Polymers

By:-
ASMA PARVEEN
Department of Industrial Chemistry
Brahmanand College,Kanpur

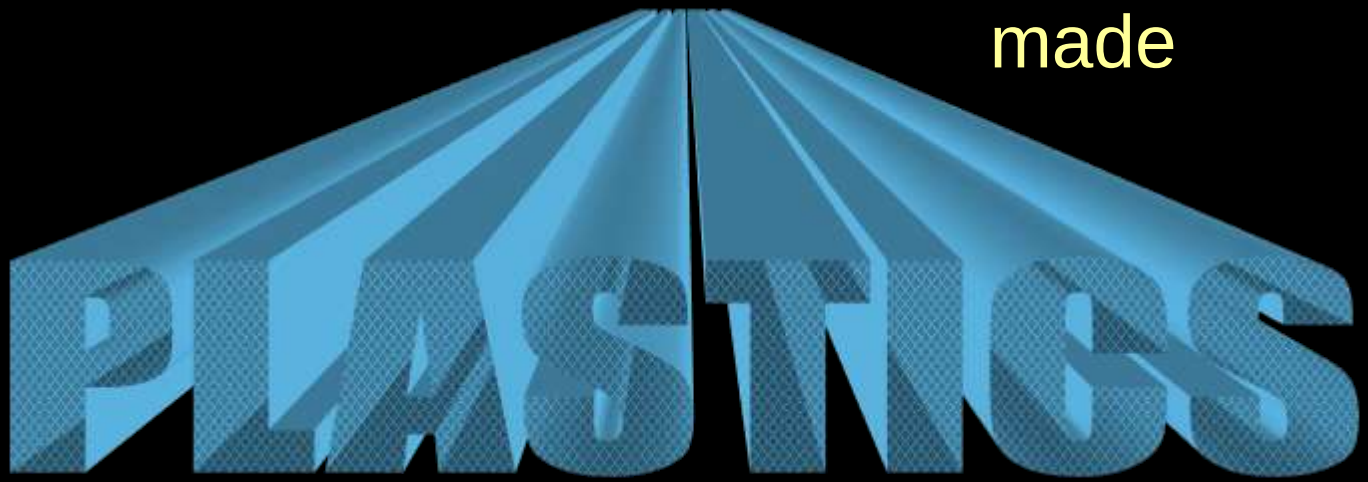

WELCOME TO
POLYMER
PLANET


POLYMERS ARE EVERYWHERE
H
O
H

Polymer

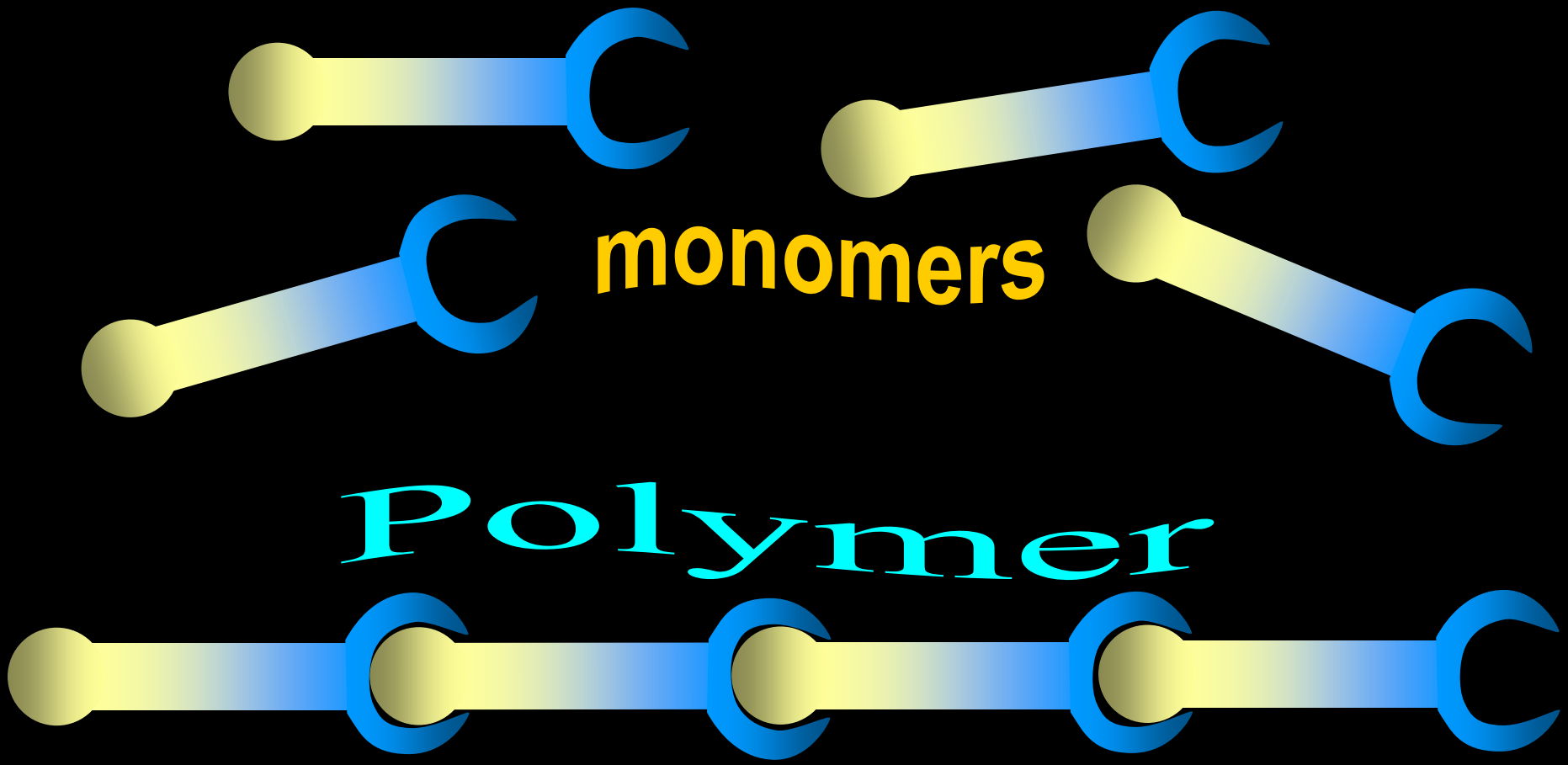
Many + Parts

This name hints at how polymers are made



Latin: Plasticus, that which can be molded

This name honors plastics useful property of being easily molded

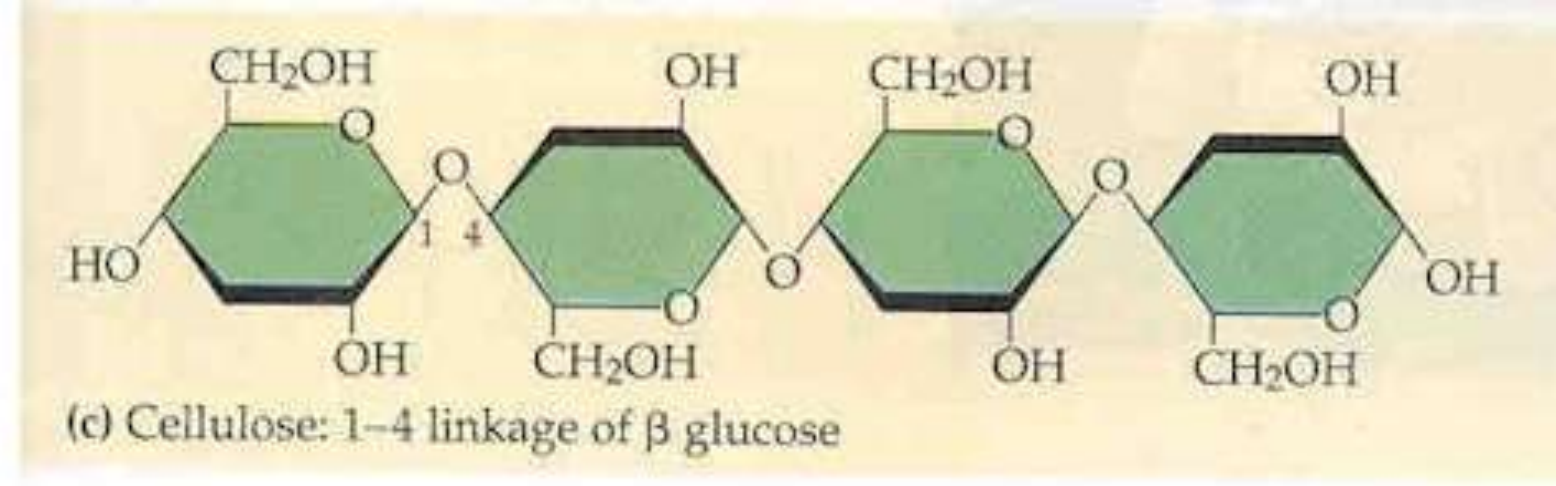


The word, polymer, implies that polymers are constructed from pieces (monomers) that can be easily connected into long chains (polymer). When you look at the above shapes, your mind should see that they could easily fit together.

Cotton: a natural polymer

What is its building block (monomer)?

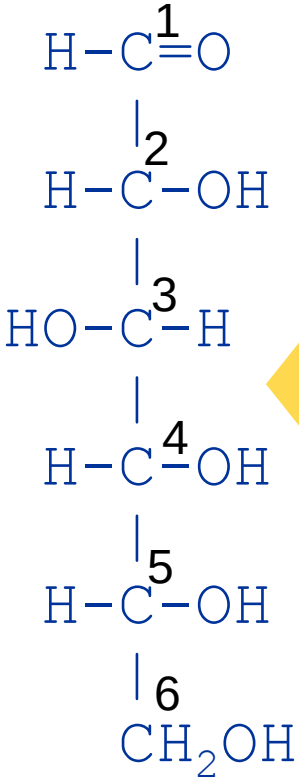
Cotton fiber is mostly cellulose, and cellulose is made of chains of the sugar, glucose linked together a certain way.



(c) Cellulose: 1–4 linkage of β glucose

Glucose

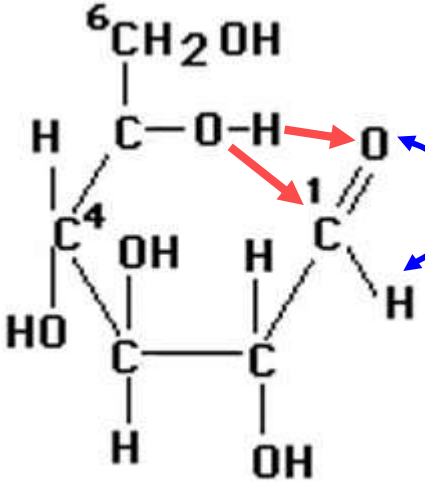
Structural formula.
Straight chain glucose



bends

Glucose

glucose bending

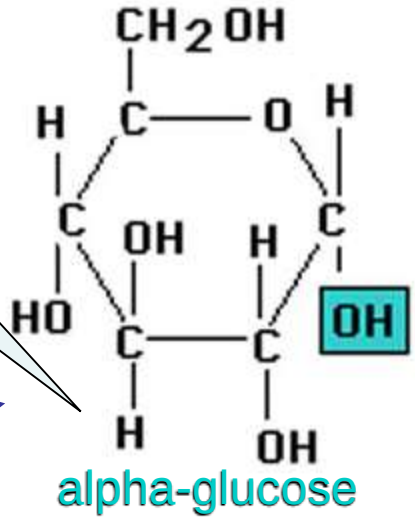


flips either way

Glucose

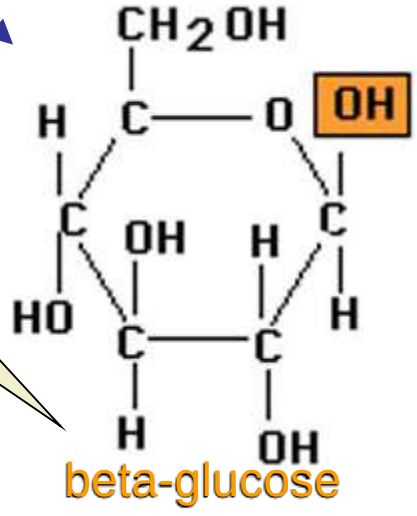
Two ring-shape versions

Used in making starch



alpha-glucose

Used in making cellulose



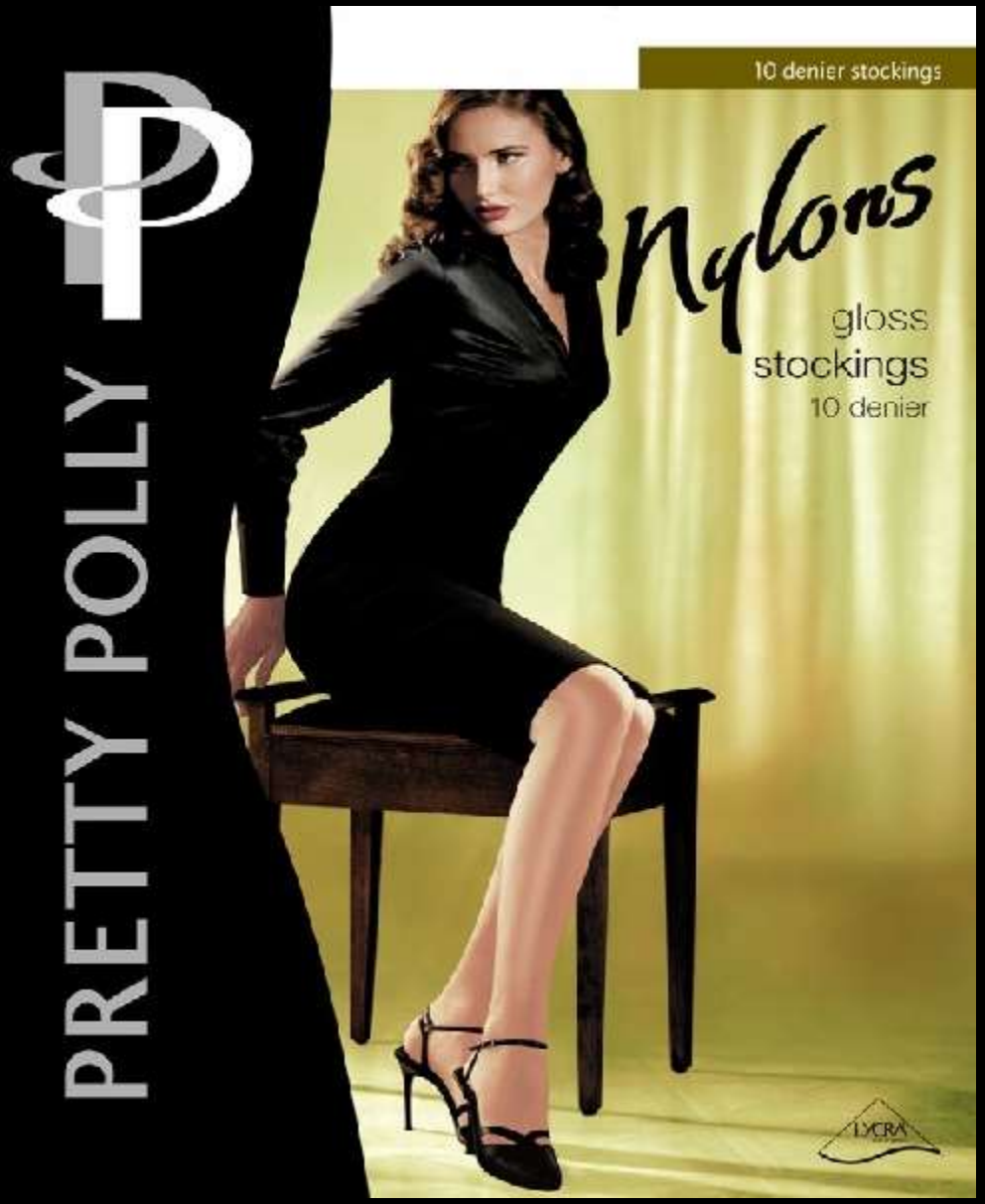
beta-glucose

Glucose bends itself into 4 different shapes **millions** of times a second

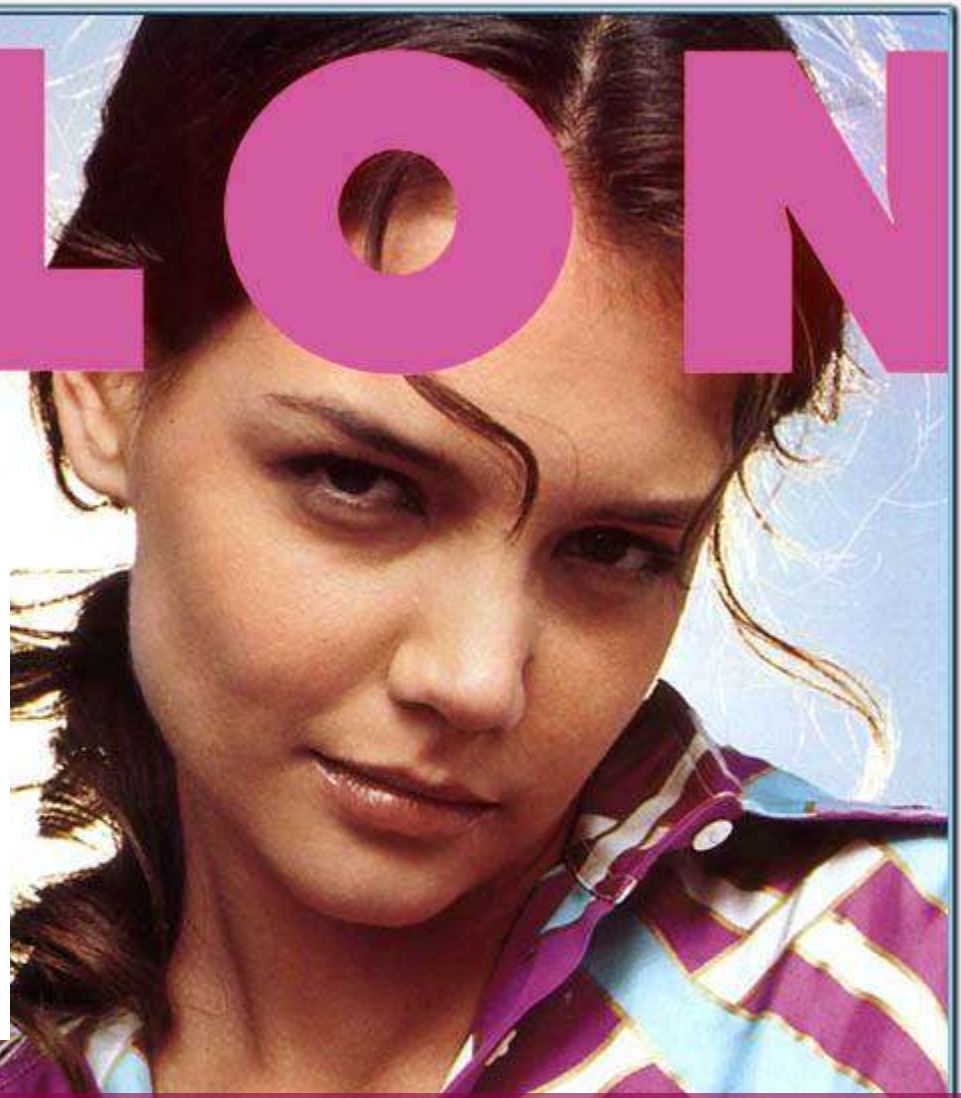
NYLON

A man-made polymer


Nylon in Tires and Rope
and Clothes


PRETTY POLLY
10 denier stockings
Nylons
gloss
stockings
10 denier
LYCRA

NYLON



Nylon is used in clothes, shoes, jackets, belts, and accessories. It's not surprising a magazine is named after this polymer. Where did nylon get its name?

Nylon was discovered in 1935. The name nylon is derived from two cities where it was discovered namely New York (NY) and London (LON).

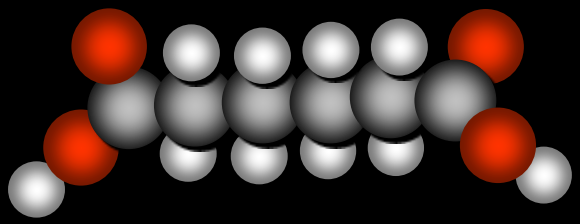
Two ingredients are mixed and a solid begins to form at the junction between the two layers of liquid.

Hot nylon spaghetti can be extracted.

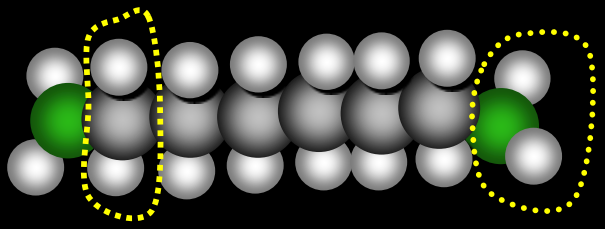
We say certain polymers are man-made, but the truth is they make themselves. Humans only have to get the ingredients near each other. The chemicals will assemble themselves.

The students are handling the nylon string that was produced. Notice there's some kind of odor that is being noticed.

Tetramethylene dicarboxylic acid (adipic acid)



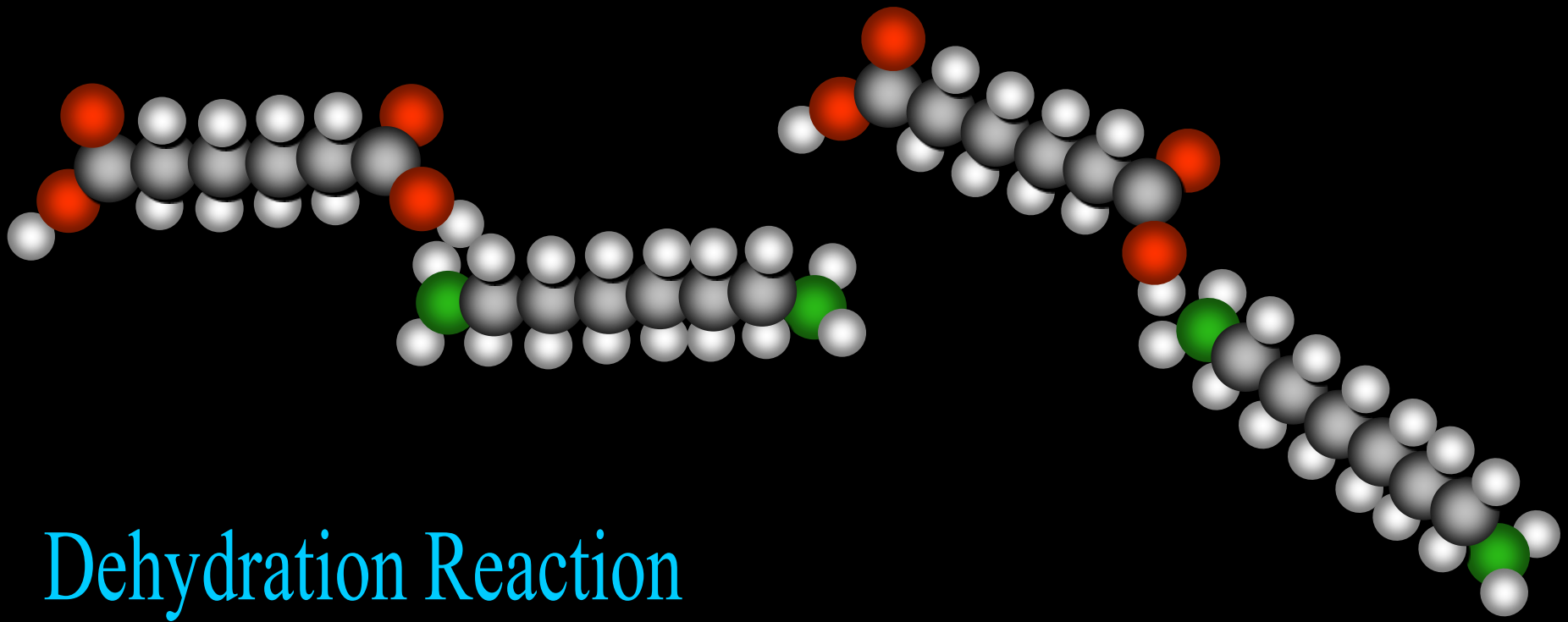
Hexamethylene diamine



methylene x 6 (hexa)

amine x 2 (di)

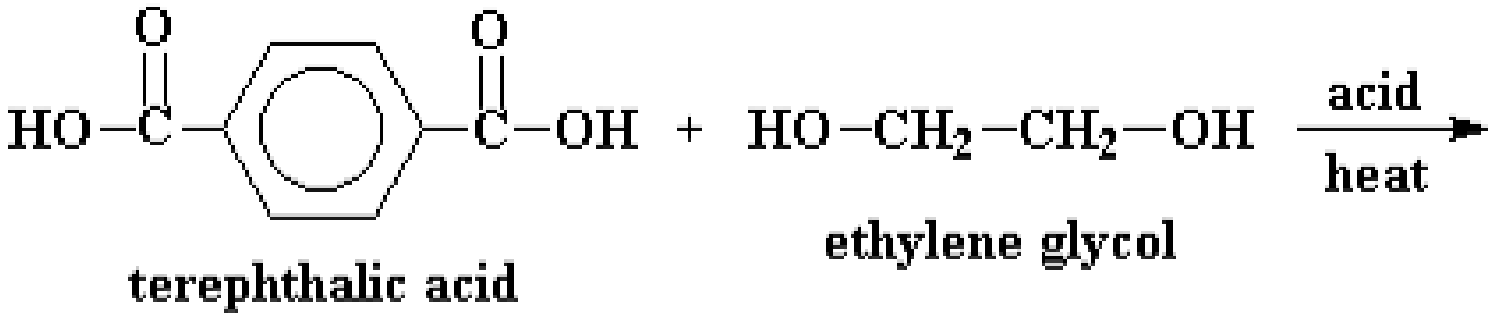
Nylon is actually a “copolymer” because is it made from two monomers. When these two monomers are in the same beaker, they combine and give off a molecule of water. This is called a “dehydration” reaction because we are taking away (*de*) water (*hydra*). (regarding odor: amines smell like fish or worse. Adipic acid is odorless)



Dehydration Reaction

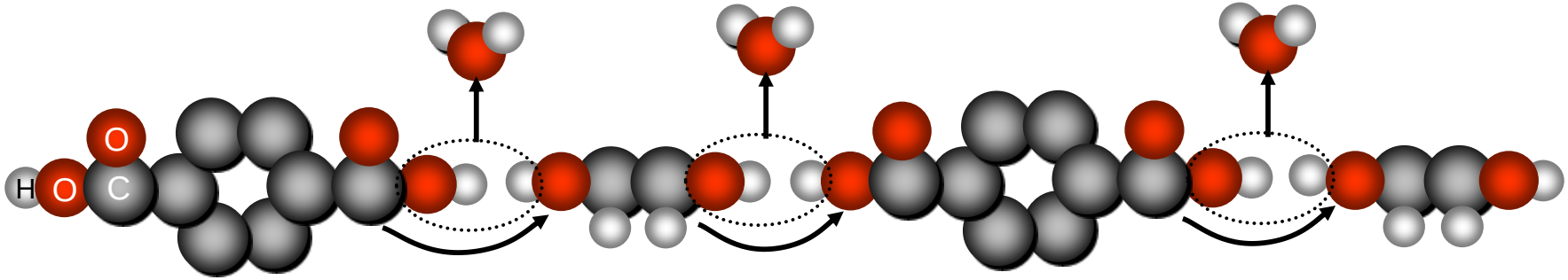
Polyester is a another copolymer. It is made from equal amounts of two different monomers. Polyester is used to make bottles and fabrics.

Polyester is made from the two monomers, terephthalic acid (note: “ph” is silent) and ethylene glycol (car antifreeze). This makes a popular plastic called PETE, which is short for Polyethylene Terephthalate. The synthesis is also a *dehydration* reaction because water is given off.

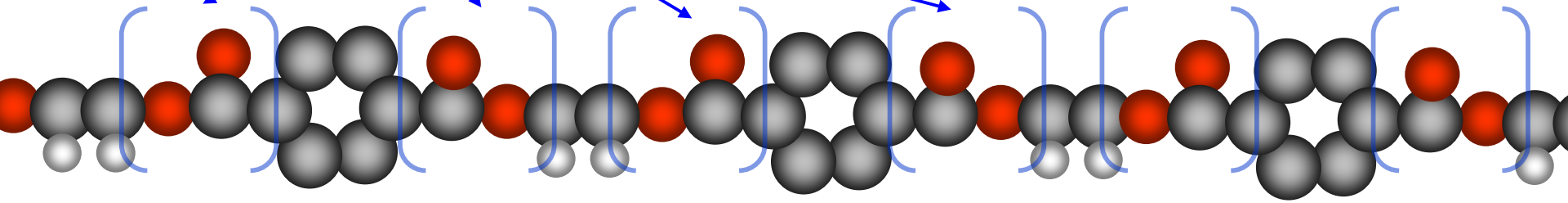


terephthalic acid

ethylene glycol



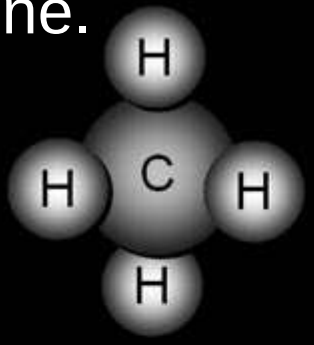
ESTER groups formed Hence the name POLYESTER



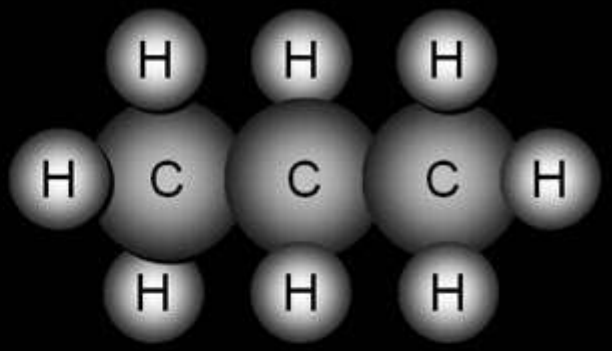
A polymer made form just one monomer is polyethylene. It is the most common plastic you see.

It is used for bottles, buckets, jugs, containers, toys, even synthetic lumber, and many other things.

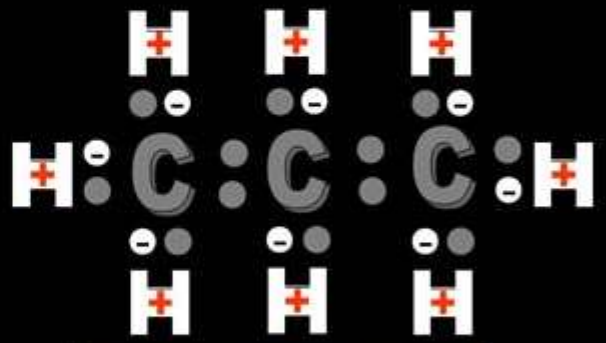
Before we show how polyethylene is made from its monomer, ethylene, let's review the structure of some similar compounds to ethylene.



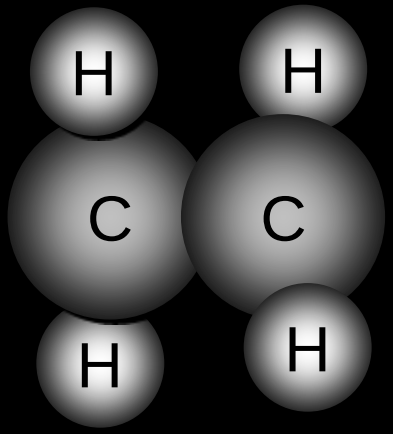
Methane
(natural gas)

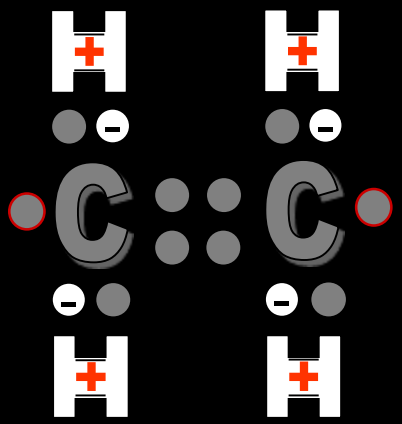


Propane

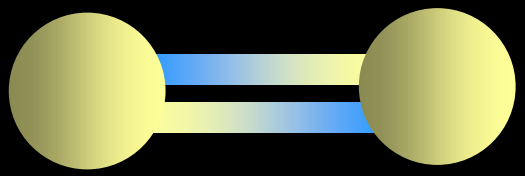


Ethylene has two carbons; plus, instead of the two carbons sharing just one electron each, they share two electrons each. High temperature or UV light can cause two of these shared (paired) electrons to become unshared (unpaired).

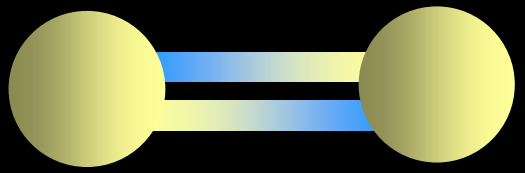




These unpaired electrons are eager to pair up with another electron. If this ethylene molecule bumps another ethylene molecule, the unpaired electrons will cause the one it bumped into to lend one of its inner electrons.

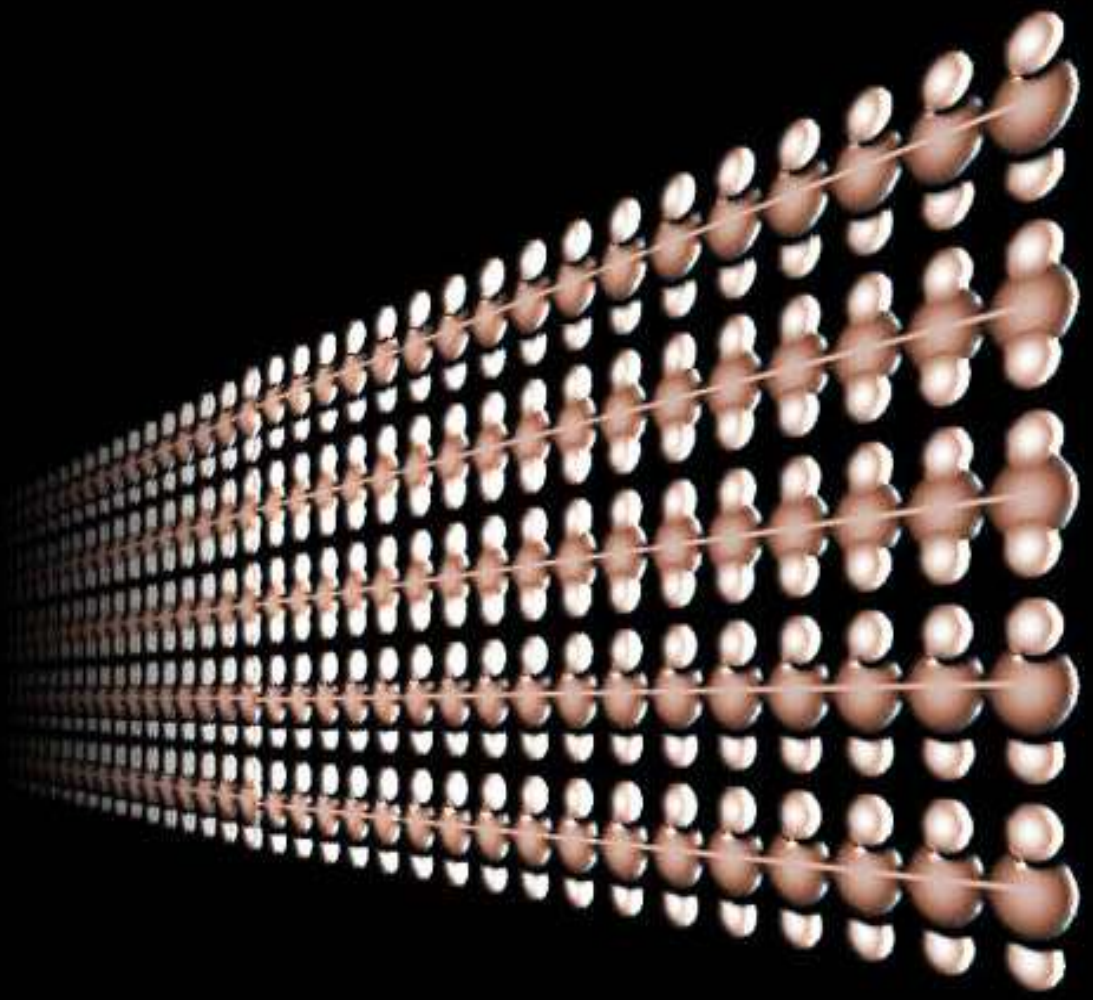


Here’s another way to see the chain reaction. These are the carbon atoms with their double-bond (2 shared electrons each). The hydrogen atoms are not shown. A collision breaks the first bond.

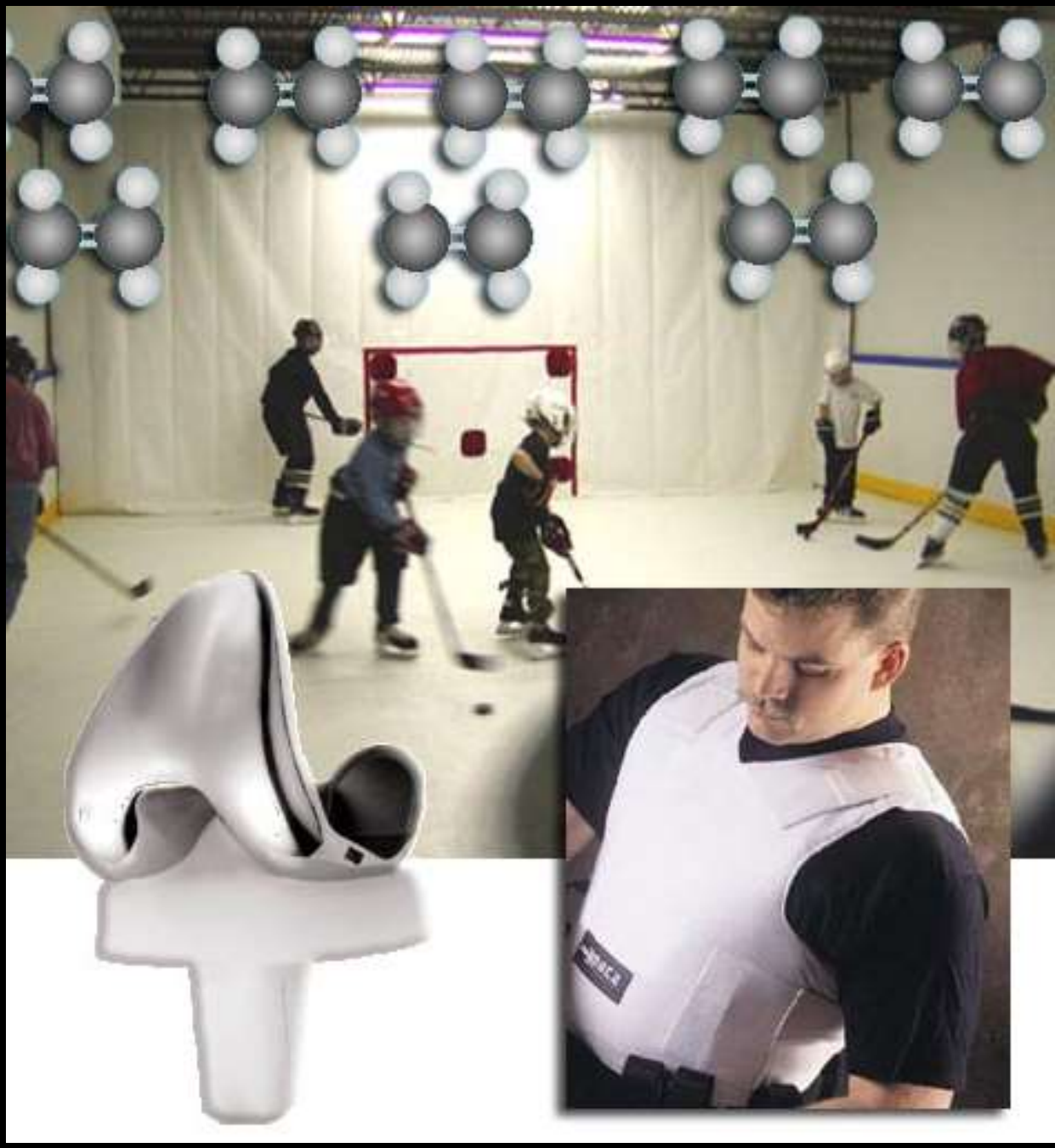


Once the first double bond is broken, a chain reaction will occur. In about a second an entire chamber of compressed ethylene gas turns into the polymer, polyethylene.

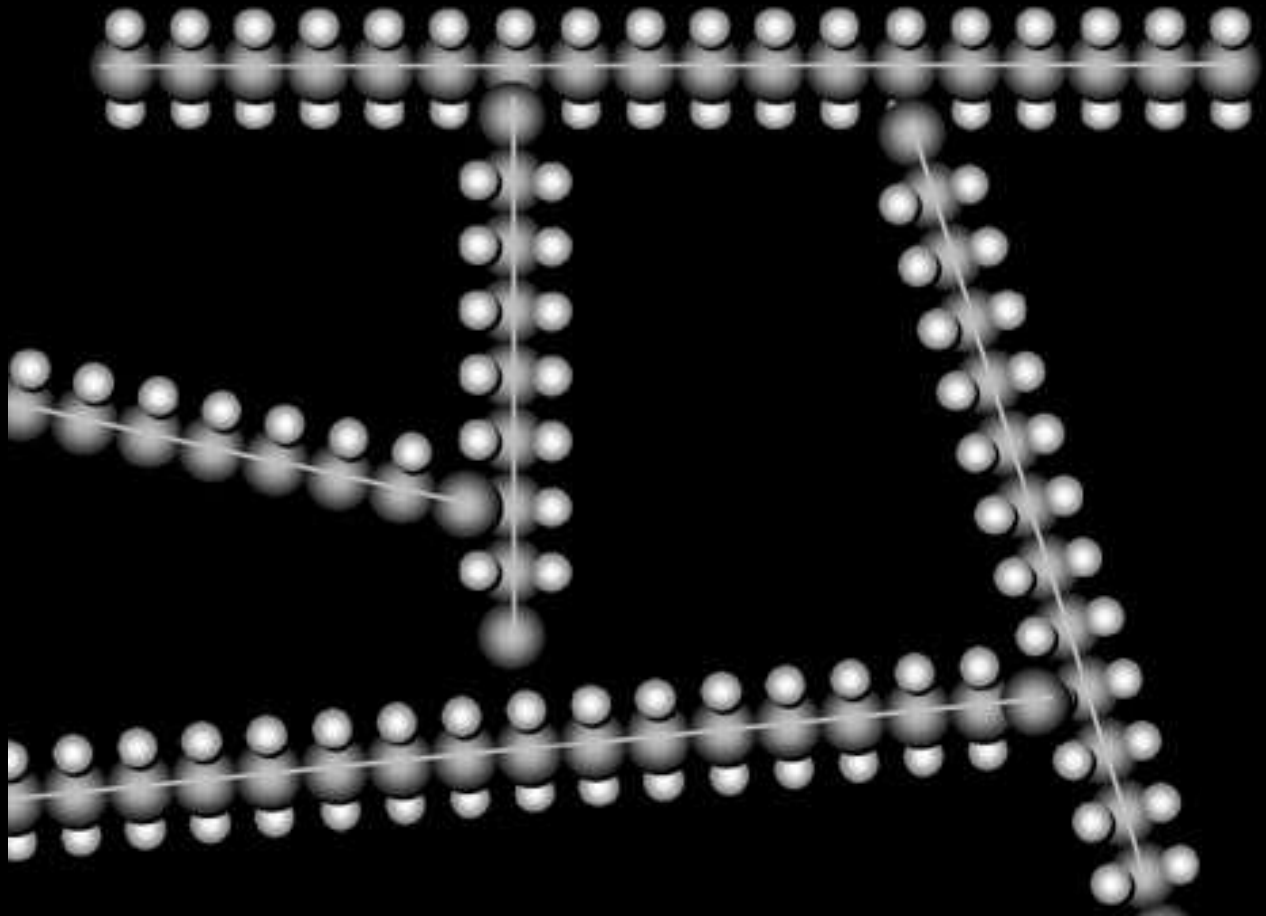
There are two types of polyethylene polymers (plastics). One is when the polyethylene exists as long straight chains. The picture here shows the chains of one carbon with two hydrogen atoms repeating. The chain can be as long as 20,000 carbons to 35,000 carbons. This is called high density polyethylene (HDPE).



When the chains get up to 500,000 carbons long, they are tough enough for synthetic ice, replacement joints, and bullet-proof vests. Think about it. You start with ethylene gas molecules that can't stop a feather from passing through them. But after the double-bond of one ethylene molecule breaks, it causes a chain reaction that connects thousands to it. In less than a second, these long straight chains of carbon and hydrogen are strong enough to stop a bullet or play ice hockey on. Isn't chemistry wonderful.

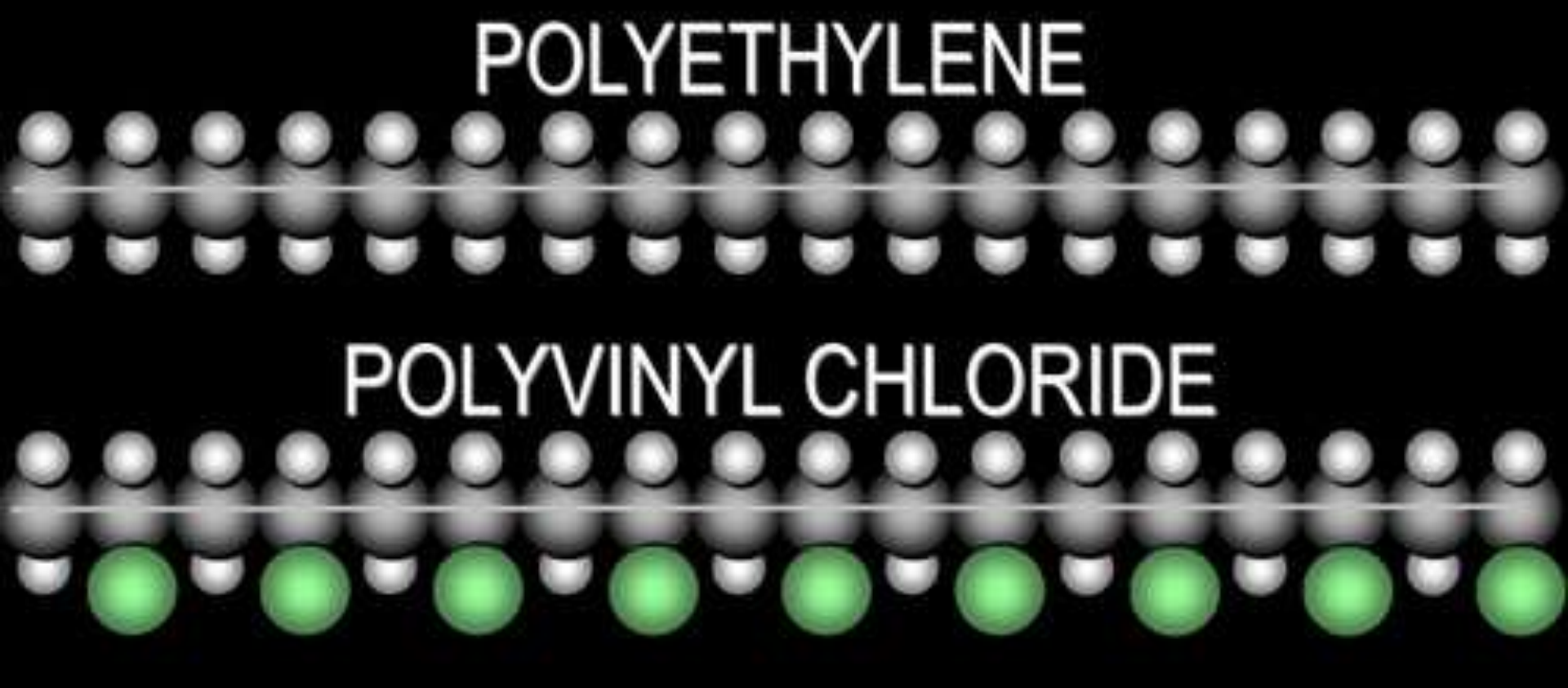


We've mentioned high density polyethylene (HDPE); you probably were thinking, there must be low density polyethylene (LDPE). You are correct. It is made by causing the long chains of ethylene to branch. That way they cannot lie next each other, which reduces the density and strength of the polyethylene. This makes the plastic lighter and more flexible.



Low density polyethylene is used to make plastic bags, plastic wrap, and squeeze bottles, plus many other things.

Another polymer, which is almost the same as polyethylene, is **P**oly**V**inyl **C**hloride or PVC. The difference is that every other hydrogen is replaced with a chlorine atom (green sphere).



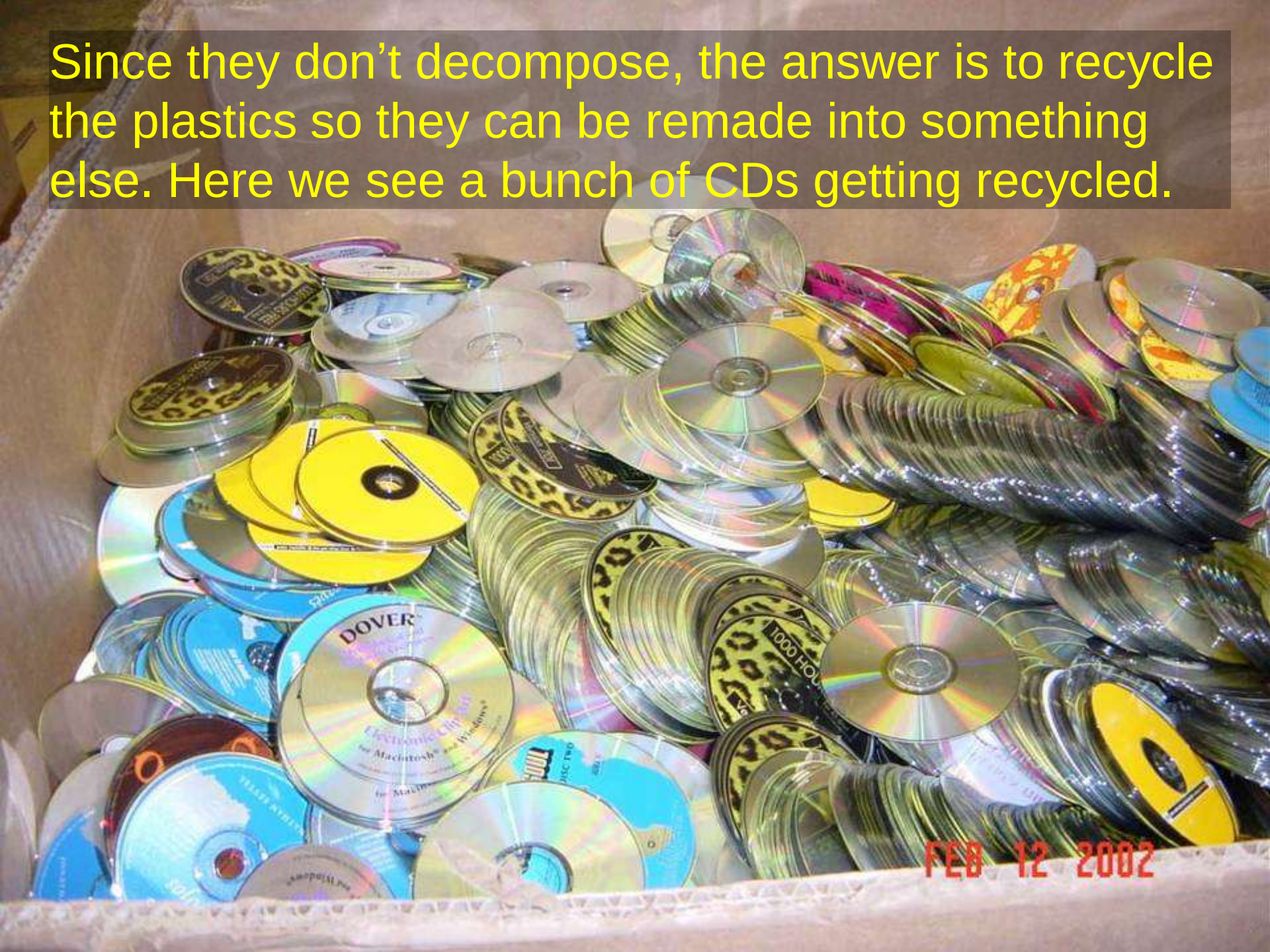
$(CH_2CHCl)_n + O_2 \rightarrow CO_2 + CO + HCl + H_2O$

PVC pipes are used in our homes and they are even handy for making a table or chair. PVC is also used as insulation around electric wires in the home and the automobile. PVC is quite safe until it burns. The chlorines in the PVC combine with the hydrogen atoms in the PVC to form hydrogen chloride gas (HCl). When this contacts water in lungs or mouth, it turns to hydrochloric acid ($HCl_{(aq)}$).

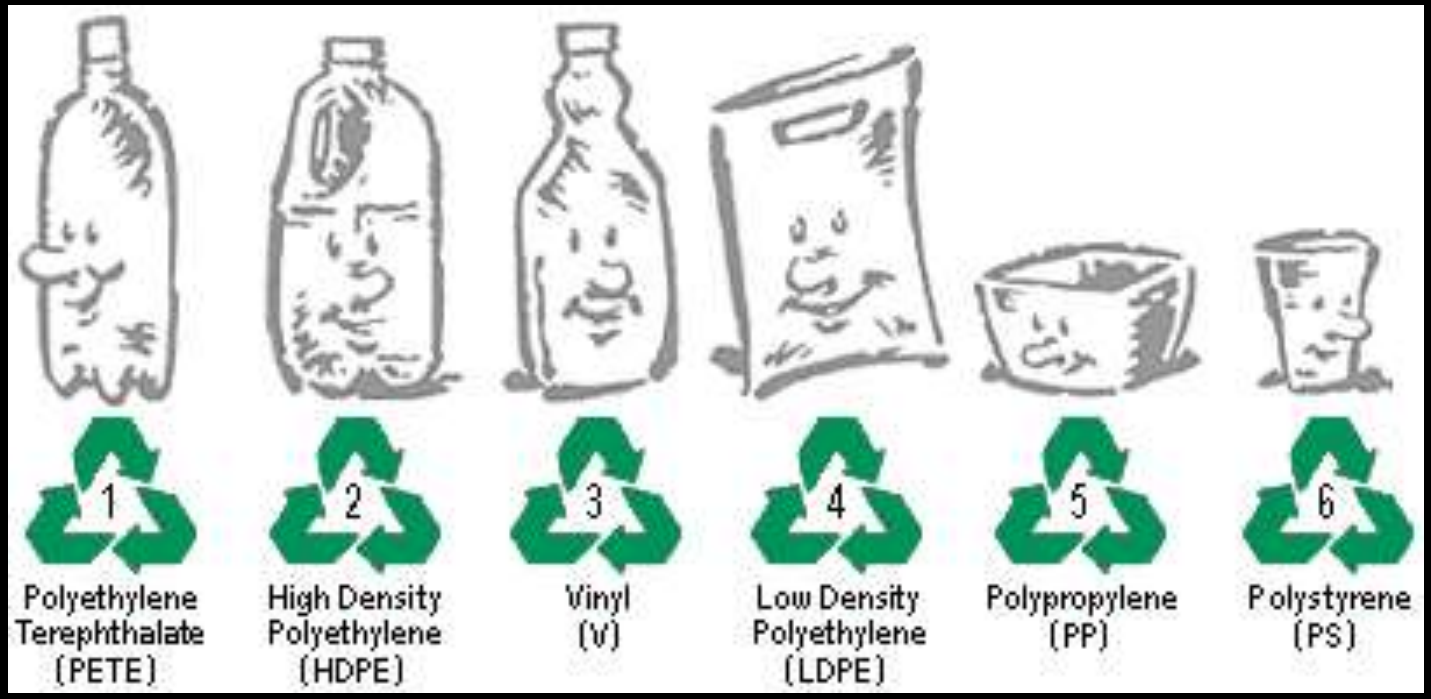
There are many types of plastics, but they all are based on taking one or two small molecules and starting a chain reaction that connects hundreds or thousands of these small molecules into long chains or branching chains. By controlling the length and the branching, you can control the final hardness or flexibility of the polymer plus qualities like resistance to solvents, acids, or heat.

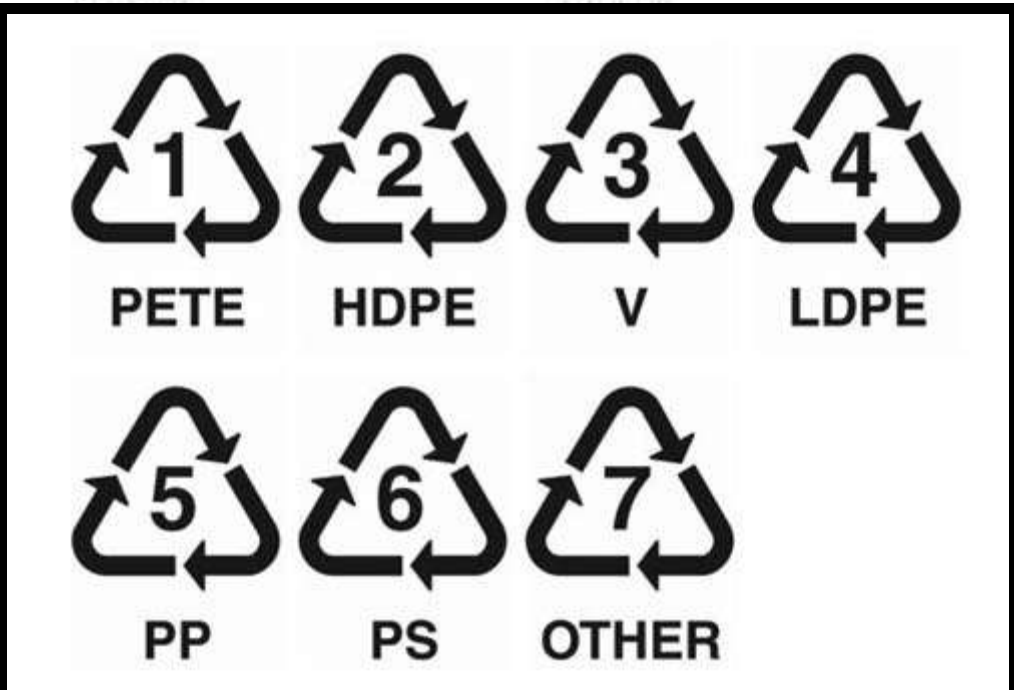
The favorite properties of plastics are that they are inert and won't react with what is stored in them. They also are durable and won't easily decay, dissolve, or break apart. These are great qualities for things you keep, but when you throw them away, they won't decompose.

Since they don’t decompose, the answer is to recycle the plastics so they can be remade into something else. Here we see a bunch of CDs getting recycled.



The decks, fence, stepping stones, house shingles, and the sweat shirt, were all made from recycled plastic.


1
Polyethylene Terephthalate (PETE)
2
High Density Polyethylene (HDPE)
3
Vinyl (V)
4
Low Density Polyethylene (LDPE)
5
Polypropylene (PP)
6
Polystyrene (PS)


1
PETE
2
HDPE
3
V
4
LDPE
5
PP
6
PS
7
OTHER

The mile long boardwalk at Yellowstone National Park was made from recycled plastic.


Recycle or we will have a polymer planet.

THANK YOU