PLASTIC FILMS

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FOLLOWED BY:

'ARE MICROPLASTICS BAD FOR YOUR HEALTH OR IS MORE RIGOROUS SCIENCE NEEDED'

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TYPES OF PLASTIC FILMS

- Polyethylene, (or more commonly, Polythene)
- Polypropylene
- Polyethylene terephthalate (Polyester)
- Polyvinyl Chloride (PVC)
- Nylon
- Various photo and bio degradables

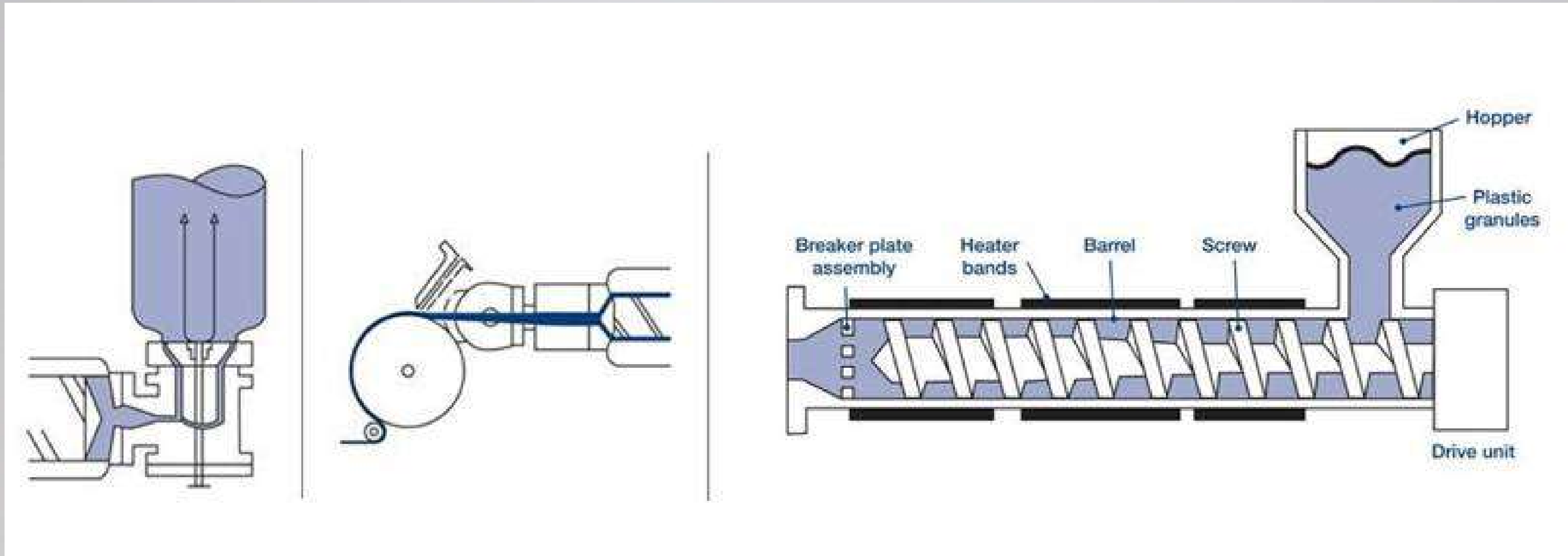
POLYTHENE FILM APPLICATIONS

- Food and other **Packaging**
- Agriculture (mulches, poly tunnels, silage etc)
- Building (damp proof membranes)
- Horticulture (sacks for composts, soils etc)
- Waste (bin bags, refuse sacks)
- Transport (stretch films)

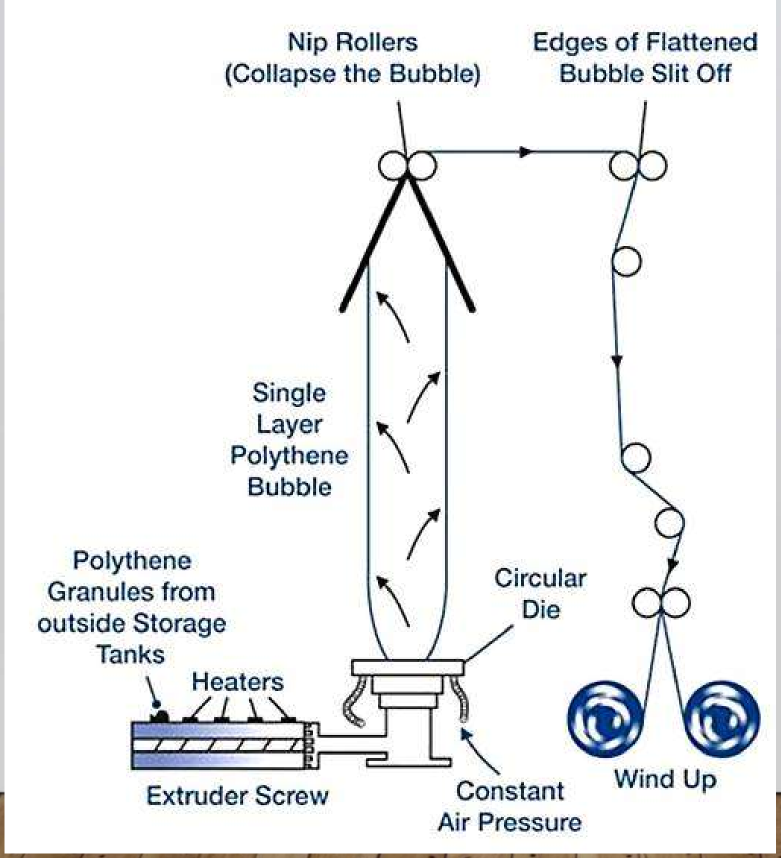
COMMON APPLICATIONS OF THE LESS COMMON FILMS

* Polypropylene: **Packaging** for biscuits, crisps and cigarettes, adhesive tapes
* Polyester: Various **packaging** uses often laminated to polythene and aluminium, Document Protection, adhesive tapes, electrical insulation, drum ‘skins’.
* PVC: Stationary items, blister packs, shower curtains, electrical tapes
* Nylon: **Packaging** and medical applications
* Degradables: Composting waste bags, **packaging**, carrier bags and now much, much more

TYPICAL FILM MANUFACTURE



TYPICAL BLOWN FILM MANUFACTURE



BLOWN FILM MANUFACTURE

CAST FILM PRODUCTION

CAST & BLOWN FILMS

- **Polythene** – 15% cast and 85% blown
- **Polypropylene** – nearly all blown
- **Polyester** – all cast and then stretched (stentered)
- **PVC** – nearly all cast
- **Nylon** – nearly all blown
- **Degradable films** – photo blown; bio a mix of cast and blown

Note: Maximum widths – blown over 18m; cast 4.0m

- Of the over 1 million tonnes of plastic film/bags used in Europe each year, most is produced by the blown technique and most is polythene.

AFTER USE, WHAT NEXT?

Recycling v Photo Degradation v Bio Degradation

(note that, currently 91% of plastics ends up in landfill or pollution). Plastic Films, even more becomes landfill.

THE RECYCLING PROCESSES

MANY PROCESSES ARE INVOLVED MAKING THIS AN EXPENSIVE AND ENERGY DEMANDING AND LABOUR- INTENSIVE ACTIVITY

SHREDDING

WASHING

SEPARATION

GRANULATION

DRYING

COMPACTION

PHOTO DEGRADABLE FILMS

Mainly conventional polythene or polypropylene with starch, cellulose or ferric carboxylate blended into the formulation.

Most commonly used in agriculture as a mulch. Rarely fully degrade in soil for years so can be a major problem.

Not a practical option for general degradable films

BIO DEGRADABLE FILMS

Cellulose Acetate and its various derivatives including:

Cellulose Sulphate, Carboxymethyl Cellulose and many others.

Has been around for decades wrapping biscuits and cigarettes where adhesives rather than heat are used to seal the products.

Also has high water absorption

These seem to fully degrade in commercial composting

Not practical to heat seal so limits on applications

BIO DEGRADABLE FILMS

Starch-based biodegradable films

Starch-based biodegradable films are often made from corn, sugar cane residue, potatoes or wheat

The original work in the 80s generated simple starch polymers which were difficult to make into commercial films. Since then, ongoing developments including fermenting the starch to **Polylactic Acid (PLA)** have improved them.

They usually require plasticisers (Glycerol or similar) plus blending with other materials to process and also to provide good physical properties. These materials can include cellulose, chitosan (see later) and reinforcement fillers.

The current most favoured fully bio-degradable film is PLA

BIO DEGRADABLE FILMS

Pros of starch-based film

- Residual material is biodegradable and compostable.
- Reduced fossil fuel content (depending on loading of filler)
- Faster degradation of litter
- No net increase of carbon dioxide in the global ecosystem

BIO DEGRADABLE FILMS

Cons

- Source of starch can be problematic (competition against food use, rainforests being cleared to grow crops for bioplastics). Poorer mechanical strength than additive based – filling a starch bag with wet leaves and placing it curb-side can result in the bottom falling out when it is picked it up.
- Degradation in a sealed landfill takes at least six months. They have a limited Shelf life.
- Some starch-based film needs to be composted in industrial facilities because the temperature of the compost needs to be at 58°C. If mixed with other plastics for recycling, the value of recycling is reduced.

BIO DEGRADABLE FILMS

Chitosan – a polysaccharide derived from chitin, a fibrous substance found in the exoskeletons of crustaceans like shrimp and crabs.

It is the second most abundant polysaccharide after cellulose.

Good film forming, biocompatible and antibacterial properties should make it ideal for packaging.

However, let down by poor mechanical properties, weak water resistance and poor thermal stability.

Attempts to improve these by blending with other lignin or polymers are ongoing.

Worth keeping an eye on future developments

NEWER BIO DEGRADABLE FILMS

Poly (butylene adipate-co-terephthalate) (PBAT) film

It is a biodegradable plastic, often marketed as a viable alternative to polyethylene.

While PBAT is biodegradable, its self-degradation can take longer than some in nature and can become crispy and challenging to degrade after exposure to ultraviolet (UV) light. However, it does compete with PLA in some applications.

Polyhydroxyalkanoates Film Materials

Polycaprolactone (PCL) is a green, non-toxic synthetic aliphatic polyester material with numerous advantages on flexibility, processing and much more

However, it has the characteristics of poor water solubility, slow degradation, low melting point and poor mechanical strength, so it needs to be modified in the actual use process. Work in progress

NEWER BIO DEGRADABLE FILMS

Polybutyl Succinate (PBS)

Can be produced from both petrochemicals and renewable sources such as sugarcane.

Similar properties to polythene. As very expensive, often blended with other polymers; some natural like plasticised whey protein so it fully degrades: Some with synthetic copolymers which inevitably would leave microplastics when degraded. Also, high cost likely to limit much development

Polyhydroxylalkanoates (PHA)

Produced by microbial fermentation engineering using sugars and lipids.

Has to be blended, often with Lignin nanoparticles to improve thermal stability and strength.

Again, high cost but ongoing development. Can be produced from natural resources and it fully degrades so worth keeping an eye on.

NEWER BIODEGRADABLE FILMS

Polycaprolactone Film Materials (PCL)

Polycaprolactone is a non-toxic synthetic aliphatic polyester material with numerous advantages on flexibility, processing and much more

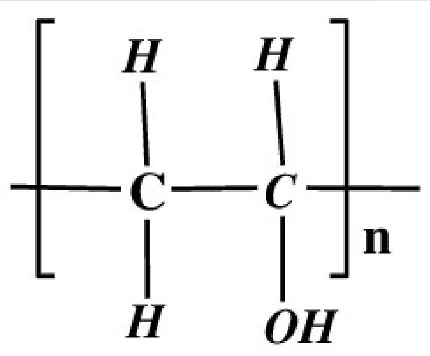
However, it has the characteristics of poor water solubility, slow degradation, low melting point and poor mechanical strength.

Most recent success has been with blends including poly lactic acid and green tea extract to give enhanced barrier and mechanical properties.

Again, more work needed for this petroleum derived film.

HYDRODEGRADATION

PVA or PVOH – Polyvinyl alcohol



Water soluble and breaks down to carbon dioxide and water

Used in laundry 'pods' and similar

Unlikely to find much of a wider market

OTHER WAYS TO FULLY DEGRADE PLASTIC FILMS

Wax worms

The larvae of the wax moth Galleria mellonella can eat polyethylene bags. Researchers found that enzymes in wax worm saliva can break down polyethylene.

Mealworms

The larvae of the beetle Tenebrio molitor can eat Styrofoam, polyethylene, polyvinyl chloride, and polyurethane. They process the plastic with microorganisms in their digestive tracts.

The idea of using **insects** to break down plastic is environmentally sustainable, cost-effective, and doesn't require special conditions. The larvae's excrement can also be used as compost.

However, the process is still too slow to solve the plastic crisis.

OTHER WAYS TO FULLY DEGRADE PLASTIC FILMS

Natural breakdown from fungal species such as Phanerochaete chrysosporium, Aspergillus, Cladosporium, Fusarium, Penicillium and Phanerochaete also just takes so long.

SUMMARY

- Plastic pollution continues to be a huge problem and shows no sign of getting any better.
  Materials such as PET and HDPE/LDPE are 'necessary evils' – solving some problems while creating others, because of their persistence in the environment.
  Plastic film is getting thinner and thinner, making it all but worthless to recycle – but without it, food doesn't last as long and organic waste balloons.
- Compared to traditional plastic films, bio and hydro degradation films are more expensive to produce and have poorer mechanical and barrier properties but work continues to address these issues.

It's a complicated problem that is not going to be fixed with a single simple answer. Just use less until something better is developed!

ARE MICROPLASTICS BAD FOR YOUR HEALTH?

And Is More Rigorous Science is Needed?

RECENT RESEARCH

March last year – Reported that microplastics were found in deposits of fat in arteries (arterial plaques) and those with this condition were more likely to experience heart attacks or strokes.

Since it was published this study has been mentioned more that 6,600 times on social media and more than 800 times in news articles and blogs.

So, this caused a lot of understandable concern among the general public.

RECENT RESEARCH

Other studies have followed.

Many however, rely on small sample sizes and lack appropriate controls

For example, modern laboratories are themselves hotspots for nano and microplastics and approaches that are being used to detect plastics make it hard to rule out the possibility of contamination or prove definitively that plastics are in the sample.

Also, many findings are not biologically plausible based on what is known about the movement of tiny particles within the human body (examples follow)

What we do know is that micro/nano plastics are everywhere and Danish researchers calculated that we inhale over 3000 of these particles every day.

RECENT RESEARCH

Techniques used to determine whether these particles have accumulated in the body include:

+ **Pyrolysis gas chromatography mass spectrometry** – this uses high temperatures (over 600c) to break down everything to a mix of molecules to provide a ‘signature’ that researchers can use to assess whether plastics were present. Some compounds are produced that indicate the presence of plastics can be produced when none-plastic substances are pyrolyzed. Fatty acids break down to the same compounds as polyethylene!

+ **Energy dispersive X-ray spectroscopy with scanning electron microscopy** can reveal the presence of carbon-based molecules but not what they were part of originally.

RECENT RESEARCH

A study published this year examined 91 brains from autopsied bodies and found that almost 1% was plastic particles – that equivalent to 4.5 plastic bottle tops.

Finally, other studies have reported the presence of large plastic particles up to 3mm in length in human blood samples and another found microplastics up to 25 micron in brain tissue suggesting that they were inhaled and then travelled along the nerves to the olfactory bulb in the brain.

Yet previous research suggests particles bigger than 1 micron are probably too big to pass through the lung's blood-air barrier and any particle bigger than 10 microns is too large to pass through the gut-blood barrier

RECENT RESEARCH

This is not to say there is no problem with micro/nano plastics – far from it

Just be aware that some frightening announcement in the press might just be a PhD researcher, looking for more funding, not doing all the basics correctly.

QUESTIONS