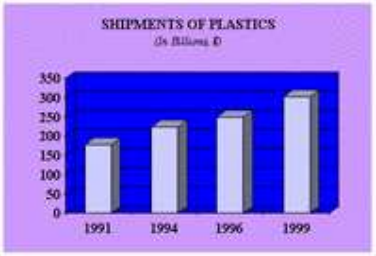
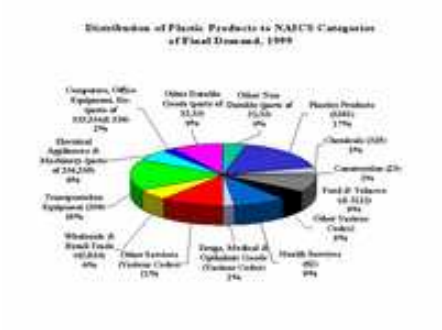
Polymers

- Source and Uses of Plastics
- Polymer Synthesis
- Polymer Structure & Properties
- Paper or Plastic?

U.S. Plastic Production



Plastic Uses

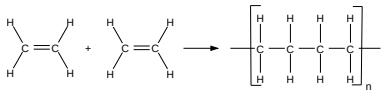


Source of Plastics

The raw materials (monomers) for plastics come from crude oil (petroleum). Shown below are the typical uses for a barrel of crude oil. *(See textbook Figure 9.9, p 377).*

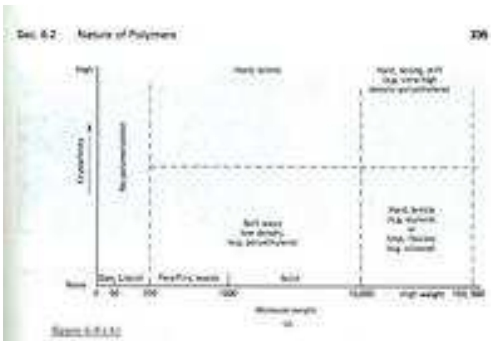
Use	Gallons	%
Gasoline	19.7	47%
Diesel/Home heat	8.4	20%
Jet Fuel	4.2	10%
Lubricants/wax/...	4.2	10%
Boiler Oil	2.9	7%
Asphalt	1.3	3%
Chemicals	1.3	3%

Polyethylene Synthesis



Polymers typically contain between 50-100,000 monomer units.

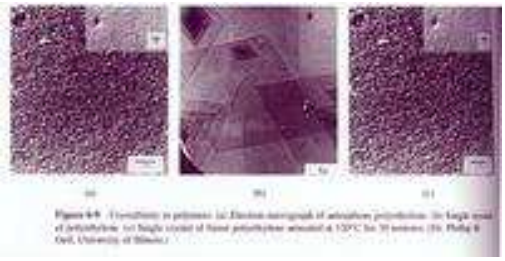
Polymer Properties



Degree of Crystallization

Higher degrees of crystallization give rise to more rigid, higher melting plastics.

Heat and Crystalline Structure



Polyethylene Properties

- Long (spaghetti-like) strands
- “No” attraction between strands
- Arrangement gives varying crystallinity
- “Necking” or processing orients strands

HDPE

High-Density Polyethylene

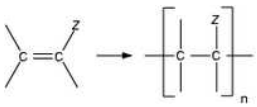
- High molecular weight (n $\simeq$ 10,000)
- Little branching
- Higher melting point than LDPE (130°C).
  - Dishwasher-safe
- Uses:
  - Milk and water jugs, gasoline tanks, cups, ...

LDPE

Low-Density Polyethylene

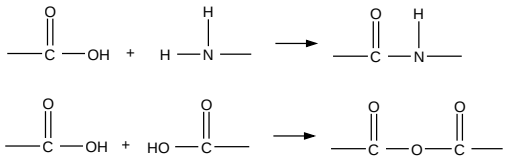
- Low molecular weight (n$\simeq$ 500)
- High-degree of branching
- Lower melting point than HDPE (100-125°C)
- Lower strength
- Uses:
  - Plastic bags, toys, electric insulation, ...

Polyolefins



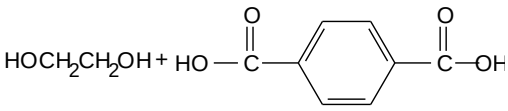
Monomer	Name	Uses
CH_2=CHCl	PVC	Pipes, ...
CH_2=CH-C_6H_5	Polystyrene	Styrofoam, ...
CH_2=CH-CH_3	Polypropylene	Bottle caps, ...
CF_2=CF_2	Teflon	Non-stick coating, ...

Condensation Polymers



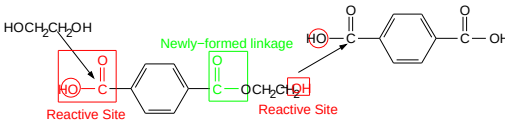
In both cases, water (H_2O) is formed.

Polyethylene Terphthalate



Reaction of monomers to make PET.

Polymerization of PET



Uses:

- Clothing, soft drink bottles, videotapes, ...

Nylon

$H_2N\text{-}(CH_2)_6\text{-}NH_2$ + $HOOC\text{-}(CH_2)_4\text{-}COOH$

Uses:

- Clothing, ...

Modifying Polymer Properties

Your text lists six strategies for modifying polymer properties

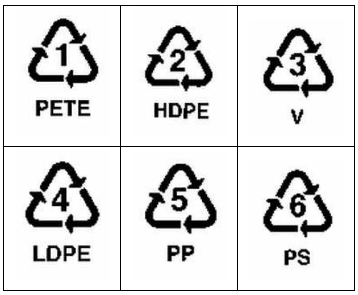
- Vary chain length
- Vary 3D arrangement of solid
- Change degree of branching
- Modify composition of monomers
- Alter bonding between chains (cross-linking)
- Change orientation of monomers within chains (tacticity)

Tacticity

Arrangement of individual monomer units in polymer may vary

- $–(CH_2\text{-}CHCl)–(CH_2\text{-}CHCl)–(CH_2\text{-}CHCl)–$
  - Head-to-tail
- $–(CH_2\text{-}CHCl)–(CHCl\text{-}CH_2)–(CH_2\text{-}CHCl)–$
  - Head-to-head
- Random arrangment also possible
  - Typically gives rise to more flexible material

Recycling



See textbook, Table 9.1 (p 366) for properties and uses of each

Density

Polymer	Density	Comments
PP	0.90-0.91	Floats on water
LDPE	0.92-0.94	
HDPE	0.95-0.97	
PS	1.05-1.07	Sinks in water
PETE	1.38-1.39	
PVC	1.18-1.65	

Recycling Costs and Benefits

Pro

- Less crude oil required
- Less landfill space required

Con

- Recycling chemistry still not “ideal”

Alternative

- Burning plastic generates energy

Paper or Plastic?

Paper	Plastic
Renewable source	<3% of crude oil used
Biodegradable	Less space
“Safer“	Cheaper
Technology “works“	Less energy to produce

Plastics industry has a web site “explaining” why recycling isn’t necessary.