PETROLEUM
CRUDE OIL & NATURAL GAS

INTRODUCTION

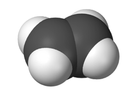
Crude oil is naturally found in in the upper portions of the earth's crust. It is produced by the compression and heating of ancient organic materials over long periods of time. It is mostly made up of hydrocarbons, mostly alkanes being chemical compounds of carbon and hydrogen. Because most hyrdocarbons are lighter than rock or water, they tend to migrate upwards through the earth's crust. Oil and natural gas fields are places where they have been trapped by impermable rock, but these are comparatively rare and most oil reaches the surface and is broken down by bio-degrading bacteria or released into the atmosphere. Oil is therefore non-renewable and the depletion of the world's oil supply is known as the "energy crisis". This may happen by 2040.

Hydro-carbons come in various lengths, and crude oil is made up of a huge variety of lengths.

These are extracted from the oil by a process called fractional distallation. The longer lengths are the parrafins, and are waxy or semi-solid. These are used on everything from electrical cables to cheese. The shorter lengths are light colored liquids, such as gasoline and other fuel oils. Even shorter lengths are found as gases, such as butane. But hydrocarbons can also be broken down by a chemical process called "steam cracking" to produce petrolchemicals, such as alkenes, monomers which can then be strung together to synthesize polymers, a string of connected molecules hundreds of monomers long.

Petrochemicals are also used to create a wide variety of solvents, adhesives, detergents, resins, fibres, lubricants and gels. But most crude oil, 84%, is burnt away as fuel oil, for example in the combustion engine, where it is broken down into carbon dioxide and released into the atmosphere, where it contributes to global warming and where its unique and rare chemical properties cannot be re-claimed.

One of the most common petroechemicals produced by steam cracking is ethylene, used to produce polyethylene, the world's most common plastic. But ethylene is also produced naturally by many plants, its main effect is to promote ripening or pollination. It also has very specific functions, for example when a seedling in the ground is obstructed by a rock or stone, ethylene is produced inside the plants cells, inhibiting the forward growth, thickenening the plant walls and creating curvature; thus the plant begins to grow sideways and around the obstruction. Ethylene is also used as an anaethetic, and it creates a feeling of euphoria. Possibly this has to do with the human ability to sniff out flowering plants as a source for food.



An ethylene molecule

HISTORY

Ancient persian tablets indicate the use of petroleum by the upper classes, for medicinal and lighting purposes.

It is recorded that the chinese were drilling for petroleum, using bamboo, to depths of several hundred metres, around 350 CE. The oil was burned to evaporate brine and produce salt.

The advent of kerosene probably saved the whales from extinction.

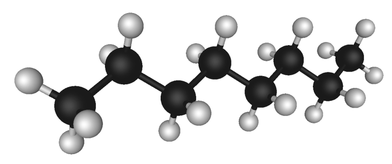
Parrafin wax has been extracted from crude oil for hundreds of years and still today has many applications. It expands considerably when heated and is therefore used in thermometers, especially in cars. It can also be used to treat constipation. In various forms it can also be used as a test for nitrates on the hands of handgun users, covering for edam cheese, a food glazing agent E907, surfboard wax, anti-caking agents for fertilizer, the material in Crayola crayons, skin moisturizer and rocket fuel.

Great advances were made in the understanding of crude oil and its properties in the 19th century, and this led the way for the 20th century plastics explosian.

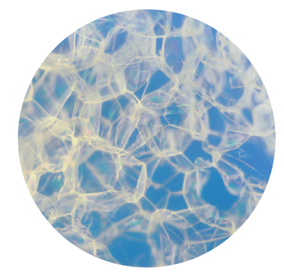
FRACTIONAL DISTILLATION

most of the remaining **16%** undergo

STEAM CRACKING
to produce petrochemicals



A hydro-carbon chain



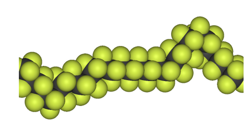
84%
of petroleum distallates are used as
FUEL

There are many ways to define plastics. One method is to define them by polymer structure, either cross linked (Thermoset, requiring the use of a catalyst in molding) or straight (Thermoform/Thermoplastic, possessing the ability to be heat formed. In industry the method of polymerization is used to define polymers, because polymers can be synthesized in numerous ways and different methods produce slightly different molecular structure, which has important consequences for recycling. More distinctly plastics are named by their polymer backbone, i.e polyethylenes, polystyrenes, polyvinyl chlorides, polyurethanes etc., and another way of classifying plastics is by their glass transition temperature.

- The first kind of plastics were natural plastics chemically altered - i.e vulcanised rubber and Parkesine.
- The first purely synthetic plastic was Bakelite.
- Next were PVC, polystyrene and nylon, which have familiar uses. Nylon as well as being used for fabrics, is also very wear resistant especially when impregnated with oil and can be used for gear and other mechanical parts.
- Then there was Neoprene, synthetic rubber, technically not a plastic but an elastomer because it can stretch and deform, but come back to its original shape. Synthetic rubber has also been used as rocket fuel. All of these plastics were very important in World War 2 and helped change the global economy, especially by reducing the importance of natural rubber.
- Acrylic and Polyethylene came next, polyethylene in two forms, low density, cling fims, plastic bags, and wraps LDPE and high density HDPE used in plumbers pipe etc. Ultra High Molecular Weight Polyethylene (UHMWPE) has also be synthesized, with properties similar to Teflon, and is known as Spectra or Dyneema. It is competing with Aramid (woven Teflon) in body armour applications. PET or PETE is a modified form of Polyethylene. PET is very strong and resilient plastic, but is prone to chemical attack. If itis treated with fluorine though it forms a polymer similar to PTFE, or Teflon, a very inert plastic. PET bottles have this treatment, creating a layer of very inert plastic one molecule thick on the surface of the bottle, to protect against chemical attack and increase durability and lifespan.
- Polypropylene is similar to polyethylene but more robust and used in everything from cars to furniture.
- Polyurethane is used in blown form (open cell) in rubber mattresses) and non-blown form as part of the material Spandex.
- PTFE or Teflon is a a very unique and robust plastic. Slippery, hard and scratch resistant. It was discovered by accident by a researcher developing a new kind of refridgerant. One of it s first applications was the building of the atom bomb. French engineer Marc Gregoire created the first non-stick teflon frypan in 1954. It is the only know surface to which a gecko cannot stick. It cannot stretch like an elastomer and in fact is prone to creep - this can be good in some applications such as seals on mated surfaces, but too much creep and the seal is compromised. Springs can be used to prevent this. Very good for sliding parts such as bearings, gears and slides plates. Ignition of Teflon creates large amounts of heat, so for example is used in fighter jets' decoy flares against homing missiles.

Petrochemicals that undergo synthetic polymerization are known as

PLASTICS



A PTFE (Teflon) molecule

Non-plastic petrochemicals include:

solvents, adhesives, detergents, resins, fibres, lubricants and gels

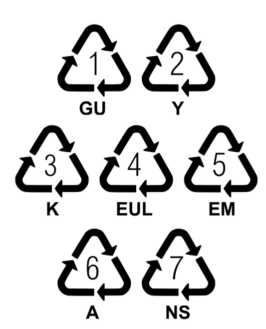
HEALTH ISSUES

- An agent used inthe synthesis of PTFE (Teflon), PFOA, is a know carcinogen. Dupont is investigating alternative chemicals.
- Vinyl chloride used to make PVC is a known carcinogen and can leach into food. It is discouraged from use in food applications. The european union has banned the use of DEHP, a PVC plasticizer, in children toys.
- Polystyrene is a possible human carcinogen. The EPA monitors it in US drinking water. Some compunds leaching from polystyrene can affect human hormones.
- The primary building block of Polycarbonates is Bisphenol A, which can also interfere with human hormones in a way similar to eostrogen. It is possible it can lead to obesity, diabetes and heart disease.
- Burning plastic can release toxic fumes. Often this depends on the burn temperature. Low temperature burning creates toxic fumes, but high temperature furnaces transform the material directly into non-toxic hydrogen and carbon, though these still contribute to the greenhouse effect.

LANDFILL
is where the majority of plastics end up.

Most plastics biodegrade very slowly. Often landfill sites are cocooned to prevent chemicals leaching into soil (such as from batteries and some plastics) but this also means the materials take even longer to bio-degrade.

How long a plastic will take to bio-degrade under certain conditions can be tested in the laboratory by introducing aerobic or anerobic microbes and measuring the quantity of by-product produced, CO2 or methane respectively. Methane is also a greenhouse gas, 21 times more powerful than CO2, so this is one side effect of bio-degradation by aneorbic microbes in cocooned landfills. However, modern landfills can utilize methane by-product gas as an energy resource.



RECYCLING
plastics is a complicated issue

Most plastic recycling currently is about recovering scrap and reprocessing - for example melting polyester softdrink bottles and spinning into polymer fibres. Unfortunately its is quite labour intensive due to a high level of sorting involved.

Recycling plastic is difficult compared to glass or metal. Similer but slightly different co-polymer blends of the same plastic from different manufactures tend not to dissolve into one another when heated, but phase seperate instead. This weakens the material and and prevents it from being re-used for high strength applications such as drink containers. So for example, PET bottles are not remade into PET bottles, but rather textiles that would normally be made from polyester. Fillers, dyes and additives also complicate plastic recycling - they are difficult or impossible to remove.

Colored PET bottles for example have to be sorted by color, such as clear, green, or mixed for example. Clear is the most desired by re-processing companies and mixed is the least. Recent use of amber colored PET bottles for beer have further complicated the process and de-valued the recycled product. This has an impact on design, for if a PET bottle is designed in a new color, it can impact the current conventional recycling processes.

New-biodegradable plastics known as bio-polymers can further complicate these recycling processes and de-value the resulting product should they mix with the more common plastics. On the other hand, bio-polymers do not have as much variance in molecular structure and so should be much easier to recycle in the future.

NEW RECYCLING PROCESSES

Alternative methods for recycling plastic involve reverse polymerization, converting the polymer back into monomers for chemical feed. Currently the technology is un-economic. The very few plants that have processed this way have closed down.

Thermal depolymerisation (TDP) is a less precise way of converting the polymers back into petroleum, but technically is not recycling as polymers do not result and the chemicals produced could be used as fuel. This process could also be used for any organic waste.

However, it is not all bleak - the unique properties of different plastics often mean that there is a unique recycling solution for many particular plastics - for example agricultural waste products can be coverted into bulk resin and PET bottles into carpet. This is sometimes referred to as "up-cycling".

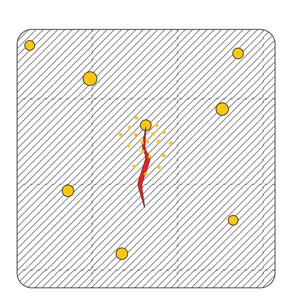
ALTERNATIVE PETROLEUM & PLASTIC TECHNOLOGIES

BIO-POLYMERS

As petroleum prices rise, so will the cost of plastics. This may encourage more developments and more willingness to to recycle, but it will also encourage the development of new plastics from other sources, such as fructose, or corn starch in the case of Plastarch. These are known as bio-polymers. The benefit is that they come from renewable sources and have better abilities to biodegrade, recycle or be composted. Currently most bio-polymers are suitable for low-density applications such as cling film or blown packaging pellets, and some success has been seen with fabrics also, such as Lyocell. New developments are happening fast and some designers believe bio-polymers will be the ubiquitous proto-material of the future.

SELF-HEALING PLASTIC

This is a new invention still undergoing scientific development. Microcapsules containing a polymer chemical feedstock are placed inside the plastic during synthesis. A catalyst for this chemical feedstock is also distributed inside the plastic. When a crack develops to a certain size, it will hit a microcapsule, releasing the feedstock and allowing it to come into contact with the catalyst. The resulting cross-linked polymerization heals the crack.



Microcapsules within self-healing plastic

FISCHER-TROPSCH METHOD

This is a technique to synthesize hydrocarbon lengths and produce synthetic fuel. It may be a method in the future to produce plastics and synthetic fuel from currently unusable sources such as coal and oil sands, but the technology is expensive and only select industries, such as the U.S. airforce, are developing it. The Fischer-Tropsch method could avert or postpone an energy crisis but it will not solve the larger problem of greenhouse gas emissions produced by combustion engines.

TDP
THERMAL-DEPOLYMERISATION

TDP is a technique to replicate the geological processes of compression and heat that produce crude oil, and in theory can convert any organic waste into petroleum. The technology has been in development for decades but so far has limited applications. The biggest operating TDP plant in the world has been designed to process turkey excrement into crude oil. Potentially, plastics and other synthetic waste products could produce even greater energy yeilds but more technological refinement is needed. Unlike the Fischer-Tropsch method, TDP has the potential to be a carbon-neutral technology.