



Plastics & Recycling

With Dustin Hoffman and Clint Eastwood



Circa 1967



My POV

- **My Father was a Chemical Engineer who (briefly) managed a Polyester Resin Plant**
- **I have a degree in Environmental Engineering**
- **I've spent my life using and disposing of Plastic**

What are Plastics?

- **Synthetic organic polymers**
- **In other words:**
- **Manmade containing carbon in long chains**
- **Comes from Greek “plastikos” – can be shaped and molded**
- **Primary source is hydrocarbons from petroleum and natural gas**

Qualities of Plastics

- **Cheap versus other options**
- **Lightweight (& strength to weight ratio is high)**
- **Durable**

These are both blessings and curses

Contents of Plastics

- Carbon
- Hydrogen
(always)
- Oxygen
(often)
- Nitrogen
- Chlorine
- Fluorine

(make it permanent like PVC)

Sulfur, and many other chemicals for specific qualities they add

Early History of Plastics

- **1862 – Celluloid - nitrocellulose and camphor resin**
- **1907 – Bakelite - formaldehyde and coal tar**
- **1930's – Nylon (Dupont), Plexiglass, Polystyrene, Saran Wrap, Kapton insul**

Post WWII Proliferation Life Magazine 8/1/1955



Throwaway Living

DISPOSABLE ITEMS CUT DOWN HOUSEHOLD CHORES

The objects flying through the air in this picture would take 40 hours to clean—except that no housewife need bother. They are all meant to be thrown away after use. Many are new; others, such as paper plates and towels, have been around a long time but are now being made more attractive.

At the bottom of the picture, to the left of a New York City Department of Sanitation trash can, are some throwaway vases and flowers, popcorn that pops in its own pan. Moving clockwise around the photograph come assorted frozen food containers,

a checkered paper napkin, a disposable diaper (seriously suggested as one reason for a rise in the U.S. birth rate) and, behind it, a baby's bib. At top are throwaway water wings, foil pans, paper tablecloth, guest towels and a sectional plate. At right is an all-purpose bucket and, scattered throughout the picture, paper cups for beer and highballs. In the basket are throwaway draperies, ash trays, garbage bags, hot pads, mats and a feeding dish for dogs. At the base of the basket are two items for hunters to throw away: disposable goose and duck decoys.

THROWAWAY LIVING CONTINUED



FEEDING BOWL for pets comes with a wrought-iron stand and disposable, waterproof bowls to eliminate washing-up chore. Stand and six dishes cost \$1.



DISPOSA-PAN eliminates scouring of pots after cooking. It consists of steel frame and heavy foil pans to throw out. Frame with eight pans is \$2.98.



BARBECUE GRILL is meal cooker with stand, asbestos shell and wire grill, charcoal to last one hour and excelsior topping for a quick light. It costs 79¢.



PETE



HDPE



V



LDPE



PP



PS



OTHER

Chemistry of Common Plastics

1. PET – Polyethylene Terephthate ($C_{10}H_8O_4$)
2. HDPE – High Density Polyethylene (C_2H_4) $_n$
3. PVC – Poly Vinyl Chloride (C_2H_3Cl) $_n$
4. LDPE – Low Density Polyethylene (C_2H_4) $_n$
5. PP – Polypropylene (C_3H_6) $_n$
6. PS – Polystyrene (C_8H_8) $_n$
7. Polycarbonate ($C_{16}H_{14}O_3$) $_n$

Plastics Production: 400 million metric tons

1. PET – 9%
2. HDPE – 13%
3. PVC – 10%
4. LDPE – 16%
5. PP – 18%
6. PS – 6%
7. Other, including polyester, polyamide and acrylic fibers – 28%

Alphabet Soup of other Plastics

- **ABS** – related to polystyrene
- **PU** – polyurethane
- **PA** – nylon
- **PCE** – cleaning solvent
- **PEEK** - polyetheretherketone
- **PEI** – Ultem, similar to polycarbonate
- **PF** – Bakelite
- **PMMA** – epoxy, plexiglass, lucite
- **PSU** – high temperature
- **PTFE** –Teflon

And More

- **MF – melamine**
- **UF – urea formaldehyde (wood adhesive)**
- **Polyamide – Kapton**
- **Silicone**
- **MX – a mixture of any of the above**

Bio-Plastics

- **PLA – bio degradable (at high temperatures)**
- **Furan- resin in foundry sands**
- **Plastarch – thermoplastic from cornstarch**
- **PHB**

Behavioral Psychology of Plastics

- **Symbolizes abundance and prosperity**
- **Packaging encourages overeating – impulse buying**
- **Water in plastic bottles is sold as “safer” – true in some regions**
- **Littering is a behavior rising out of minimal perceived value of plastic**



Recycling

Plastics and others



Two Definitions of Recycling

- **Recovering and reprocessing waste materials for use in new products**

- **Allowing consumption of goods and services that meet basic needs and quality of life without jeopardizing the needs of future generations**

Recycling in History

- **Origins in modifying something for reuse to overcome scarcity**
 - 1. Monks washed the ink from parchment to reuse**
 - 2. Artists painted over canvases**
 - 3. Building materials like stone, brick and metals were scavenged**
 - 4. Depression era Americans saved or patched for reuse**

Today, it is a side effect of abundance. People discard old to buy new.

Recycling in the early 20th Century

- Returnable milk bottles – bottle exchanges cleaned and redistributed
- Glass Coke bottles – on average used 22 times

Current Recycling Levels

- Iron and Steel – 70%-90% is recycled
- Office paper – more than 50%
- Cardboard – similar to Iron & Steel
- Aluminum – 35% overall, 50% of cans
- Electronics waste – 12%- 17%
- Plastics – 5 - 9%

Economics of Recycling

- **Depends on cost and quality of recycled product compared to virgin**
- **Sorting mixed products can be difficult**
- **Energy and water use are often significant factors**
- **Life Cycle Analysis is a feasible and fair way to compare**
- **Facilities require investments and market for recycled products changes**

Behavioral Psychology of Recycling

- **Confronting people with the waste we generate**
- **Virtue signaling**
- **Atonement**
- **Producers transfer responsibility to consumers**
- **Once it leaves the curb, we did our part**
- **Incentives like can and bottle deposits work**
- **What really happens to our recycling?**

History of U.S. Plastics Recycling

- **Keep America Beautiful 1953 – originally anti litter**
- **Chasing Arrows logo designed in 1970**
- **Curbside recycling starts in 1981**
- **“7 types of Plastic” with chasing arrows 1988**
- **Single stream recycling starts in 1992**
- **China stops taking our plastic in 2018**



The Good, The Bad, and the Ugly

Enter Clint Eastwood





Good of Plastic Recycling

- **Drink bottles (PET-#1) and Milk bottles (HDPE-#2)**
- **Most other thermo-plastics can be recycled if segregated**
- **Mixed plastics can be burned for energy if not sortable**
- **Movements like Plastic Free July are effective in building awareness**
- **Infrastructure and research improving options**
- **Bio – plastics hold promise**
- **US and Europe are not large sources of ocean plastics**

Bad of Plastics Recycling

- **Thermoset plastics are difficult to recycle**
- **90% of ocean plastics come from 10 rivers in Asia and Africa, or maybe not**
- **Bio-plastics are hard to distinguish from petroleum-based ones**
- **Incinerating plastics adds GHG and can release toxic chemicals**
- **Recycling alone will probably never scale enough to eliminate disposal**



Ugly of Plastics Recycling

- **Turtle w/straw – goes on for 8 minutes**
- **There are 5 “garbage patches” in the oceans today**
- **Beaches are littered by people who use the beach as well as by currents**
- **Micro-plastics are ubiquitous**
- **10,000 shipping containers per year are lost at sea, many filled with plastics**
- **1000 year life of plastic was made up by a 9 year old**
- **in East Palestine, Ohio, several train cars filled with mono-vinyl chloride derailed and were deliberately ignited**

A Better Future

- Research is finding substitute materials and new recycling methods
- Recycling programs improve awareness & commitment of consumers
- Plastics should be priced to include reuse, recycling, or disposal cost
- Life Cycle Analysis can be mandated and reduce opacity of information
- Move capture upstream: ocean → river → sources
- Design plastics to breakdown
- Reduce, Refuse, Reuse



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Jay True
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