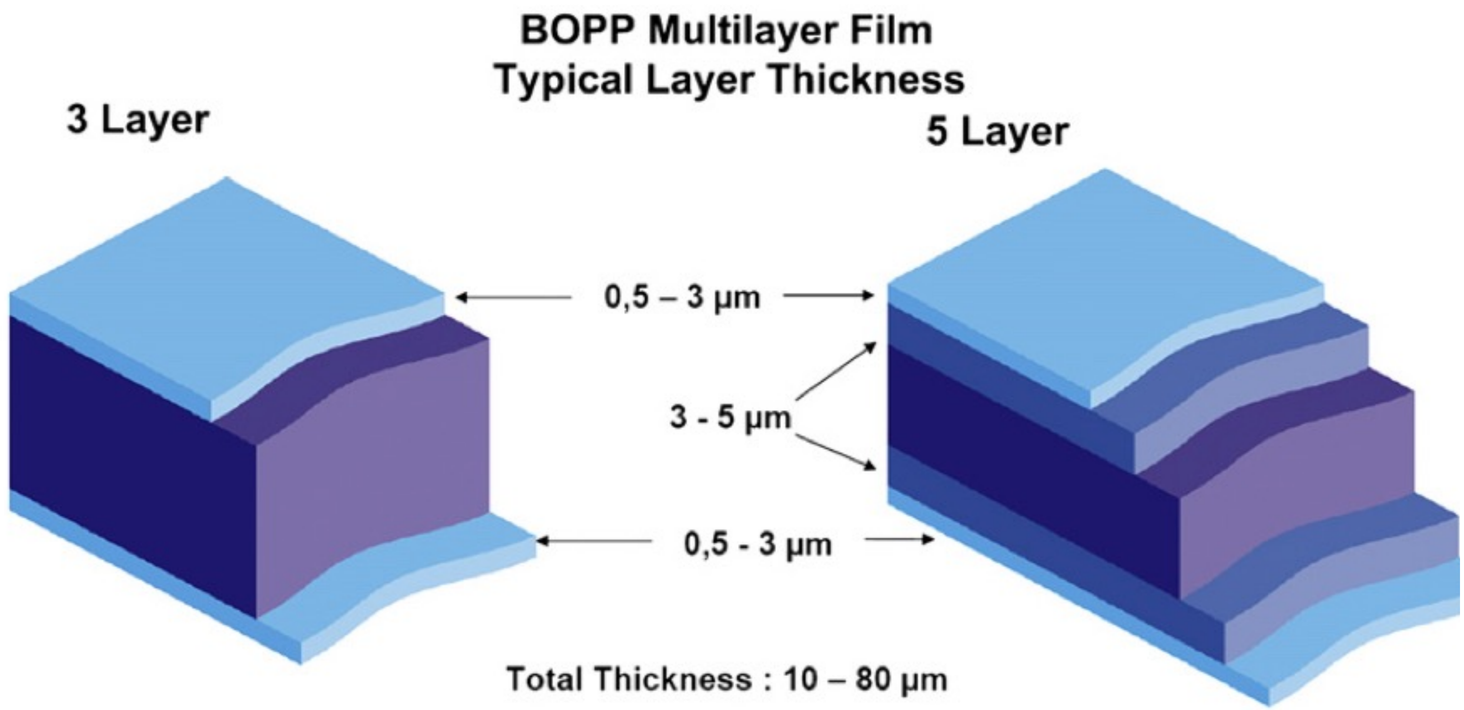


Fig. 16-6 Typical layer thickness of BOPP multilayer film.

Biaxially Oriented Polypropylene Film

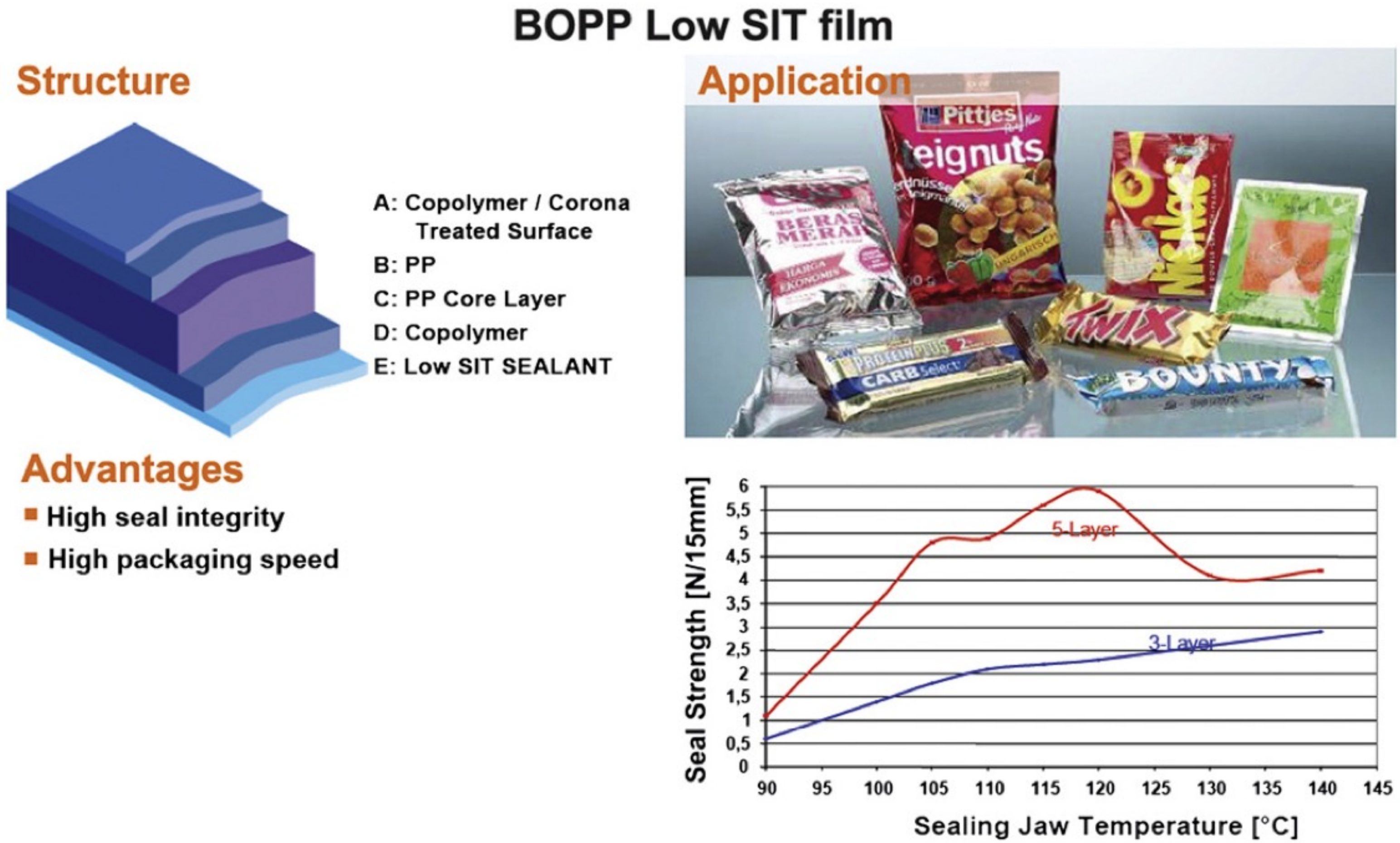


Fig. 16-7 Five-layer low seal initiation temperature (SIT) BOPP film structure advantages, applications and seal strength.

5 Layer Film Applications

Film Type Category	Thickness µm	Examples for End Use Application	
Wrap around labels	35 - 50	White voided film, both side high gloss, one side treated	
Wrap around labels	35	White voided metallized film, High gloss surfaces, very high yield	
Food packaging	35	White voided metallized film, heat sealable, high protection against light	
Food packaging	30 - 50	White voided film, both sides heat sealable, high protection against light	
Business cards Maps, Bags	40 - 80	Synthetic Paper	
Paper Lamination	15 - 40	Matte film	

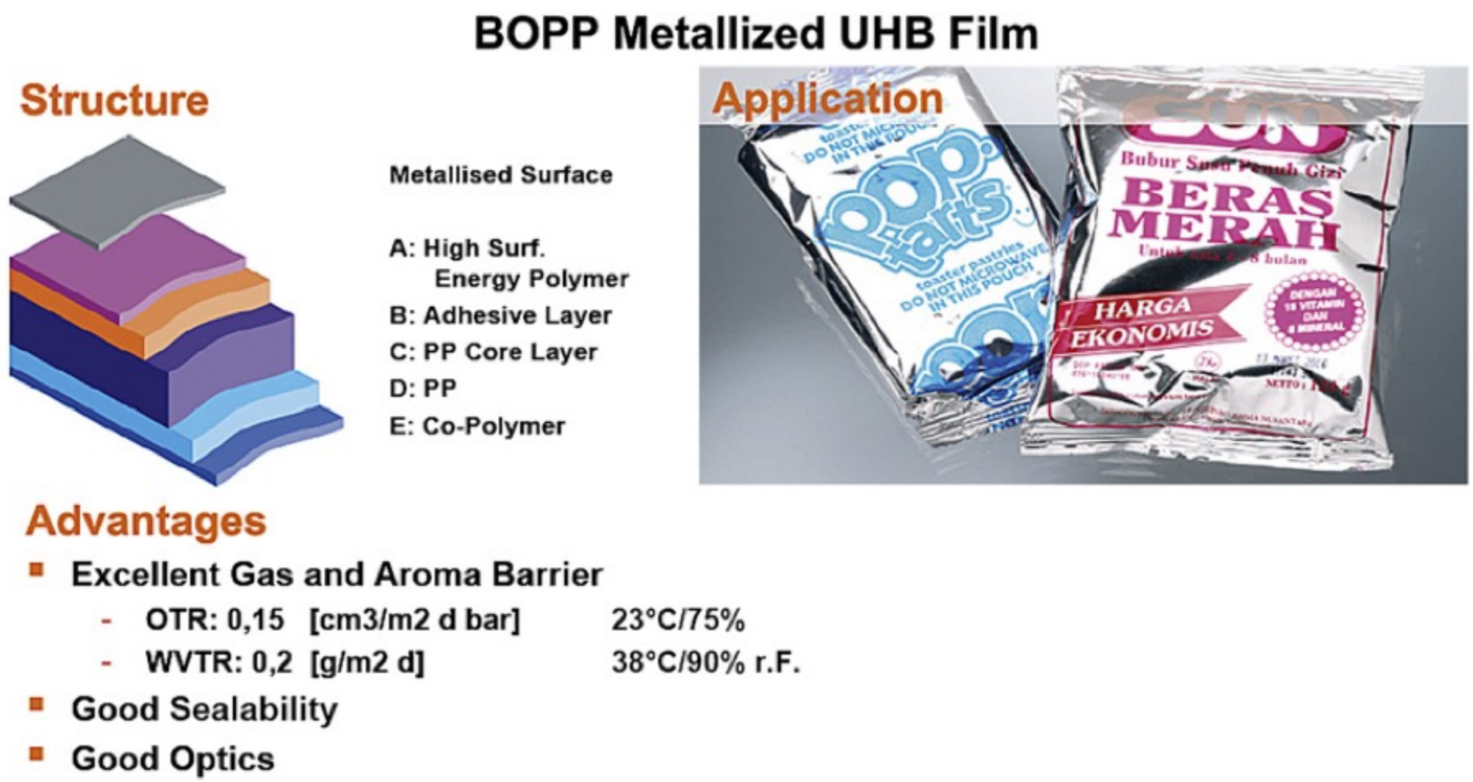


Fig. 16-9 Five-layer metallized UHB BOPP film structure and advantages.

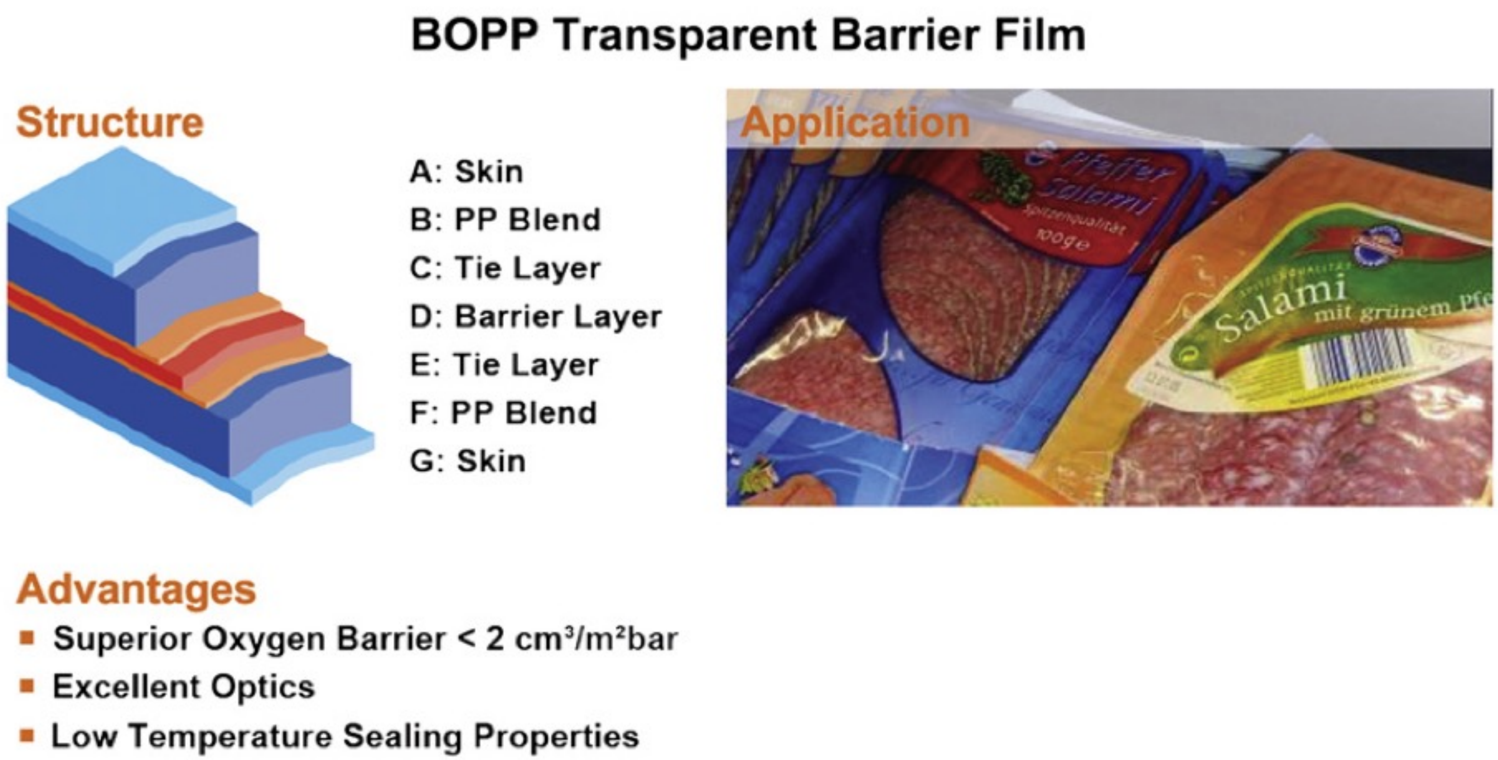


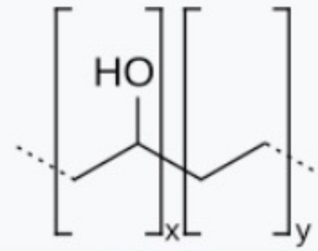
Fig. 16-10 A typical seven-layer configuration.

Ethylene vinyl alcohol (**EVOH**) is a formal copolymer of ethylene and vinyl alcohol. Because the latter monomer mainly exists as its tautomer acetaldehyde, the copolymer is prepared by polymerization of ethylene and vinyl acetate to give the ethylene vinyl acetate (EVA) copolymer followed by hydrolysis. EVOH copolymer is defined by the mole % ethylene content: lower ethylene content grades have higher barrier properties; higher ethylene content grades have lower temperatures for extrusion.

The plastic resin is commonly used as an oxygen barrier in food packaging. It is better than other plastics at keeping air out and flavors in, is highly transparent, weather resistant, oil and solvent resistant, flexible, moldable, recyclable, and printable. Its drawback is that it is difficult to make and therefore more expensive than other food packaging. Instead of making an entire package out of EVOH, manufacturers keep costs down by coextruding or laminating it as a thin layer between cardboard, foil, or other plastics.[1][2]

It is also used as a hydrocarbon barrier in plastic fuel tanks and pipes.

Ethylene vinyl alcohol



Names	
Other names	Ethenol, polymer with ethene
Identifiers	
CAS Number	25067-34-9
ChemSpider	None
CompTox Dashboard (EPA)	DTXSID701010954
Properties	
Chemical formula	$(C_2H_4O\text{-}C_2H_4)_x$

Except where otherwise noted, data are given for materials in their standard state (at 25 °C [77 °F], 100 kPa).

Infobox references

Higher ethylene has lower barrier but lower temp processing

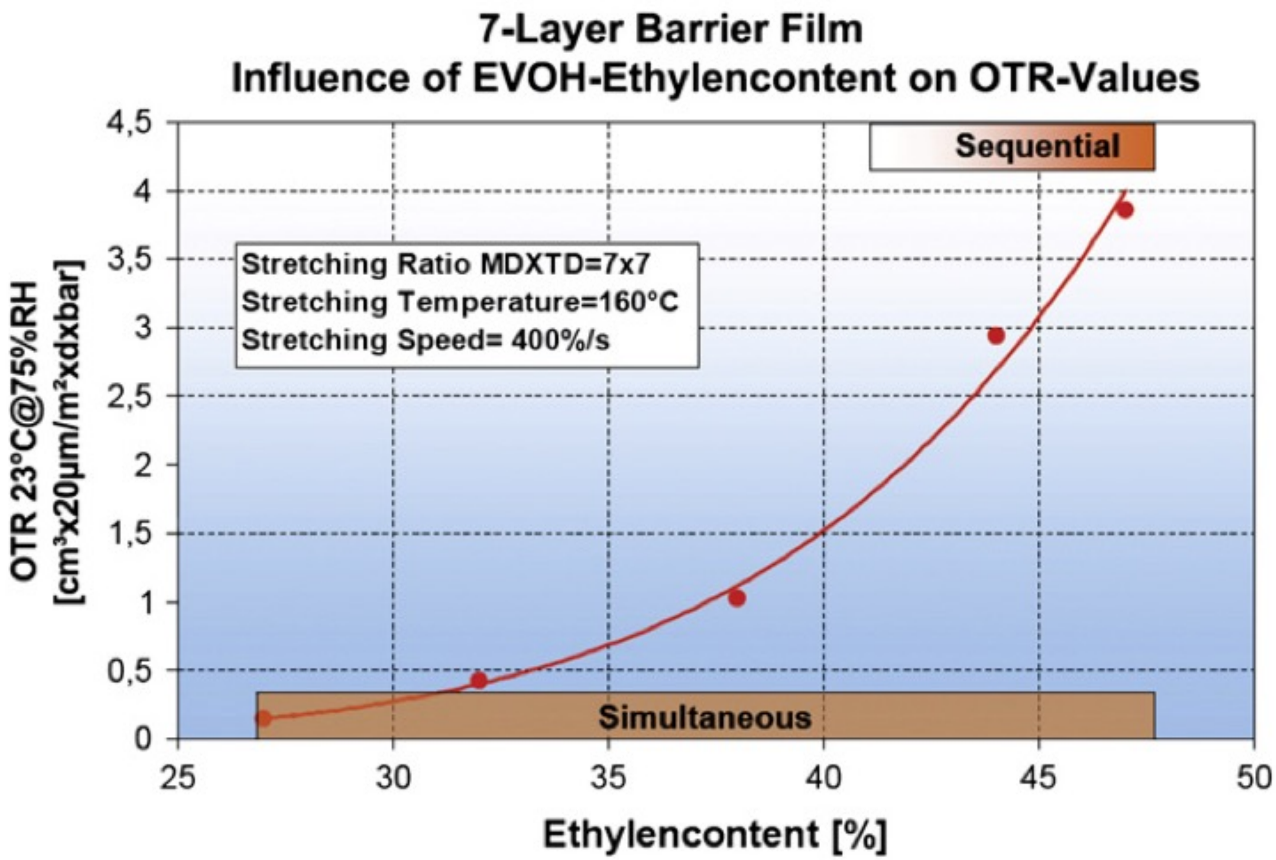


Fig. 16-11 Evaluation of the oxygen barrier with the use of various EVOH types.

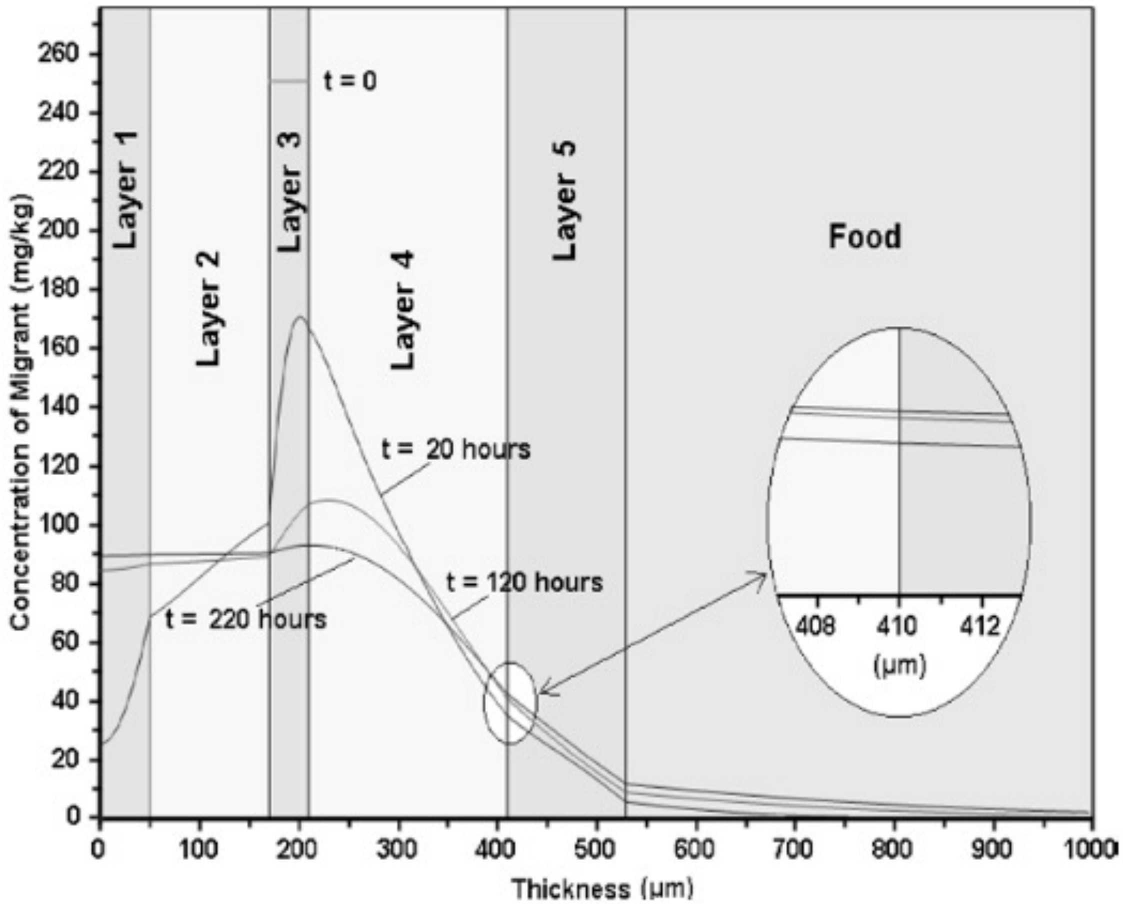


Figure 8.5 Calculated spatial profiles of the concentration for a five-layer system in contact with a highly viscous food.

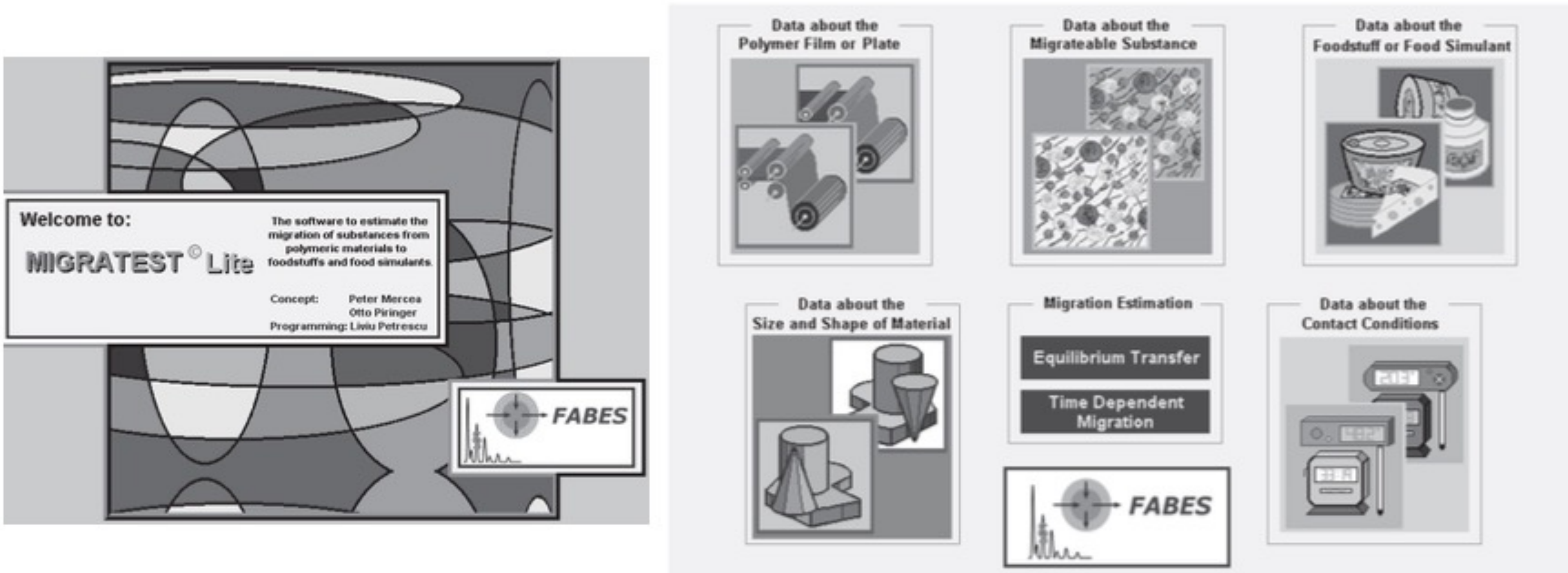


Figure 9.1 The welcome window and main control panel of the software MIGRATEST©Lite.

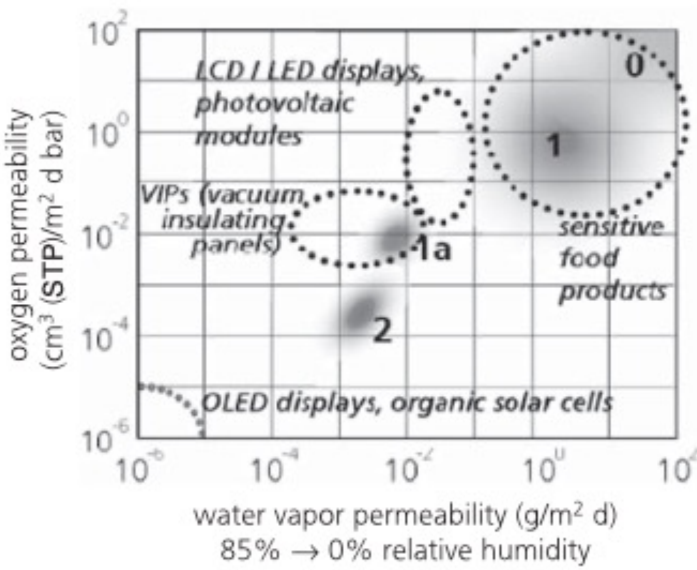


Figure 10.1 Barrier properties as required for different product sectors (dotted circles) and performance of the following encapsulation/packaging materials (shaded areas): (0) polymeric substrates alone, (1) polymeric substrates with one inorganic barrier layer, industrial standard, (1a) polymeric substrates with one inorganic barrier layer, special coating processes, (2) systems with two pairs of inorganic/polymeric layers. Reference temperature: 23°C. After (Langowski, 2003b).

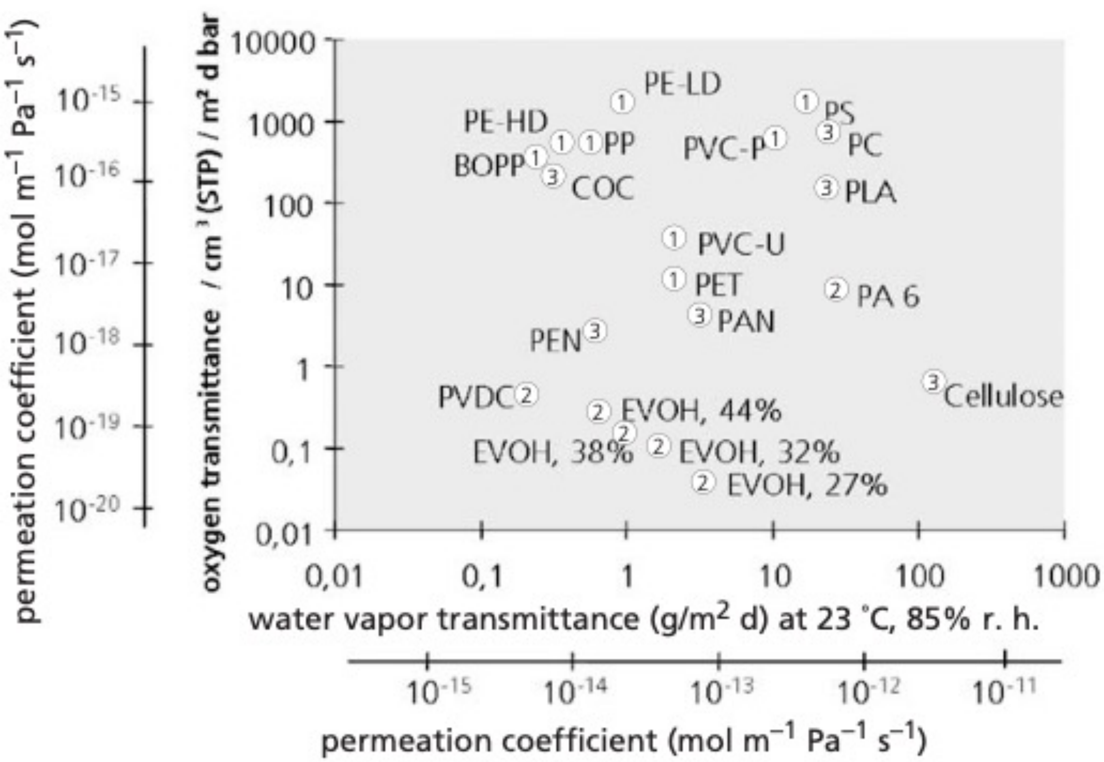


Figure 10.2 Transmittance (i.e., permeability normalized to 100 μm material thickness) for oxygen and water vapor, for typical packaging polymers, at 23°C. Additional scales are shown for permeation coefficients in SI units. ① : Commodity thermoplastics, ② : frequently used barrier polymers, ③ : specialty polymers.

PE-LD	Low-density polyethylene
PE-HD	High-density polyethylene
PP	Polypropylene
BOPP	Biaxially oriented PP
COC	Cycloolefin copolymer
PEN	Polyethylene naphtalate
PET	Polyethylene terephthalate
PAN	Polyacrylonitrile
PA 6	Polyamide 6
PVC-U	Polyvinyl chloride, nonplasticized
PVC-P	Polyvinyl chloride, plasticized
PLA	Polylactic acid
PS	Polystyrene
PC	Polycarbonate
PVDC	Polyvinylidene chloride
EVOH	Ethylene-vinylalcohol copolymer (percentage: fraction of ethylene)
Cellulose	regenerated cellulose hydrate (former name: Cellophane)

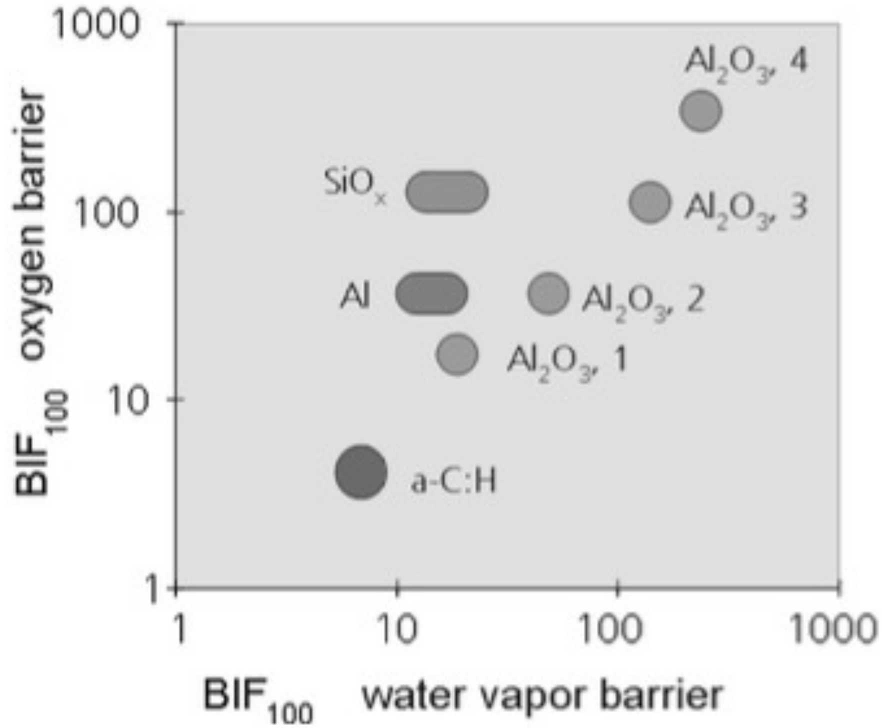


Figure 10.18 Barrier improvement factors BIF_{100} (normalized to 100-μm substrate film thickness), for different layer materials, coating methods and substrates, as shown below. Values for BIF_{100} extend to 370 (for oxygen) and to 230 (for water vapor) (from Langowski, 2003b).

Layer material	Method of coating, substrates
Al	Boat evaporation, onto standard industrial film substrates (BOPP, PET)
SiO_x	Different methods from laboratory to industrial scale (electron beam coating, plasma assisted, plasma assisted chemical vapor deposition, reactive sputtering) onto standard PET and PEN substrate films
a-C:H	Experimental coating with amorphous carbon via plasma assisted chemical vapor deposition, on standard PET film
Al_2O_3, 1	Reactively sputtered aluminum oxide, on standard PET film, Al_2O_3 thickness: 50 nm
Al_2O_3, 2, 3, 4	Reactively sputtered aluminum oxide, on special PET film, Al_2O_3 thickness values: (2): 20 nm, (3): 50 nm, (4): 200nm

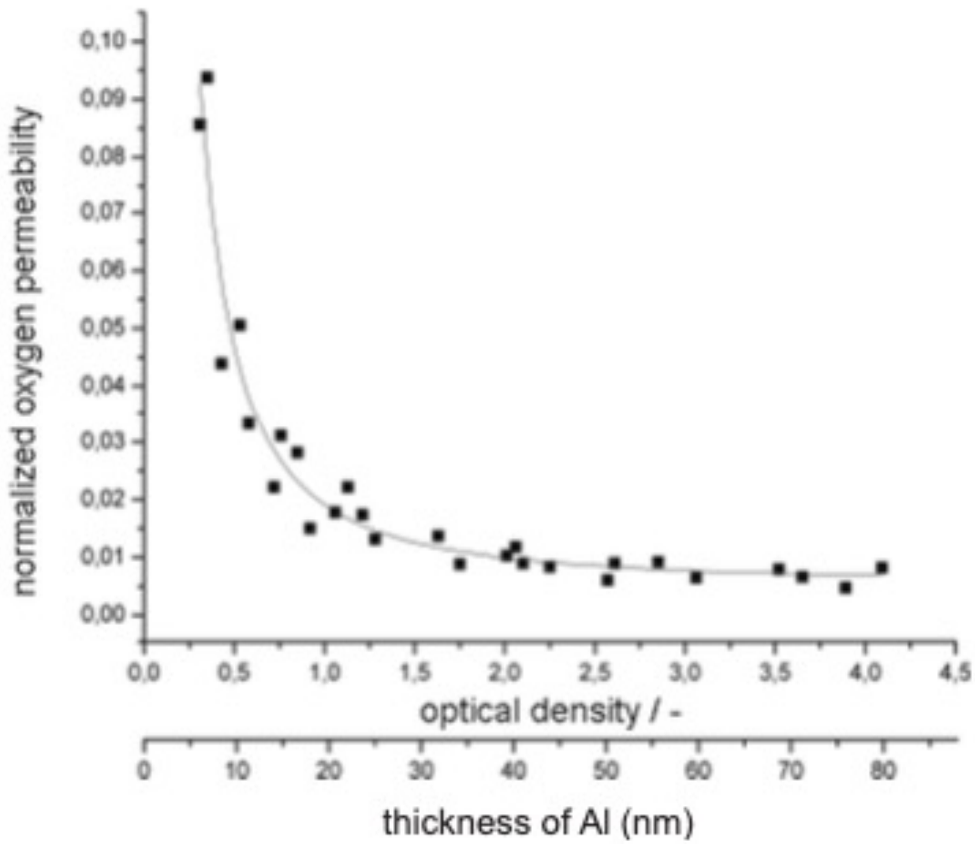


Figure 10.16 Oxygen permeability of a 12-μm-thick PET film coated with Al layers of varying thickness, which is proportional to their optical density. The oxygen permeability has been normalized to the permeability of the uncoated substrate film (from Hanika, 2004).

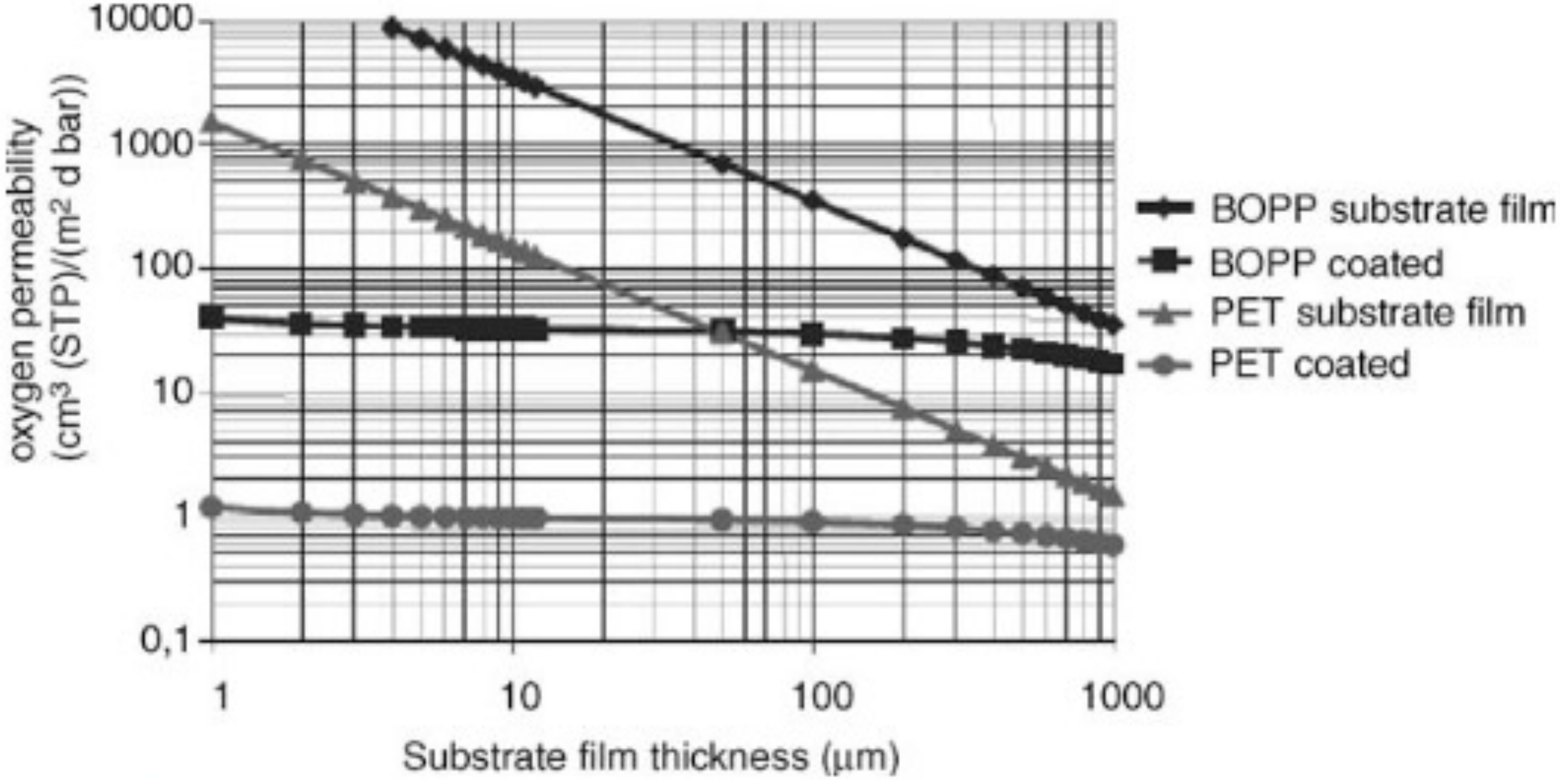


Figure 10.6 Permeability of noncoated substrates and substrates coated with a barrier layer of realistic defect structure, calculated according to Eq. (10.10), shown in dependence on substrate thickness (Source: Fraunhofer IVV, internal results).

Table 10.5 Experimental results for polymers filled with nanoparticles on the basis of exfoliated, surface-modified layer silicate minerals. Reductions of the permeability relative to the unfilled polymer are given as barrier improvement factor (BIF). Where available, aspect ratios and filling grades are indicated, the latter in percent by volume (v/v) or by weight (w/w).

System/authors	BIF for O_2	BIF for water vapor	Filling grade[a] (%) Aspect ratio α	Theoretical value for BIF (Eq. (10.17))
PA 6/synthetic mica (Yasue 2000)	6	3.5	4, w/w	
PET/Na-montmorillonite (Frisk 1999)	6	–	1, v/v, $\alpha = 500$	3,5
	11	–	1, v/v, $\alpha = 1000$	6.1
	18	–	3, v/v, $\alpha = 500$	8.8
	>45	–	$\alpha = 1500$	40.5
EVOH/modified kaolinite (Lagaron, 2005)	4.6	1.3	5, $\alpha = 80$	3.2
PLA/modified kaolinite (Lagaron, 2005)	1.9	1	4, $\alpha = 80$	2.7
PLA/synthetic fluorine mica, organically modified (Sinha 2003)	5.7	–	10 w/w, $\alpha = 275$	16
PI/modified montmorillonite (Yano 2000)	2.5	2.2	2 w/w, $\alpha = 200$	3.1
	13.9	7.2	8 w/w, $\alpha = 200$	9.8

[a] Filling grades in % w/w are often determined from the ash content of the polymer after incineration and thus should be higher in reality.

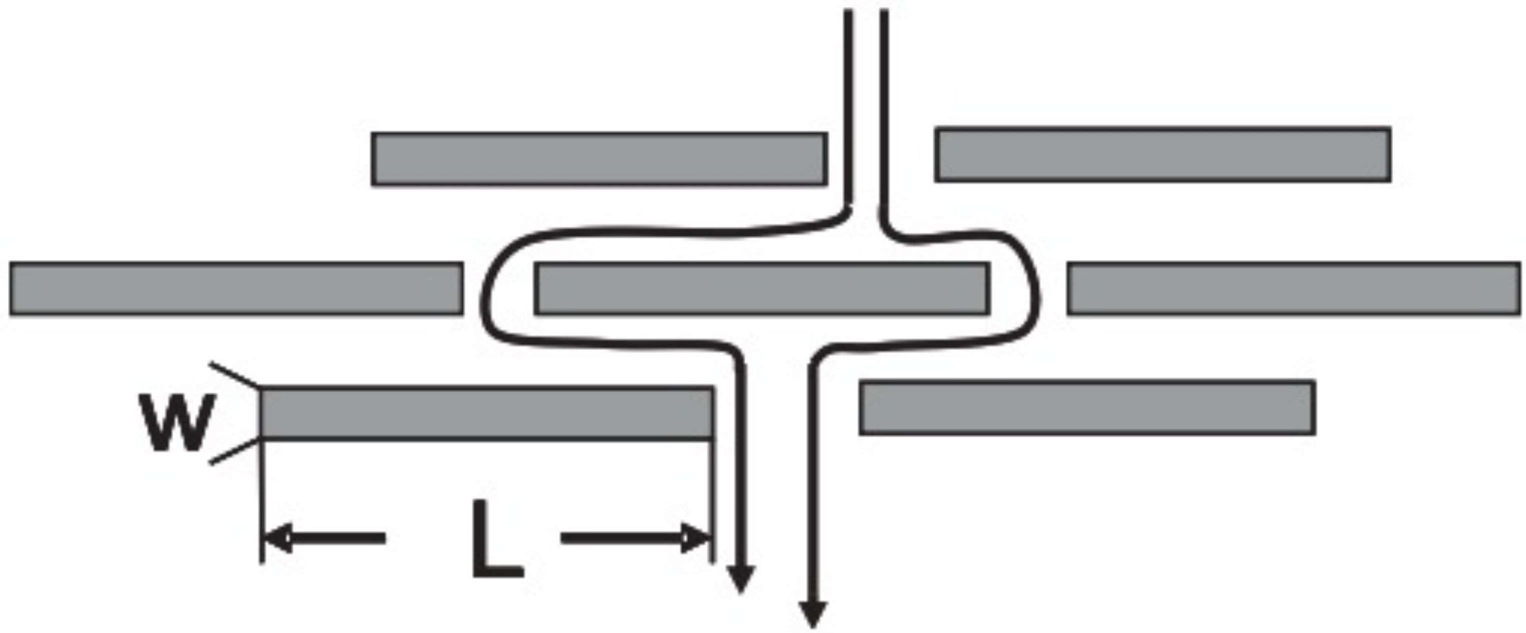


Figure 10.13 Simplified representation of the path of molecules through a polymer filled with aligned rectangular platelets of thickness w and length L.

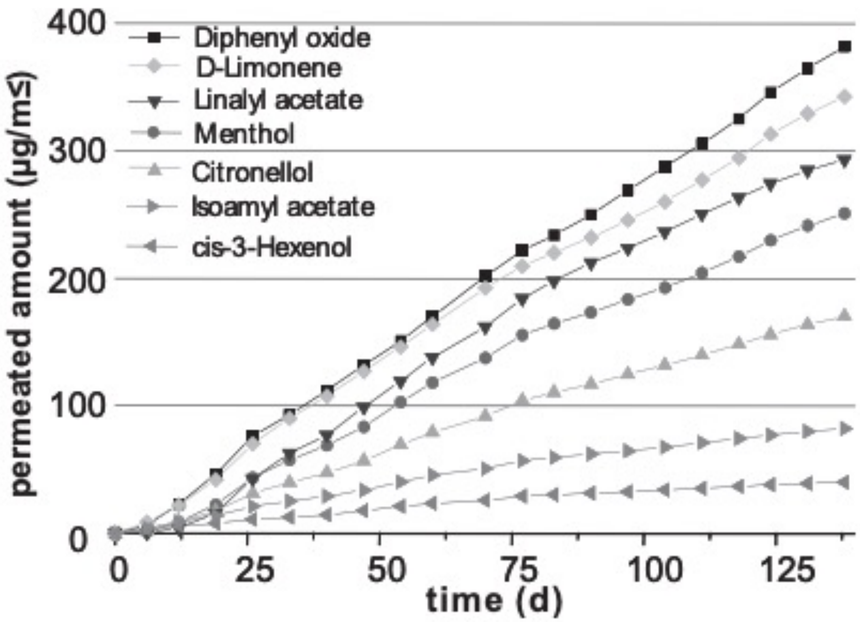


Figure 10.20 Amount of selected flavor substances having passed a 16-µm-thick BOPP film, in dependence on time. Source: Fraunhofer IVV, see also (Moosheimer, et al. 2000).

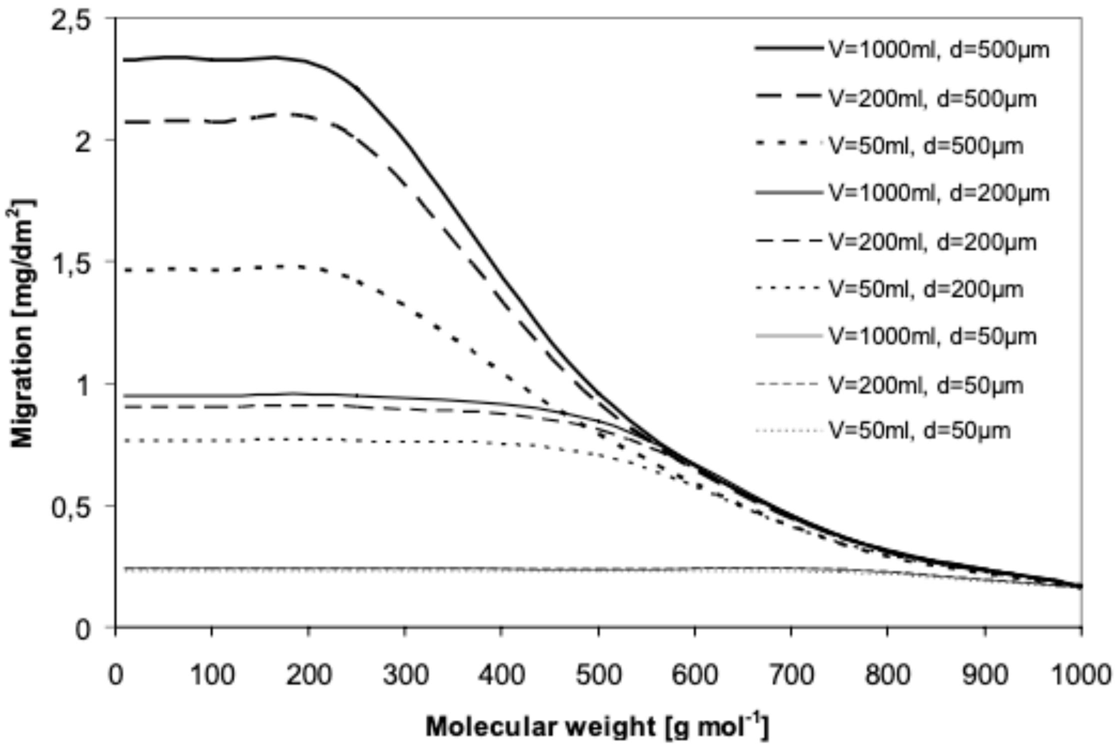


Figure 11.10 Migration in mg/dm^2 in dependency of the molecular weight up to 1000 g/mol from an HDPE film ($C_{P,0} = 500$ ppm, 10 days/40 °C, contact area 6 dm^2/kg food) as a function of HDPE film thickness *d* and fat content in food (expressed as volume *V* of fat fraction in food, that is when $V = 1000$ ml or 50 ml, $\Rightarrow$ food has 100% or 5% fat).

Forms of Flexible Packaging

Soft-loop handle bag

Wave-top bag

T-shirt bag

Die cut handle bag

LDPE, HDPE, iPP

Shrink wrap (LDPE), stretch wrap (LLDPE) , bubble wrap (LDPE), twist wrap (iPP multilayer)

Stand-up pouches SUP
PET, BOPP, nylon, PE, tie layers, aluminized or foil

Lay flat/pillow pouches
LDPE, HDPE

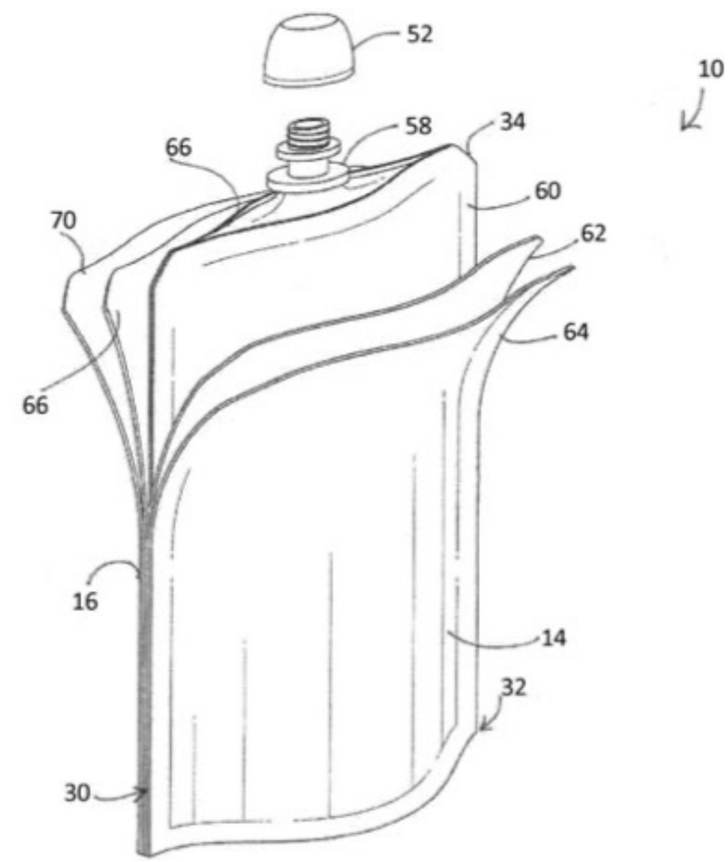


Figure 4.3 A perspective view of a flexible pouch in a partially deconstructed configuration (2018, **US2018009587** A1, NESTEC SA).10, Flexible pouch; 14, Front wall; 16, Rear wall; 30, First side edge; 32, Second side edge; 34, Upper edge; 52, Cap; 58, Dispensing device; 60, 66, Inner layers; 62, 68, Intermediate layers; and 64, 70, Outer layers.

Labels and Sleeves

iPP, OPP, glycol-modified PET (PET-G), LDPE, PVC, PS.
PET-G Shrink wrap label and sleeves for PET containers

Polymer made of the same material as the container or film do not act as further contaminates and can be recycled with the film or container.   e.g. OPP label on HDPE or PP bottles

Table 4.3 Effect of Plastic Labels and Sleeves on the Various Processing Steps of the Recycling of Plastic Bottles

Polymer	Recycling Step	Effect	Evaluation
PET stream			
PVC	Sorting on bottles	PVC L/S detected = up to 3 bottles without PVC L/S ejected	Increase in losses and waste to be processed
	Float-sink	Undetected PVC flakes cannot be separated from PET flakes by flotation (density of the two materials >1)	Recycling stream pollution
	Sorting on pellets	PVC flake detected = up to 100 flakes ejected	Recycling stream pollution and increase in losses
	Granulation/recycling	Decomposition of PVC into carbon residues at PET conversion temperature: Clogging of extruder filters and/or quality problems with the granules	Increase in machine stoppages, increase in losses, quality problems, and increase in waste to be processed
PS	Float-sink	Depending on their density, PS flakes are sent into the PET stream ($d > 1$ g/cm^3) or polyolefin stream ($d < 1$ g/cm^3)	Pollution of the recycling stream and the polyolefin stream
	Granulation/recycling	With a fusion temperature well below that of PET, deterioration of the PS during shaping	Creation of impurities and yellowing of pale-colored materials (not visible in dark materials), and quality problems
Stretch LDPE		None	Favorable
PET-G	Float-sink	PEGT flakes not separated from PET flakes (density of the two materials >1 g/cm^3)	PET stream pollution
	Washing	Tendency of PEGT to stick to the walls of the machines during drying and transfer	Blocking of pipes
	Granulation/recycling	Yellowing of pale-colored PET streams over a certain concentration	Quality problems
PP/OPP		None	Favorable
HDPE/PP stream			
PVC	Granulation/recycling	Traces of PVC create black stains during recycling	Quality problems
PS	Float-sink	Depending on their density, flakes are sent into the HDPE/PP stream ($d < 1$ g/cm^3) or into postsorted waste ($d > 1$ g/cm^3)	Recycling stream pollution and increase in losses
	Granulation/recycling	Given their conversion temperatures close to those of PS, PP, and HDPE, the shaping process is identical. PS incompatible with HDPE and PP	Tendency to agglomerate and impair the final properties of the material (creation of areas of weakness, incipient breaks)
Stretch LDPE		None	Favorable
PP		None	Favorable

HDPE, High-density polyethylene, LDPE, Low-density polyethylene, L/S, Labels or sleeves, OPP, Oriented polypropylene, PET, Poly(ethylene terephthalate), PET-G, Glycol-modified PET, PP, Polypropylene, PS, Polystyrene, PVC, Poly(vinyl chloride).
Adapted from Cotrep (Comité Technique pour le Recyclage des Emballages Plastiques). General notice 12 – the behaviour of labels and sleeves during the recycling of PET, HDPE and PP bottles; February 3, 2012. https://www.mondigroup.com/en/newsroom/mondi-flexible-packaging-leapfrogs-ahead-in-the-recycling-game/.

Straps/Tapes/Six-Pack Rings

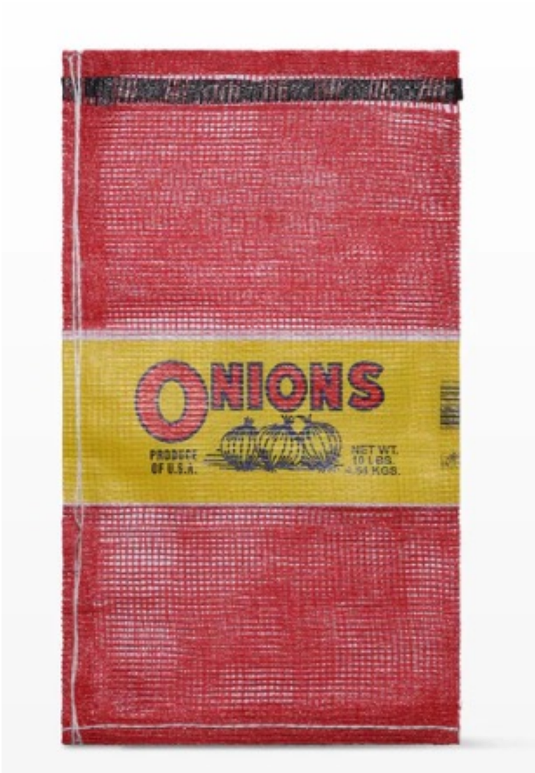
Straps and Tapes: Thin, flat plastic bands PP or PET

6-Pack Rings are LDPE

None are recyclable

Woven Bags/Net Bags/Sacks

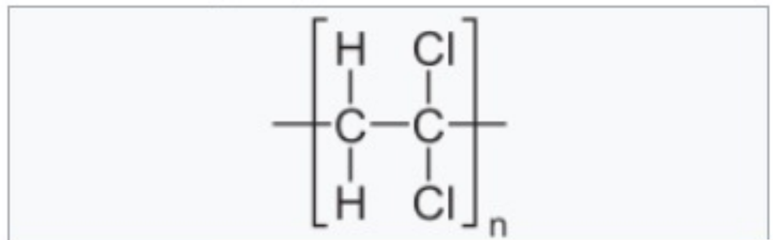
HDPE, PP, PET, Nylon
BOPP
For industrial materials, the bags are recycled



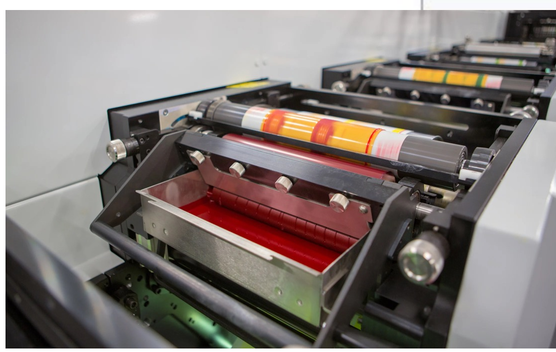
Coated/Printed Film

PVDC, improves barrier for transparent films

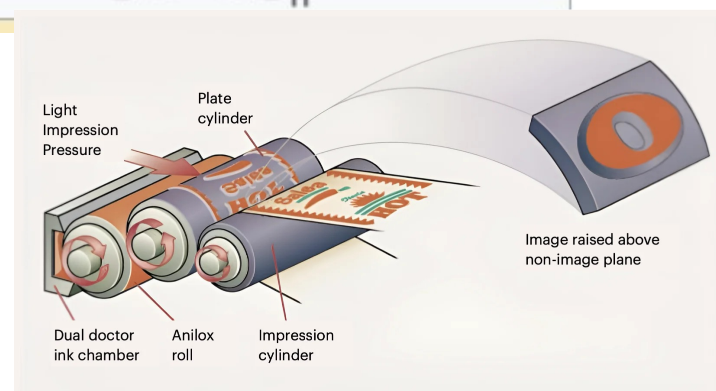
Polyvinylidene chloride



Printing:
Flexographic-

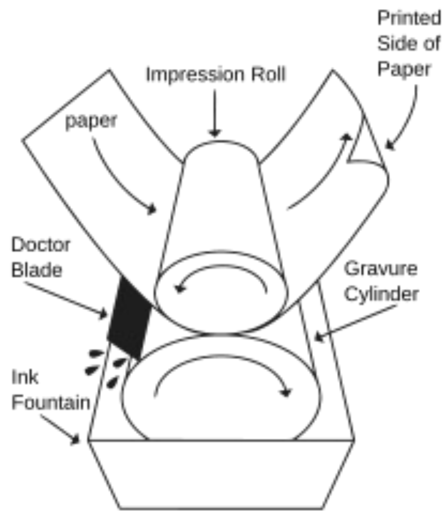


UV or IR cure



Printed or coated film can be recycled for trash bags coating can’t be removed.

Rotogravure-



Digital-

Applications of Flexible Packaging

Food and beverage-

Largest Segment

Multilayer films with Aluminum foil and Polyolefins or PET/polyamide

Coating with PVDC to improve O_2 barrier

Heat sealing material like wax

Table 4.4 Forms of Flexible Plastic Packaging for Food [25]

Packaging Form	Exemplary Food Products
Stand-up pouches	Frozen prawns, scallops, fish fillets; frozen fruits; and vegetables; Frozen prepared food such as chicken wings, shrimps; Baby food; Pet food
Zipper lock pouches	Sugar, oatmeal, grated cheese, rice, grain, coffee, dried fruits and nuts, candies
Zipper lock bags	Grape bags, deli meat, and cheese bags
Crinkly bags	Chips, candies, dried pasta, cereal, and cookie bags
Crinkly wrappers (nonstretchable);	Cheese wrappers, vacuum seal packaging, plastic safety seal on bottles and jars, plastic inner seal on yogurt
Crinkly wrappers	Cheese slice wrappers, snack and chocolate wrappers, candy wrappers, individual cookie wrappers
Cellophane	Flower and gift wrapping
Flexible packaging with plastic seal	Fresh pasta, prepackage deli meat, prepackage cheese packaging
Net plastic bags	Oranges, lemons, limes, avocado, nuts, onions
Woven plastic bags	Rice
Shrink wrap	Meat, poultry, cheese, vegetables

Cleaning Products-
Soap wrappers
Laundry detergent pods (polyvinyl alcohol PVOH)
Liquid detergent pouches
Hand soap tubes
powder soap pouches
Dishwasher pouches
Dishwasher pods
Pouch packing for cleaning chemicals

Medical/Personal Care/Cosmetics

Printed Aluminum Layer
Forming Film
LDPE, LLDPE, BOPP, OPP, PET, polyamide, PVC, PVDC

Considered medical waste

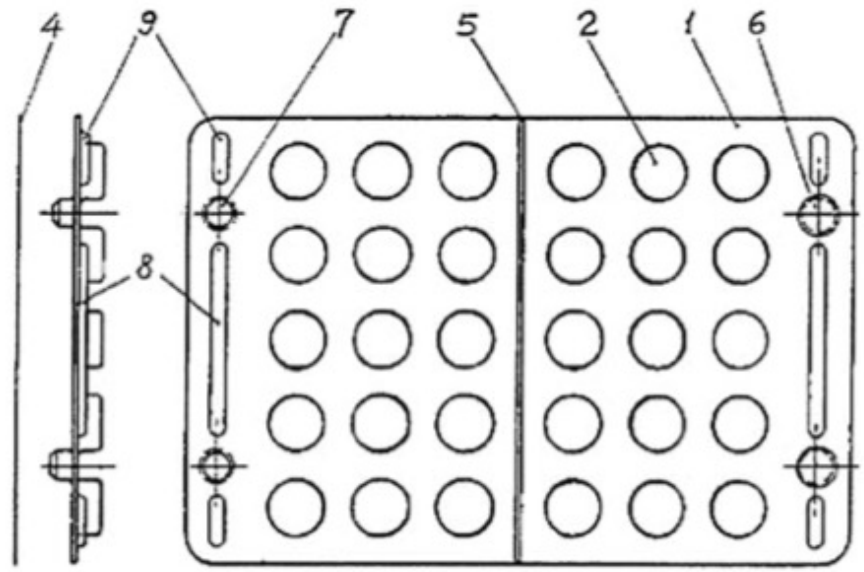
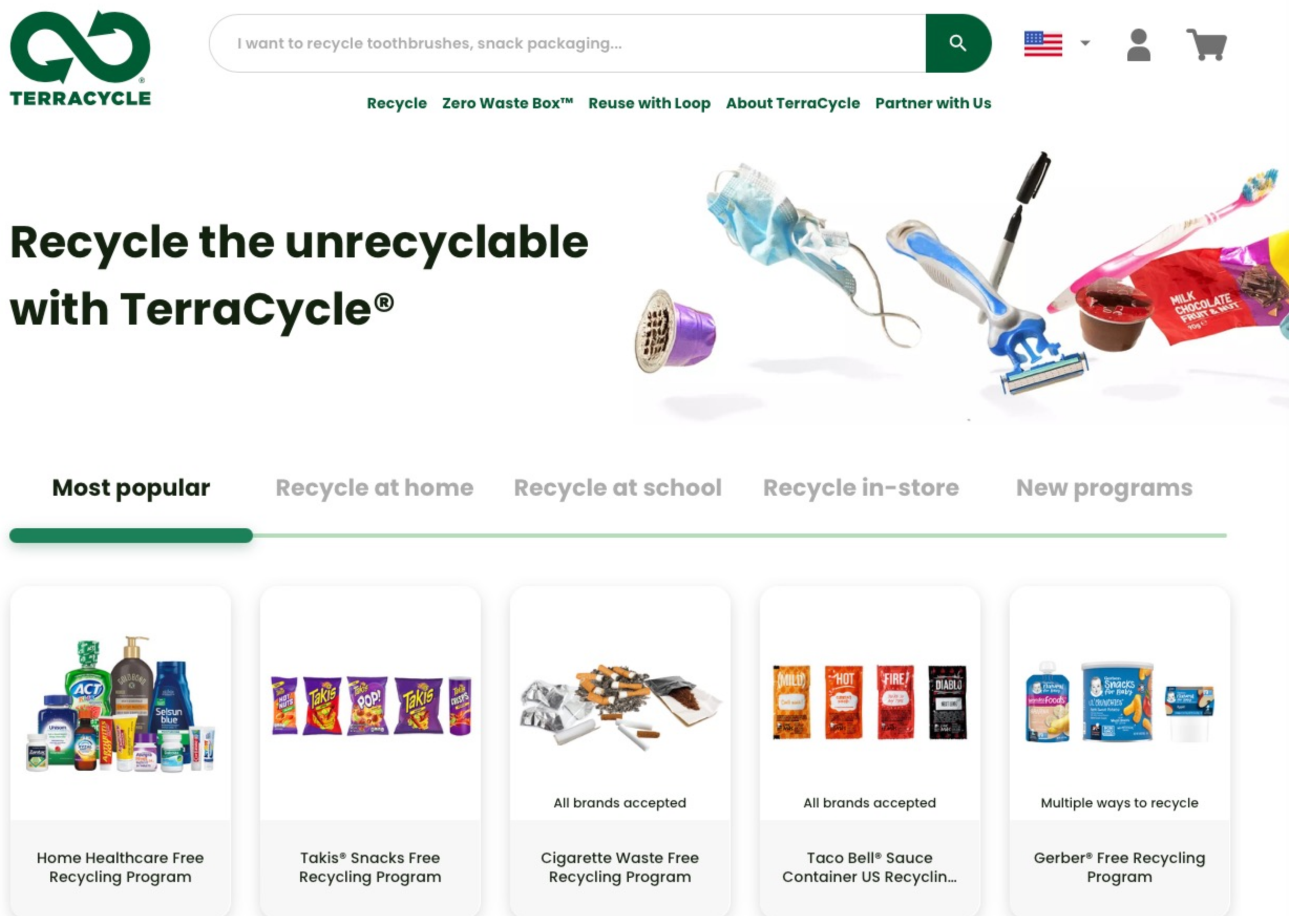


Figure 4.4 Example of a blister type flexible plastic packaging card (1996, **US5549204**, TOREN CONSULTING PTY LTD). 1, Flexible plastic sheet; 2, Thermoformed blisters or pockets; 3, Round tablets and pills; 4, Aluminum foil; 5, Perforated hinge line; 6, 7, Resealable fastening means; and 88, 9, Ribs.

Flexible Pouches for Infusion

-Zero volume chamber
-Retained asepsis
-Reduce waste

PVC or polypropylene


TERRACYCLE
I want to recycle toothbrushes, snack packaging...
Recycle
Zero Waste Box™
Reuse with Loop
About TerraCycle
Partner with Us
Recycle the unrecyclable with TerraCycle®
Most popular
Recycle at home
Recycle at school
Recycle in-store
New programs
Home Healthcare Free Recycling Program
Takis® Snacks Free Recycling Program
All brands accepted
Cigarette Waste Free Recycling Program
All brands accepted
Taco Bell® Sauce Container US Recyclin...
Multiple ways to recycle
Gerber® Free Recycling Program

How we’re Eliminating the Idea of Waste®

Sponsored recycling programs

Explore free recycling programs sponsored by your favorite brands and retailers.

See All Free Programs

Zero Waste Box™

It’s easy to #RecycleEverything with our paid recycling solutions.

Learn More

TerraCycle Made

Shop products made from the trash we’ve recycled together.

Shop Now

Loop

A new way to shop, waste-free. Get the products you love in reusable packaging.

Learn More

GARNIER

Garnier® Free Recycling Program

Recycle skincare and hair care packaging

Sign up and join waitlist

Recycle Curbside

- Garnier® bottles
- Garnier® bottles
- Garnier® bottles

Recycle with TerraCycle

- Garnier® tub lids
- Garnier® spray pumps
- Garnier® lids

Recycle from anywhere

Construction and Building

Stretch Film made of LLDPE

Bricks,
Tiling,
Roofing
Truss structures

Woven PP bags
For sand
Bricks
Cement

PP or PET straps for
Ceramic tile pavers
Building blocks

Recycling is common

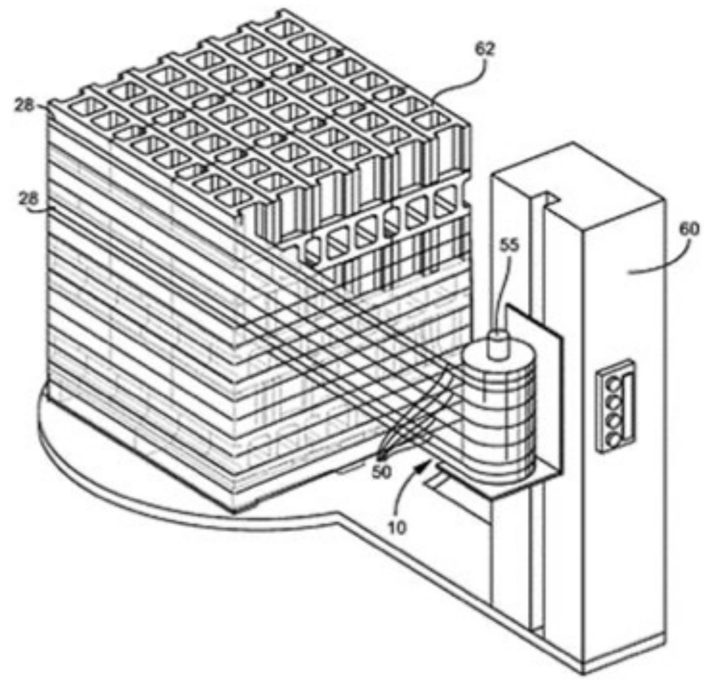


Figure 4.5 Perspective view of a reinforced stretch film being wrapped around bricks on a pallet through use of a stretch wrapping machine (2017, **US2017313020** A1, GRUBBS JR RONALD; LOPEZ LUIS ARURO). 10, Reinforced stretch film; 28, Folded edges; 50, Reinforcement strips; 55, Roll of reinforced stretch film; 60, Stretch film wrapping machine; 62, Pallet.

E-Commerce

20% of retail sales

Layers of LDPE and HDPE

Usually not for curbside recycling
Labels need to be removed or cut out

Benefits of Flexible Plastic Packaging

- Less material needed for production.
- Uses less energy to produce and less plastic than rigid containers.
- Lighter weight allowing transport of higher volumes of product.
- Generates less CO_2 during transportation.
- Creates less waste and takes up less space in the landfill.
- Extends the shelf life of many products, especially food.
- Maintains freshness.
- Provides efficient product-to-package ratios.
- Reduces food waste.
- Creates self-appeal.
- Enables visibility of the contents.
- Easy to open, carry, store, and reseal (convenience).
- Extensible into diverse product categories.

Plastics Packaging

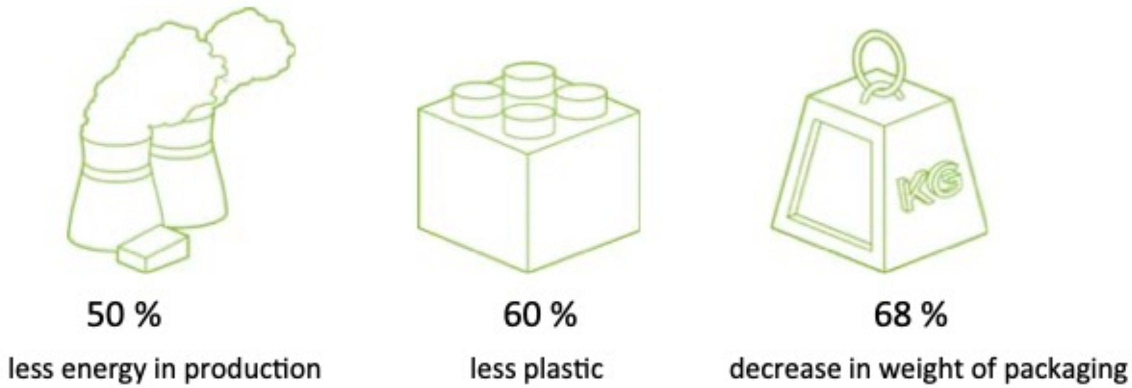


Figure 1.1 Flexible plastic packaging versus rigid packaging. *Courtesy of Enval Ltd., 2019. The Enval process [6].*

- Uses less material, less expensive,
- Can be designed to be more appealing,
- Printable, rigid packaging needs labels often made of flexible packaging
- Tunable transport properties minimize material use

Recycling and Flexible Packaging

- Most households have access to a rigid plastics packaging recovery system (e.g., PET bottles), while similar services for domestic consumers of flexible plastic packaging are still in their infancy [8].
- Many municipalities do not accept flexible packaging in curbside recycling bins. Plastic films and bags must be taken to a drop-off location, such as a grocery or other retail store, to be collected for recycling (see also Chapter 5; Section 5.2.2).
- Multilayer flexible packaging structures, such as pouches, are not recyclable.
- The recycling rate of flexible packaging is less than 1%, while the rigid packaging is around 40% [8].

Recycling and Flexible Packaging

Automated sorting, requires equipment
Sorted material must be shredded to produce flake scrap material
Flake must be pelletized
For rotational molding, spray coating pellets are ground to a powder

Sorting is the main cost and results in material more expensive than virgin resin

80% of flexible packaging are contaminated with food at 10 to 20% of the weight
Packaging films tangle and clog sorting equipment at material recovery facilities

Recycling Multilayer Flexible Packaging

There is no technology for recycling of multilayer flexible packaging or metallized films

- large variety of materials used for each layer;
- large differences in the processing properties of the polymers used for multilayer films;
- lack of systems for identification of multilayer film;
- lack of system solutions for the collection of these materials;
- lack of economically viable systems of separation of the various materials; and
- lack of standard research of the properties, processing, and applications of composites based on recycled multicomponent materials.
- Printing ink, labels, metallized material, adhesives, coatings must be removed

Recycling Multilayer Flexible Packaging

Each layer (there could be up to 10 layers) must be

- Separated
- Analyzed and categorized
- Recycled (shredded, pelletized)

Collection of Flexible Packaging

Flexible packaging recycle rate is cited at 2% by some, 3% by others and up to 20% by still others

-Not widely collected around the world

Sources:

Post-consumer
Post-commercial
Post-industrial

If you put your recycle in a plastic garbage bag it is removed from the stream at the MRF and sent to landfill

Post-consumer:

LDPE, LLDPE, HDPE, iPP and multilayer films
Much of it contaminated with organics and labels/printing

TerraCycle Zero Waste Bags

How it works

1. Choose the subscription package that's best for you and receive your supplies.
2. Start recycling. Once you fill the Zero Waste Bag, seal it, then place it at your doorstep.
3. Scan the QR code or log into your account to schedule a pickup.
4. We'll pick up your hard-to-recycle materials at the scheduled time and recycle it!

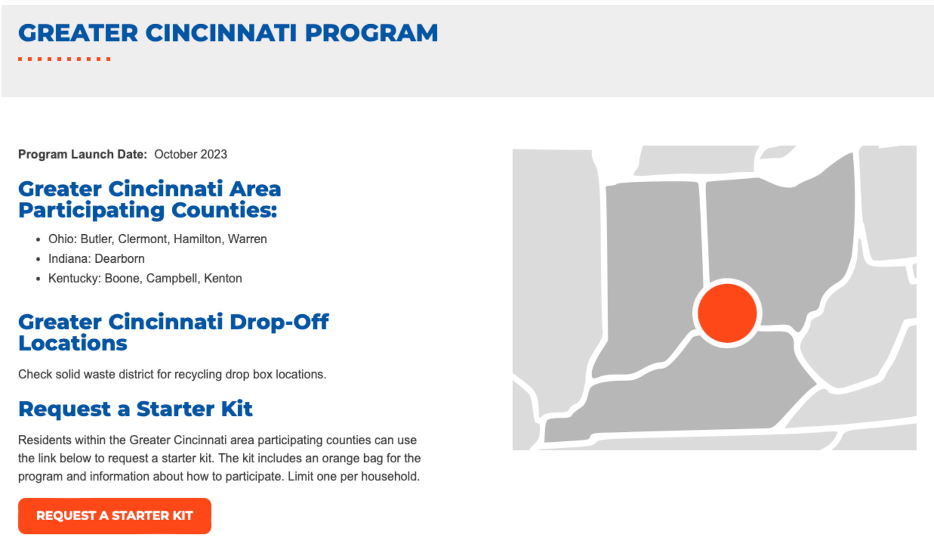
Collection of Flexible Packaging

EU Rules, originally 2025 then
Dec 2025 now 2030…

Current status:

- **From 1 January 2030**
  - all packaging must be recyclable, fulfil the criteria of recycling-oriented design and is not considered recyclable if it corresponds to performance level E, and
  - innovative packaging may only be placed on the market for five years.
- **Until 31 December 2034**, recyclability does not apply to primary packaging, contact-sensitive plastic packaging for medical equipment and contact-sensitive plastic packaging for in-vitro diagnostics.
- **From 1 January 2035**, they must meet the performance characteristics for large-scale recyclability.

Collection of Flexible Packaging



GREATER CINCINNATI PROGRAM

Program Launch Date: October 2023

Greater Cincinnati Area Participating Counties:

- Ohio: Butler, Clermont, Hamilton, Warren
- Indiana: Dearborn
- Kentucky: Boone, Campbell, Kenton

Greater Cincinnati Drop-Off Locations

Check solid waste district for recycling drop box locations.

Request a Starter Kit

Residents within the Greater Cincinnati area participating counties can use the link below to request a starter kit. The kit includes an orange bag for the program and information about how to participate. Limit one per household.

REQUEST A STARTER KIT

https://www.hefty.com/hefty-renew-starter-kit

Figure 5.1 Orange bags filled with hard-to-recycle plastic packaging (The Hefty® EnergyBag® program) [12].

Collection of Flexible Packaging

Collection of Flexible Packaging

The majority of locations are retail drop-offs. There are more than 18,000 retail collection or drop-off centers throughout the United States. Examples of flexible plastic packaging films and bags that can be brought to drop-off locations include [15]:

- shopping bags: grocery, retail, carryout, produce, newspaper, bread, and dry cleaning bags (clean, dry, and free of receipts and clothes hangers);
- zip-top food storage bags and pouches (clean and dry);
- plastic shipping envelopes (free of labels), bubble wrap, and air shipping pillows (deflated);
- product wrap of water/soda bottles, toilet paper, paper towels, napkins, disposable cups, bathroom tissue, diapers, and female sanitary products;
- furniture and electronic wrap; and
- plastic cereal box liners (not containing paper).

Examples of flexible plastic packaging that cannot be brought to drop-off locations include:

- cling wrap (or cling film);
- candy bar wrappers (multilayer);
- flower and gift wrapping (cellophane, polypropylene);
- chip or cookie bags;
- salad and green bags;
- plastic squeeze tubes;
- paper-lined plastic;
- plastic straps;
- six-pack rings;
- biodegradable packaging;
- oxodegradable packaging; and
- PVC packaging (e.g., zipper bedsheet bags).

An important issue is that consumers do not always know which packaging can and cannot be recycled. Another problem is throwing items in the wrong recycling bins. Not only does this take time to separate at a recycling facility but it can also contaminate other items in the same bin.

Shaping the Future of Waste Management

At CleanRobotics we're building intelligent waste management systems using AI and robotics to empower a sustainable future.

MEET TRASHBOT

Co-funded by the European Union

Bin-e

SMART WASTE BIN

Revolutionizing the waste management system

Bin-e is an AI-based smart waste bin, designed for public places, enabling them to simplify recycling. It sorts and compresses the waste automatically, controls the fill level and processes data for convenient waste management.

Contact us ↗

Trusted by: Kaufland, LEGO, esa, DELL, AMBIWASTE Services, ISS

Post Commercial Flexible Packaging Collection

Polyethylene clear film
Large commercial generators
    clear bags, stretch wrap film
Doesn't need to be washed
21% recycling rate
Recycled into trash bags and thicker commercial films

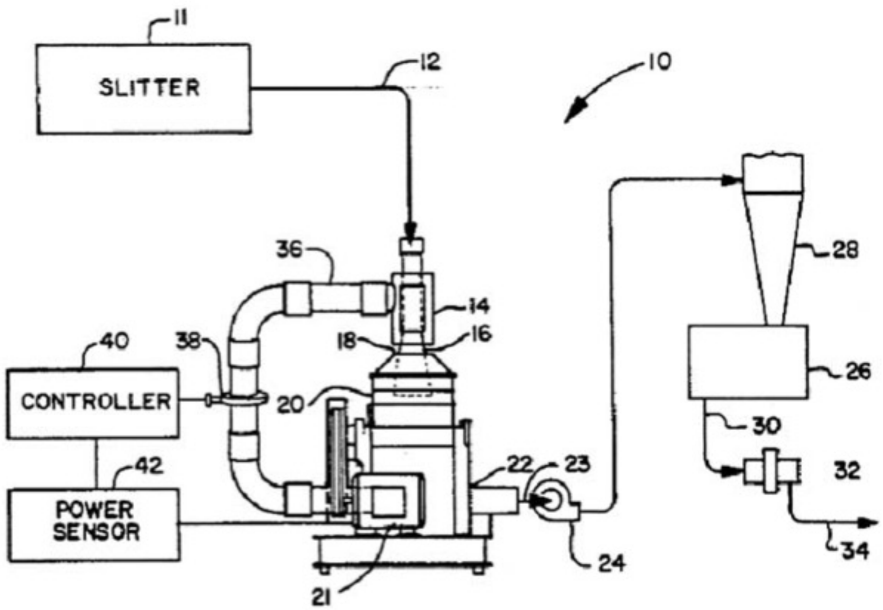
Polyethyelene post commercial mixed color film
Stretch wrap

Polypropylene woven bags

Postindustrial Flexible Packaging

A considerable amount of scrap is generated in the course of manufacture of flexible plastic packaging films, such scrap coming from trimming from roll ends (edge trims or offcuts), film breakages, filling custom orders involving less than the full width of rolls of the film, or rolls out of specification (1991, **WO9117886** A1; 1992, **US5128212** A, DUPONT). Experience shows that still in most of the cases, 2−10% of the production materials are lost due to process reasons [20].

It is estimated that 79% of postindustrial plastic films end up in landfills and oceans [7].



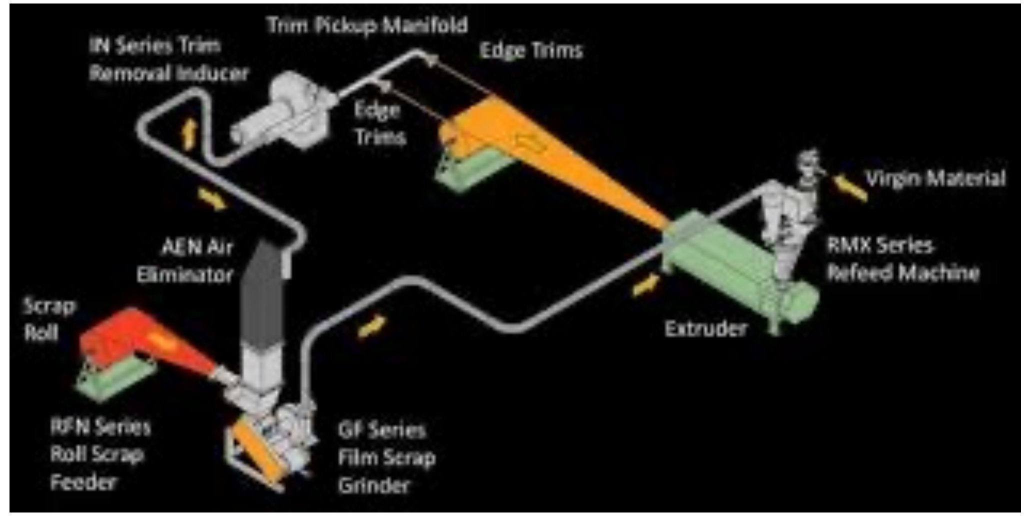


Figure 5.3 Schematic side view of an apparatus for reprocessing scrap film (1992, **US5170949** A, SPROUT BAUER INC ANDRITZ). 10, Scrap film reprocessing apparatus; 11, Edge slitter; 12, Scrap film inlet line; 14, Film−air separation chamber; 16, Film outlet opening; 18, Inlet opening of 20; 20, Scrap film cutter; 21, Motor; 22, Cutter outlet end; 23, Tubular cutter outlet line or discharge conduit; 24, Fan; 26, Fluff storage tank; 28, Cyclone; 30, Bin discharge line; 32, Pelletizer; 34, Pellet outlet line; 36, Air bypass line; 38, Control valve; 40, Valve controller; and 42, Solid-state motor power sensor.

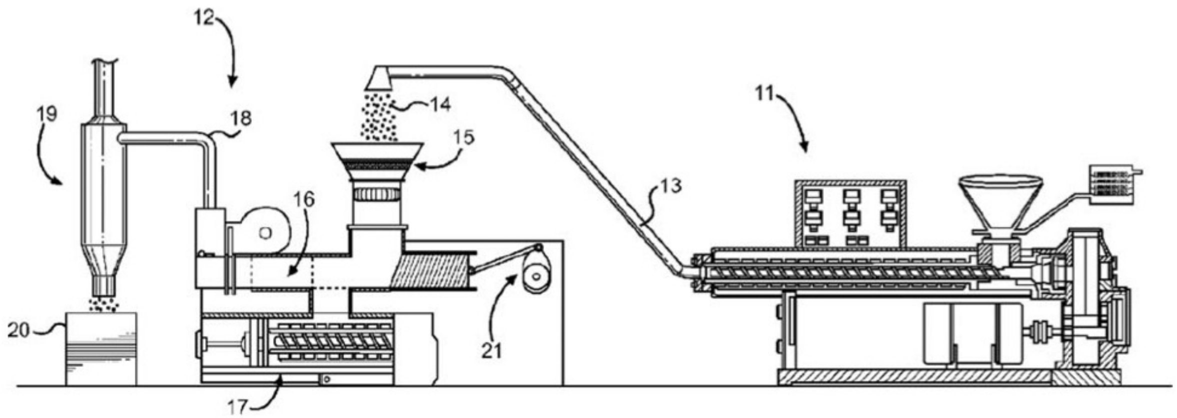


Figure 5.5 Schematic view of a plastic trim reclaim process in-line with an existing extrusion process (2012, **US2012258189** A1, WILHELM MICHAEL BRANDON). 12, Reclaim apparatus; 11, Thermoplastic extrusion process; 13, Feed line; 14, Edge trims; 15, Inlet section; 16, Bricker section; 17, Extruder/pelletizer section; 18, Forced air stand-pipe; 19, Upstanding separator; 20, Container; and 21, Driven ram.

Separation and Sorting and Volume Reduction

Separation and Sorting and Volume Reduction

Materials Recovery Facility (MFR)

- separate
- densify
- Ship to reprocessors or recyclers

Clean MFR works with separated materials

Dirty MRF works with comingled wastes including organic matter

Contamination is a big problem

- metals
- paper
- other plastics
- odd objects, batteries, metal parts, etc
- Generally flexible plastic films are a contaminant

Plastics Recovery Facility (PRF)

- Plastics specific MRF
- These don’t exist in the US

Manual and Vacuum Sorting

Feeds into a bale press
Or film screw

Figure 6.1 The FilmVac System [7]. *Courtesy of Impact Air Systems.*

Air Separators

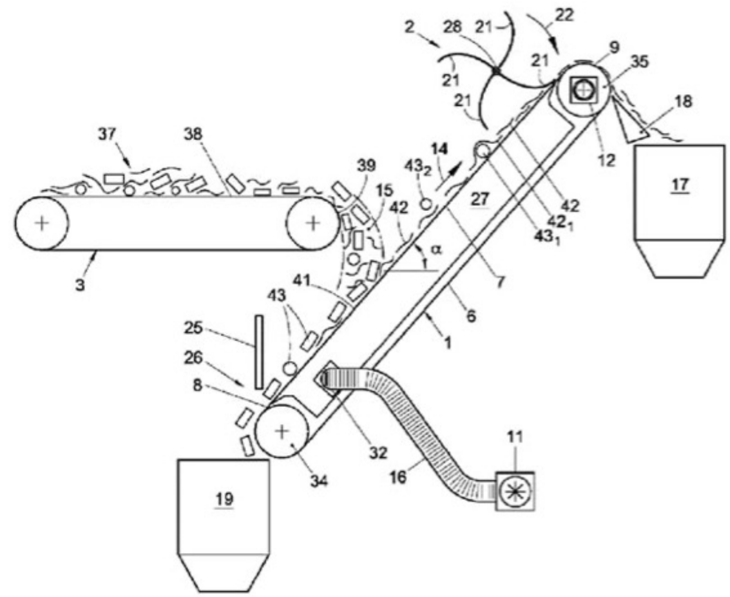


Figure 6.4 Schematic diagram of the apparatus for sorting flat material from a stream of waste (2011, **EP2314387** A1, BOLLEGRAAF PATENTS AND BRANDS B V). α, Angle; 1, Transport conveyor; 2, Sweeper in the form of a rotor; 3, Feeding conveyor; 6, Circulating conveyor member; 7, Conveyor sorting track; 8, Lower end of 7; 9, Upper end of 7; 11, Fan; 12, Motor; 14, Direction of transport; 15, Drop zone; 16, Air hose; 17, First discharge site; 18, Scraper; 19, Collecting bin; 21, Radially projecting flexible sweeping blades of 2; 22, Rotation; 25, Grader; 26, Drop zone; 27, Vacuum chamber; 28, Rotation axis; 32, Orifice; 34, Roller; 35, Roller; 37, Stream of waste material; 38, Feeding path; 39, Downstream end of 38; 41, Obliquely upwardly facing side; 42, Flat items; and 43, Nonflat items.

Air Separators

Screens

Disc screen

Vibrating screen

Trommel screen

Ballistic screen

Grabbers

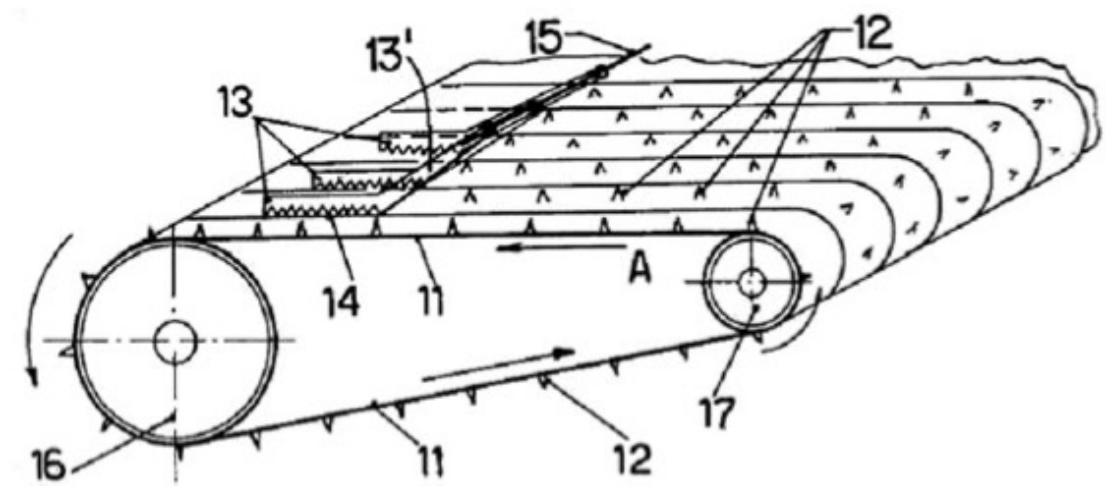


Figure 6.5 Schematic diagram of an apparatus for tearing small plastic bags (1978, **US4067506** A, R.UTI.R s.r.l). A, Direction; 11, Conveyor belt; 12, Hooks (aculei); 13, Blades; 13′, Hinges; 14, Blade's teeth; 15, Shaft; 16, Front transmission pulley; and 17, Rear transmission pulley.

Hooks grab bags

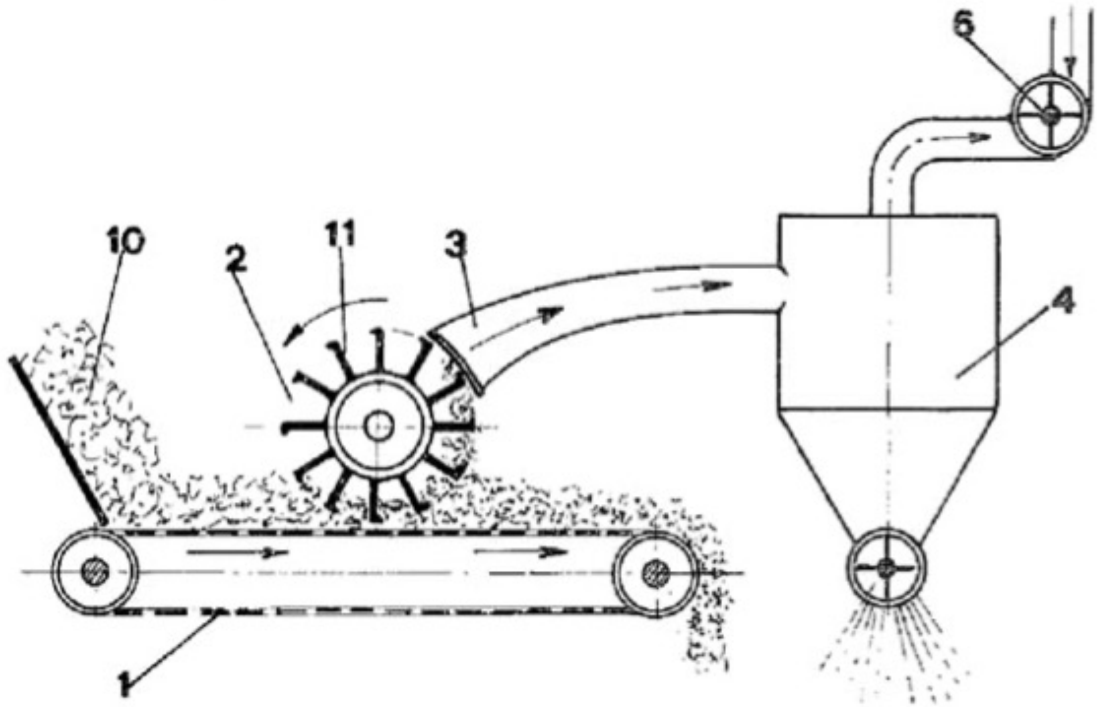


Figure 6.6 Schematic diagram of the separation apparatus (1978, **BE867777** A; 1980 **US4207986** A; 1980. **BR7805346** A of SORAIN CECCHINI SPA). 1, Conveyor belt; 2, Reel device; 3, Intake mouth; 4, Decanting or settling cyclone; 6, Fans; 10, Waste material; and 11, Spokes of the reel (2).

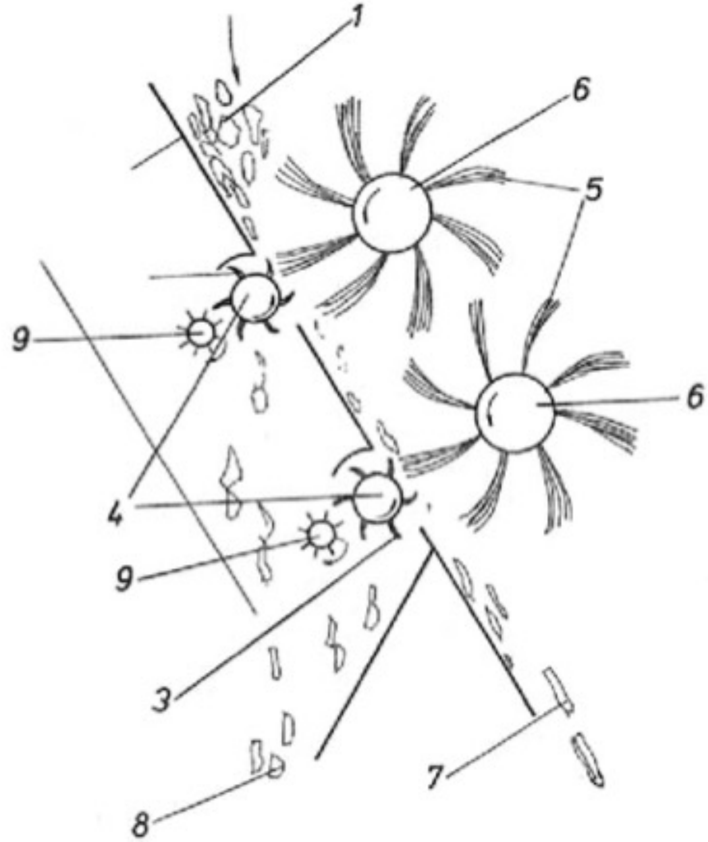


Figure 6.8 Schematic diagram of an apparatus for the sorting out of plastic film from a mixture of waste (1982, **EP0050259** A2, VOELSKOW PETER). 1, Mixture of waste; 3, Spikes; 4, Spiked roller; 5, Brush bands; 6, Brush rollers; 7, Remaining refuse; 8, Textile refuse; and 9, Combing-off rollers.

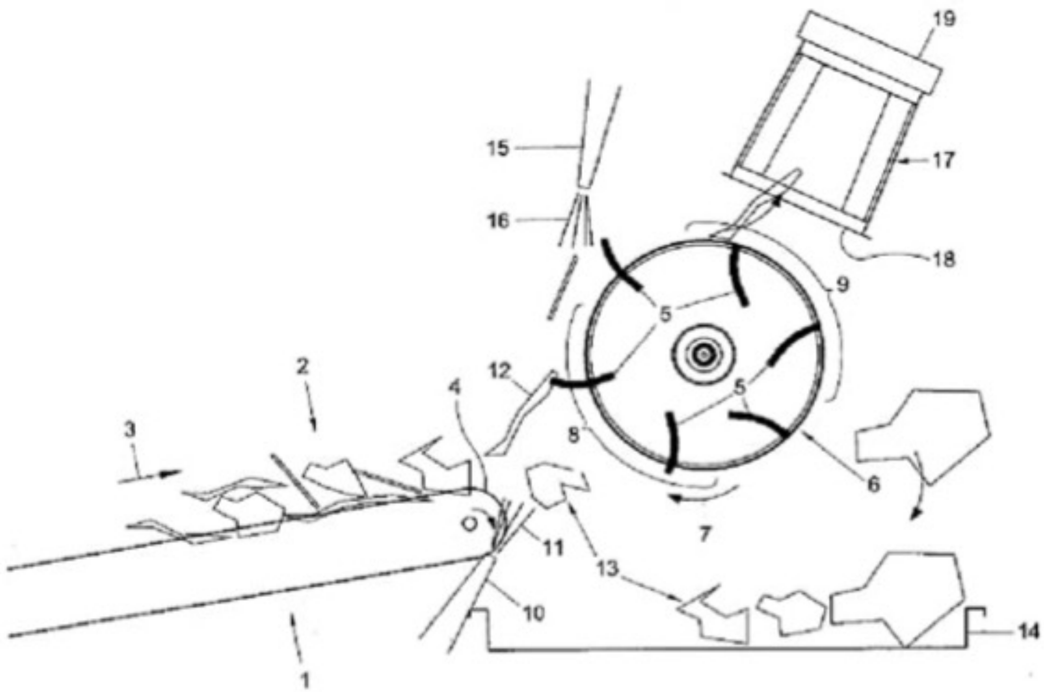


Figure 6.9 Schematic side view of the apparatus for separating plastic film from waste (2008, **EP1970130** A1; 2008, **US2008223770** A1, MACHF BOLLEGRAAF APPINGEDAM B). 1, Supply track; 2, Waste; 3, Supply direction (arrow); 4, Downstream end; 5, Hooks; 6, Drum; 7, Sense of circulation (arrow); 8, Engagement area; 9, Disengagement area; 10, Blower; 11, Upward airflow; 12, Fraction of the waste (2); 13, Remainder of the waste (2); 14, Discharge conveyor; 15, Blower; 16, Counter airflow; 17, Discharge channel; 18, Inlet; 19, and Ventilator.

Labeling Systems

Table 6.1 Resin Identification Codes (RICs) for the Seven Most Commonly Used Resin Types According to ASTM D7611-13e1 [15]

Resin	Resin Indentification Code-Option A	Resin Indentification Code-Option B
Poly(ethylene terephthalate)	1 PETE	01 PET
High density polyethylene	2 HDPE	02 PE-HE
Poly(vinyl chloride)	3 V	03 PVC
Low density polyethylene	4 LDPE	04 PE-LD
Polypropylene	5 PP	05 PP
Polystyrene	6 PS	06 PS
Other resins	7 OTHER	07 O

Table 6.2 Resin Identification Codes (RICs) for Selected Multilayers

Symbol	Description	Exemplary Uses
81 PapPet	Paper + PET	Consumer packaging, pet food bags, cold store grocery bags, ice-cream containers
84 C/PAP	Paper and cardboard/plastic/ aluminium	Liquid storage containers, juice boxes, cardboard cans, cigarette pack liners, gum wrappers
90 C/LDPE	LDPE/aluminium	Food packaging

Optical Sorters

Visible light (VIS)

high speed camera and light sensors to detect

Doesn’t detect chemical makeup

Near-infrared (NIR)

Use IR fingerprint

Doesn’t detect color

Neither work well with carbon black

- optical sorters can only be applied to monomaterials. However, most flexible plastic packages are made of many different materials;
- optical sorters scan only the material at the surface layer (ignoring deeper materials within a multilayer composite);
- there is no optical sorter system that could identify multiple, specific materials or their location on a conveyor belt;
- materials must be physically separated before they are scanned;
- optical sorters require their own special belts;
- optical sorters cannot identify black colored films;
- as plastic films have a very low surface weight, sorting with optical sensors on acceleration belts is often inefficient;
- most types of optical sorters are unable to adequately distinguish material types when they have highly glossy, dark colored surfaces, paints, and coatings [12,20].

Fluorescent Light

Add Fluorescent material for identification and separation of plastics

Could separate food contaminated films

Doesn’t seem to be used anyplace

Robotic Sorters

- cuts sorting costs by 50%;
- stabilizes labor spend by fixing labor rate for sorting stations, while lowering labor needs;
- exceeds the return on investment offered by legacy recycling equipment;
- designed to detect and separate multiple materials;
- improves bale quality by reducing contamination levels;
- can be installed with practically no retrofit on existing conveyor belts; and
- provides higher throughput yields greater recovery rates and more revenue.


AMP
ROBOTICS

Eddy Current Separators

Remove nonferrous metals

Aluminum, brass, copper

Rotating magnet create “eddy currents”

“eddy currents” cause metal to be repulsed by the magnetic field and ejected from waste stream.

These can remove aluminized multilayered films

Volume Reduction

Compactors

Figure 6.18 Sausage-like bale obtained by the Film Screw Compactor [25]. *Courtesy of Impact Air Systems.*

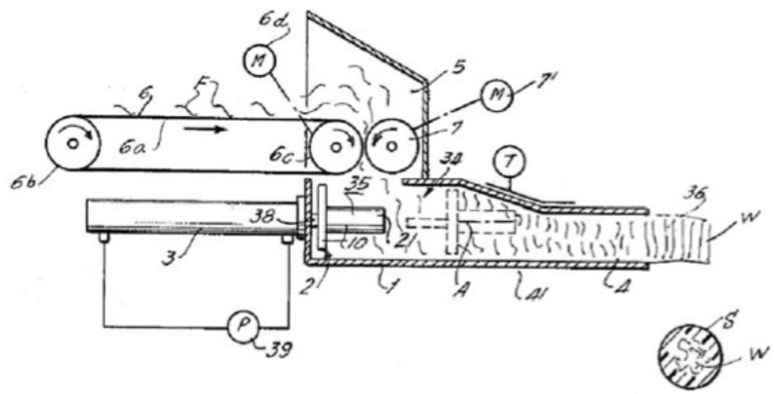


Figure 6.19 Cross-sectional view of the compacting apparatus (1973, **DE2261678** FLUMS AG MASCHF). A, Axis; IA, Line; M, Scraps of polyethylene film; S, Sheath; T, Thermostat; W, Compact sausage-like body; 1, Housing/compressing cylinder; 2, Ram/compressing piston; 3, Hydraulic cylinder/drive; 4, Funnel; 5, Feed casing; 6, Conveyor belt; 6a, Horizontal transport belt; 6b, 6c, Rolls; 6d, Electric motor; 7, Feed rollers; 7′, Electric motor; 10 Circular disc; 21, Cylindrical plunger/projection; 34, Chamber; 35, Inlet; 36, Outlet; 38, Piston rod; 39, Pump; and 41, Heater.

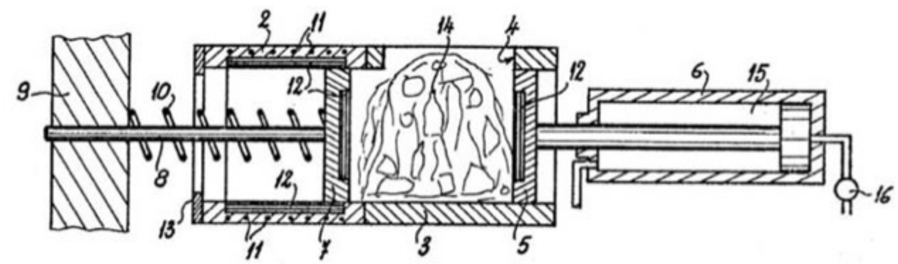


Figure 6.20 Apparatus for compacting thermoplastic sheet or film (1976, **FR2294037** A1, ALDES ATEL LYONNAIS EMBOUTISSA). 2, Container; 3, Tubular chamber; 4, Opening (load and discharge); 5, Piston; 6, Hydraulic jack; 7, Piston; 8, Guide system/rod; 9, Fixed support; 10, Helical spring; 11, Heating plugs; 12, Circuit for the circulation coolant; 13, Stopper; 14, Plastic materials; 15, Chamber of 6; and 16, Pressure regulator.

Life Cycle Analysis of Flexible Packaging is Favorable

Flexible film packaging typically results in less
- global warming potential,
- energy use, and
- volume/quantity landfilled

than recyclable rigid package alternatives [21].

Case studies: coffee; motor oil; baby food; laundry detergent pods; cat litter, beverages
In all cases lower water use, carbon footprint, fossil fuel use, product to package ratio, material to landfill

Bag-In-Box Solution for Motor Oil

21. Reclay StewardEdge. Product stewardship solutions, resource recovery systems, Moore Recycling Associates Inc. Analysis of flexible film plastics packaging diversion systems - Canadian Plastics Industry Association continuous improvement fund stewardship Ontario. Feb. 2013.

Table 1.2 Six Life Cycle Assessment (LCA) Case Studies of Flexible Plastic Packaging Versus Other Packaging Formats [17]

Case Study	Formats	Results
Ground coffee	Stand-up flexible pouch Steel can HDPE canister	Stand-up flexible pouch has a number of significant benefits than steel can and HDPE canister. This is attributed mainly to the reduced amount of material being used and the favorable product-to-package ratio. Other general benefits include product protection, brand message, and ease of use
Motor oil	Stand-up pouch with fitment DPE bottle	Large benefit across all SMM attributes for flexible packaging option—in a new product category.
Baby food	Pouch with fitment Thermoformed tub Glass jar	Flexible packaging offers better environmental attributes than glass and thermoform tub and overall less material to landfill.
Laundry detergent pods	Stand-up pouch with zipper Rigid PET container	Stand-up pouch has a number of significant benefits (fossil fuel usage, carbon impact, water consumption, and municipal solid waste) over the PET rigid container, even when taking the current recycling rate of the rigid container into consideration.
Cat litter	Stand-up bag Barrier carton Rigid pail	Stand-up bag has a number of significant benefits (fossil fuel usage, carbon impact, water consumption, and municipal solid waste) over the rigid pail and barrier carton, even when taking the current recycling rate of the rigid container into consideration.
Single-serve juice-flavored beverages	Drink pouch Composite carton PET bottle Aluminum can Glass bottle	Drink pouch has a number of significant benefits (fossil fuel usage, carbon impact, water consumption) over the other formats when considering these environmental indicators. The drink pouch also results in much less municipal solid waste than all of the package formats, except for the aluminum can, which has a slight advantage based on its relatively high recycling rate.

For Flexible Packaging

- Plastic packaging has high strength-to-weight ratio and can provide excellent packaging-to-product weight ratio.
- Plastic packaging manufacturing usually generates little solid or liquid waste.
- Life cycle studies comparing the use of flexible plastic containers with rigid plastic, fiber, glass, or metal alternatives have found that the flexible packs perform as well or better across most areas of environmental impact.
- Bags and pouches use a lot less material than rigid alternatives, resulting in significant energy and water savings in production (often up to 75%).
- Flexible plastic packaging is lightweight and saves energy in transport.
- Flexible plastic packaging is versatile and inexpensive and provides reasonable product protection.
- There is a low risk of food contamination from the packaging. However, the use of recycled plastic is avoided for some food contact applications out of caution.
- Plastic packaging, if disposed to landfill, will not decompose. This results in the continuing long-term sequestration (storage) of the fossil carbon in the plastic, rather than this being released to the atmosphere as a GHG.

Against Flexible Packaging

- Plastic packaging is generally made from nonrenewable fossil fuel resources.
- The extraction of nonrenewable hydrocarbons results in the direct emission of GHG and is a significant source of risk for pollution of the local environment.
- Flexible plastic packaging is not collected by most curbside collection systems.
- Plastics films and bags are generally more difficult to sort from commingled curbside recycling streams at MRFs.
- Flexible plastic packaging is more challenging to recover because it often involves multiple polymer layers and/or a layer of aluminum, which are difficult to separate.
- Being lightweight and more likely to be blown away by wind, flexible packaging films and bags have a higher tendency to become part of the litter stream, particularly when disposed in the environment [33].
- Most plastic packaging can take hundreds of years to fully degrade and bring damage to the ecosystem.
- Virgin polymer production is energy- and chemical-intensive.
- Flexible plastics containing recycled content are uncommon and difficult to source.
- If plastic reprocessing is undertaken, it can be water-intensive (due to the washing and separation process steps).

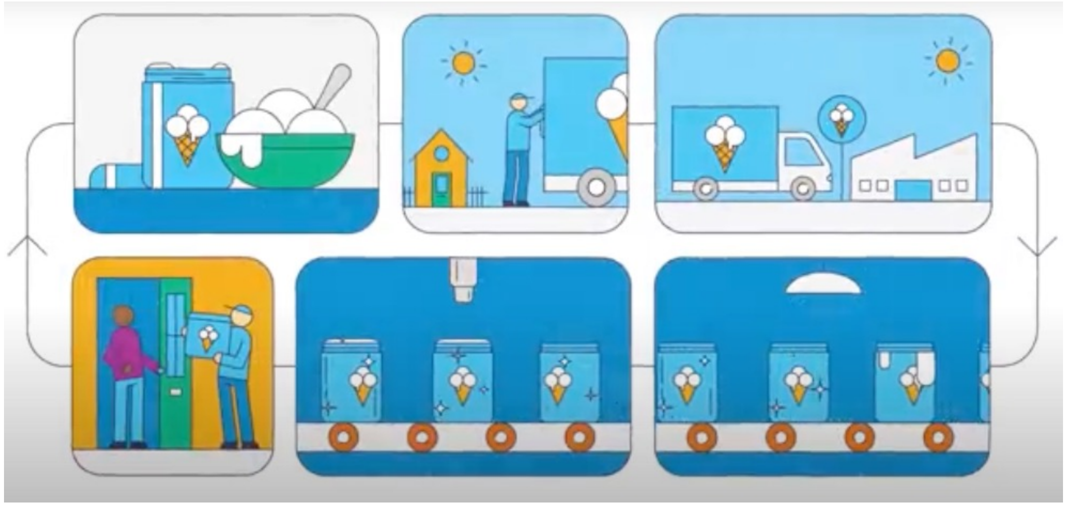
Plastics Packaging

Vision point 1: Elimination of problematic or unnecessary plastic packaging through redesign, innovation, and new delivery models is a priority.

Rethink Packaging, Product, System

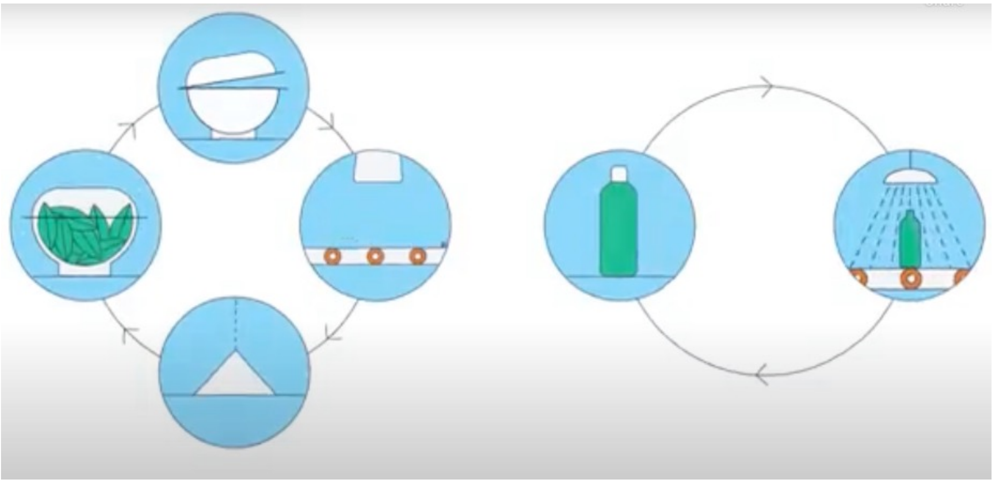
Vision point 2: Reuse models are applied where relevant, reducing the need for single-use packaging.

Plastics Packaging



Vision point 2: Reuse models are applied where relevant, reducing the need for single-use packaging.

Plastics Packaging

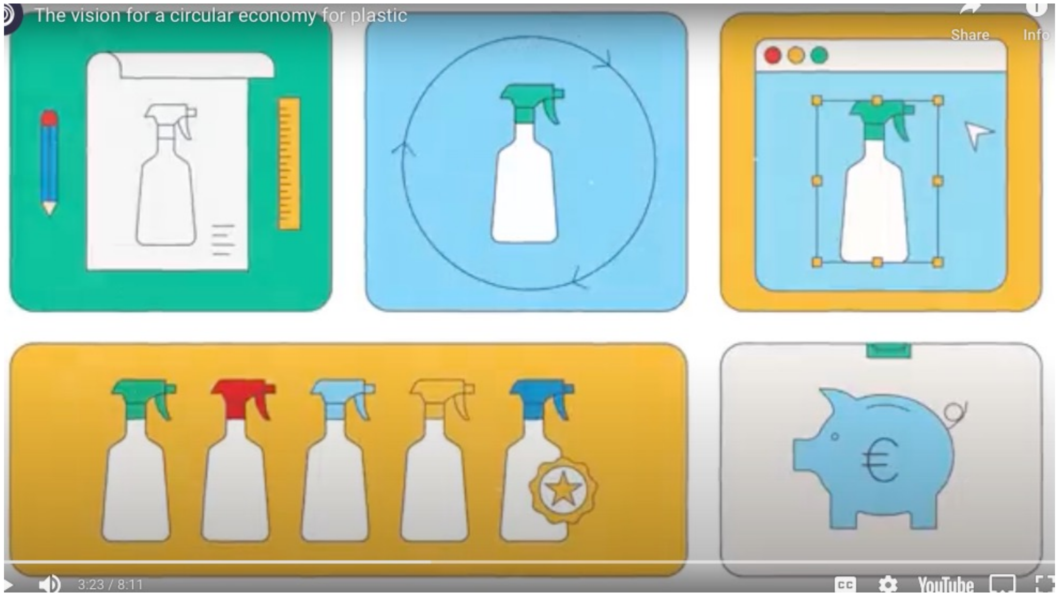


Recycle

Reuse

Plastics Packaging

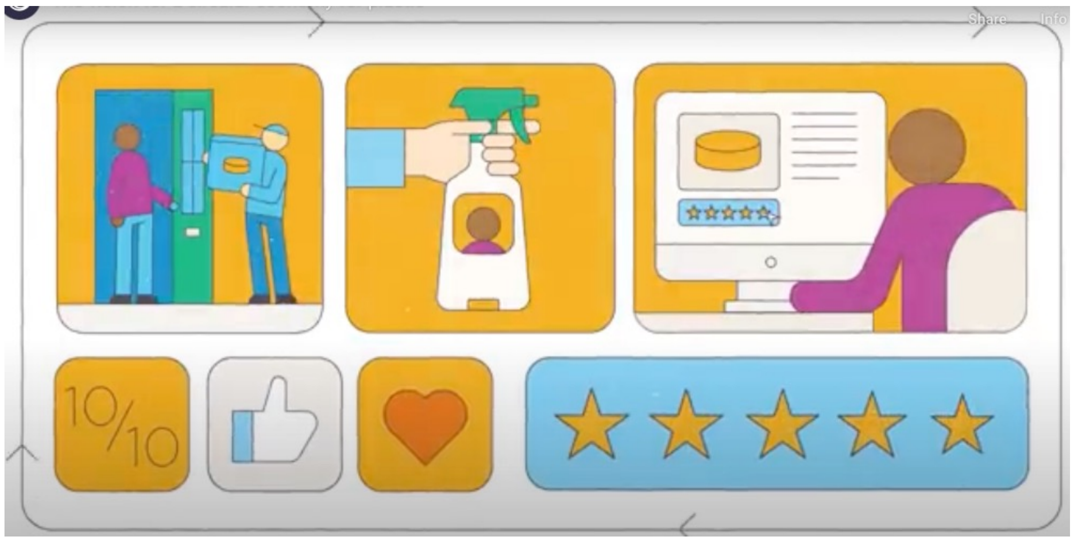
Increased quality and functionality in reuse packaging



Plastics Packaging

Standardized packaging reduces design/production costs

Plastics Packaging



Drive sales by brand loyalty through deposit and rewards schemes and personalized products and packaging (mix coke and sprite)

Plastics Packaging

Vision point 3: In a circular economy, all plastic packaging that we use is designed to be 100% reusable, recyclable, or compostable.

All packaging should be designed to fit within a system, whether a reuse, recycling or composting system.

Plastics Packaging

Vision point 4: All plastic packaging is reused, recycled, or composted in practice.

Government and business need to be involved

Plastics Packaging

Vision point 5: In a circular economy, the use of plastic is fully decoupled from the consumption of finite resources.

Use renewable energy to produce H2 to make CH3 and alkanes to make PE PP etc.

Plastics Packaging

Vision point 6: All plastic packaging is free from hazardous chemicals, and the health, safety, and rights of all people involved are respected

Plastics Packaging

https://www.youtube.com/watch?v=xmTQA-RNygQ

Plastics Packaging

What is the vision for a circular economy for plastic?

The vision for a circular economy for plastic has six key points:

1. Elimination of problematic or unnecessary plastic packaging through redesign, innovation, and new delivery models is a priority
2. Reuse models are applied where relevant, reducing the need for single-use packaging
3. All plastic packaging is 100% reusable, recyclable, or compostable
4. All plastic packaging is reused, recycled, or composted in practice
5. The use of plastic is fully decoupled from the consumption of finite resources
6. All plastic packaging is free of hazardous chemicals, and the health, safety, and rights of all people involved are respected

Plastics Packaging

The four reuse models

Business-to-consumer reuse models differ in terms of packaging 'ownership' and the requirement for the user to leave home to refill/return the packaging.

Refill at home
users refill their reusable container at home (e.g. with refills delivered through a subscription service)

Return from home
packaging is picked up from home by a pick-up service (e.g. by a logistics company)

Refill on the go
users refill their reusable container away from home (e.g. at an in-store dispensing system)

Return on the go
users return the packaging at a store or drop-off point (e.g. in a deposit return machine or imailbox)

Note: B2B packaging and 'naked'/packaging-free products are not included in this framework.

Plastics Packaging