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C11. Petrochemicals and polymers

C11.01 Petroleum

Fossil fuel: formed in the Earth's crust from material that was once living

- took place over geological periods of time
- non-renewable, finite resource
 - coal - from fossil plant material
 - petroleum(crude oil) & natural gas - formed from marine microorganism

1. The formation of petroleum

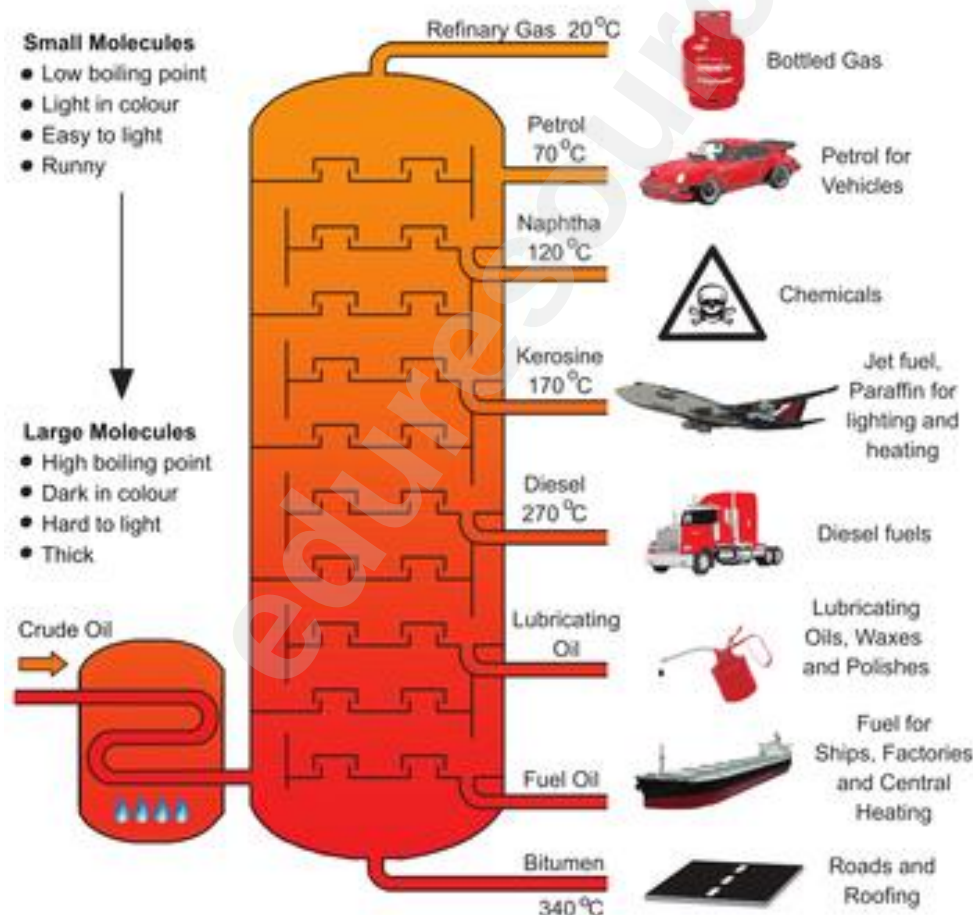
petroleum formation

1. 4 millions year ago, prehistoric marine creatures died, sank, covered by mud
2. high pressure, high temperature and bacteria acting for 1 million years
3. 처음 material broke down into hydrocarbon
4. compression of mud above hydrocarbon - transformed t into shale
5. pressure - shale become harder rock, squeezing out the oil and gas
6. move upwordards, high pressure to low [pressure
7. spread throughout the pores in coarse rock like sandstone or limestone
8. to detect, do survey and build oil rig

2. Fractional distillation

only ten percent is used as feedstock

need fractional distillation at **oil refinery**

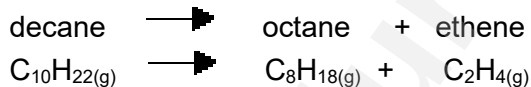
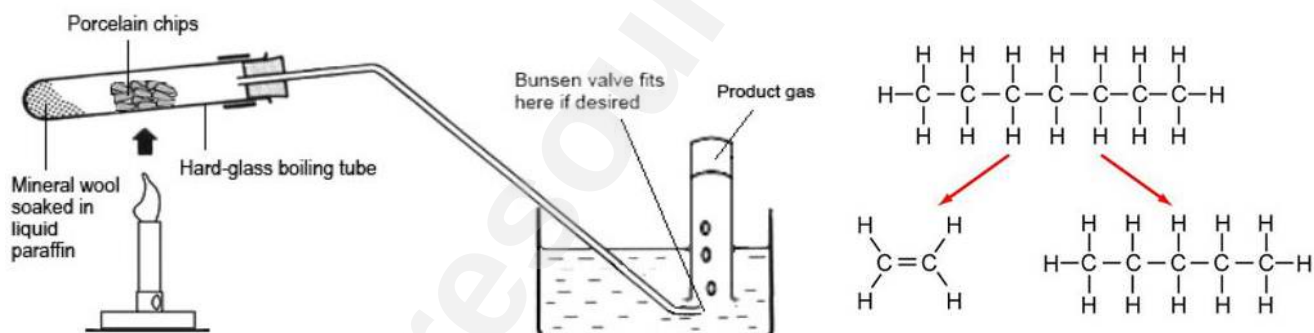


Fraction	Num of carbon atoms		boiling range	
refinery gas	1-4	C ₁₋₄	below 25	↓ b.p viscosity ↓
gasoline/petrol	4-12	C ₄₋₁₂	40-100	
naphtha	7-14	C ₇₋₁₄	90-150	
kerosene/paraffin	12-16	C ₁₂₋₁₆	150-240	
diesel oil/gas oil	14-18	C ₁₄₋₁₈	220-300	
fuel oil	19-25	C ₁₉₋₂₅	250-320	
lubricating oil	20-40	C ₁₋₄	300-350	
bitumen	over 70	C ₁₋₄	>350	

3. Catalytic cracking

catalytic cracking - larger molecules from these heavier fractions can be broken into smaller, valuable molecules

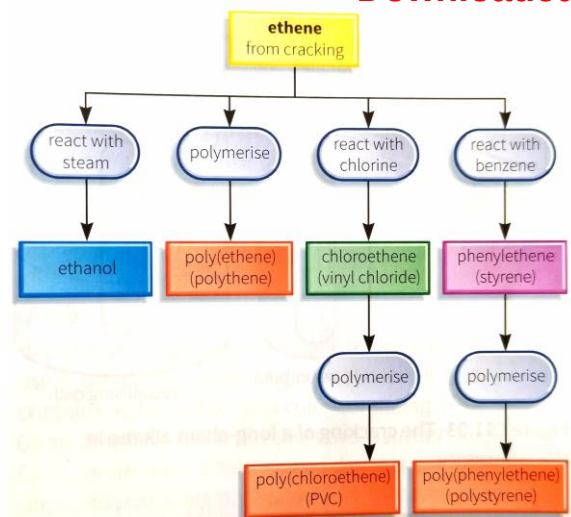
- particles of catalyst - mixed with hydrocarbon fraction at 500°C



4. Catalytic cracking general features

- alkane with a shorter chain, and short-chain alkene

- or two or more alkenes and hydrogen



5. Blending Gasoline

- some products from cracking - used to improve the quality of the petrol
- important aspect - how easily the fuel vapour ignites
 - fuel ignites too easily - engine doesn't run smoothly => knocking
 - to prevent that happening use many branched - chain hydrocarbon
 - lead added - air is released - damage brain - should not be used
 - fuel ignites too difficult - difficult to start engine - especially in cold morning
- removal of sulfur - very efficient
- CO, HC, NO_x - reduce their emission by fitting catalytic converter to the exhaust
- In engine cylinder - internal combustion
 - piston - move up and down by the combustion of fuel

C11.02 Alternative fuels and energy sources

1. Alternative transport fuels

Diesel

- contains hydrocarbon molecules consisting of between 6 - 20 carbon atoms
- slower-speed diesel engine(ships) have heavier fuel
- Engine - compression ignition engine
 - fuel ignites spontaneously without a spark
- more efficient than petrol engine, produce less CO
- temperature needed higher - more oxide of nitrogen is produced

Others

- electric, solar-powered cars

C11.03 Addition polymerisation

1. Introduction

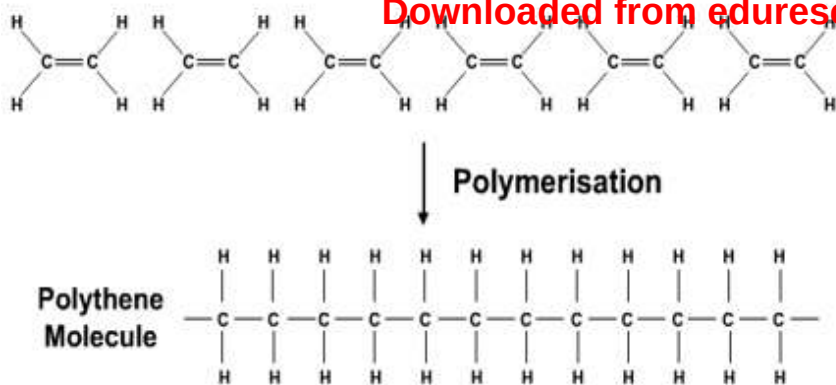
polymers: all living things contain - protein, carbohydrate - use it by altering - plastics

- large organic macromolecules
 - made up of small repeating units known as monomers by polymerisation

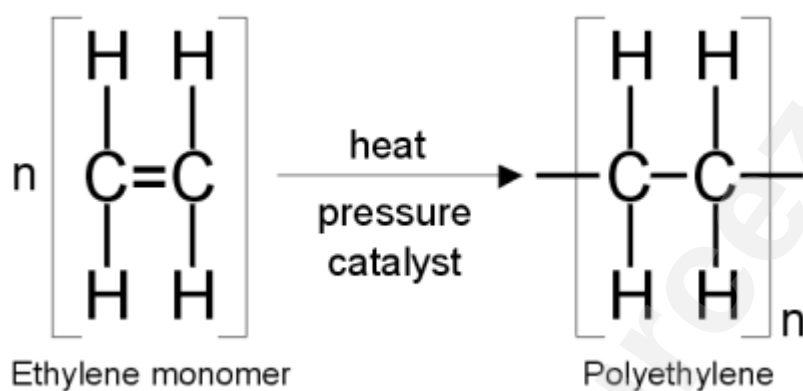
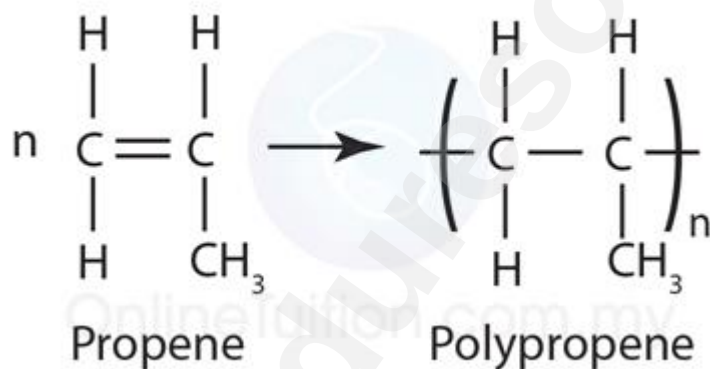
Addition reaction: double bond of carbon is broken, and other atoms attach to carbons

- monomer(ethene) -> double bonds break open -> Polymer(polyethene)
 - polyethene - durable, tough, very good electrical insulator

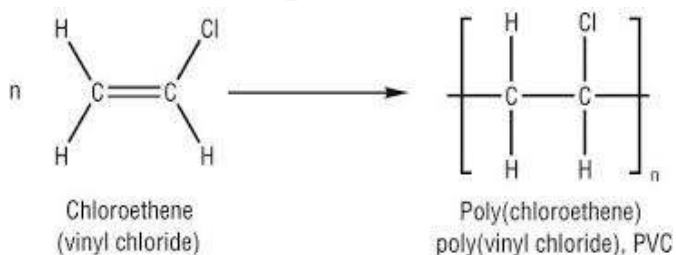
ethene ----> polyethene



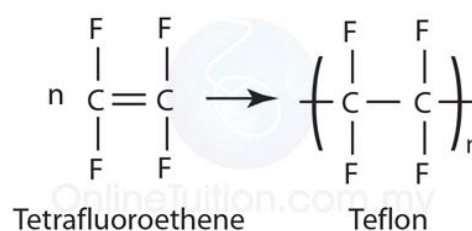
Nth form

**Propene polymerisation****Chloroethene polymerisation**

produce plastics - polyvinyl chloride(PVC)

**tetrafluoroethylene polymerisation**

produce polytetrafluoroethene or PTFE or teflon



Polymer

Monomer

Properties

Examples of use

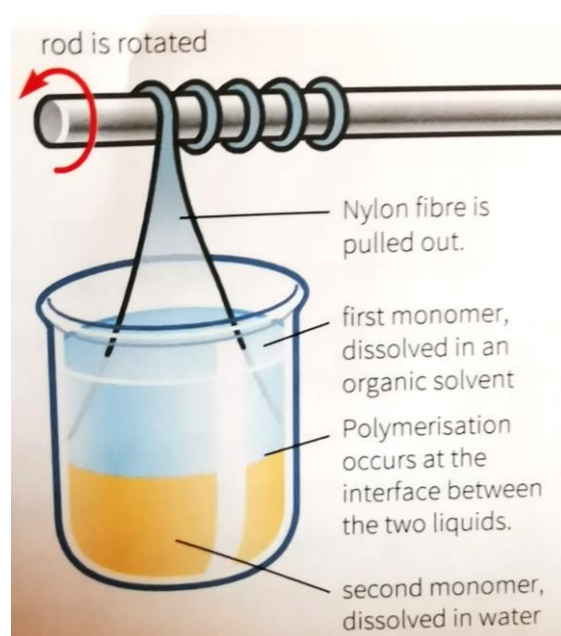
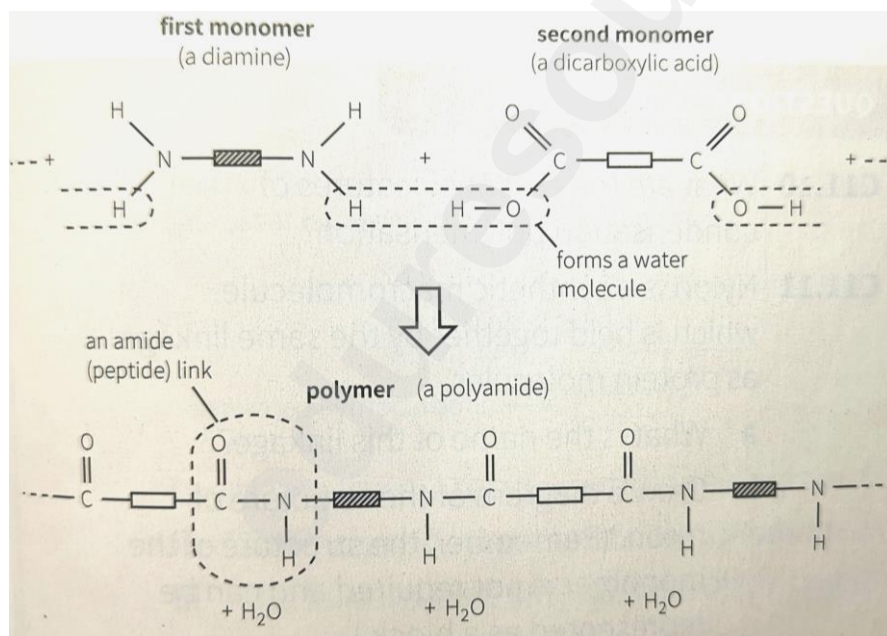
polyethene(PE) polyethylene	ethene $\text{CH}_2=\text{CH}_2$	tough, durable	plastic bags, bowls bottles, packaging
Polypropene(PP) Polypropylene	propene $\text{CH}_3\text{CH}=\text{CH}_2$	tough, durable	boxes, plastic rope
Polychloroethene polyvinyl chloride PVC	chloroethene $\text{CH}_2=\text{CHCl}$	strong, hard not as flexible as polythene	insulation pipes
Polytetrafluoroethene Polytetrafluoroethylene Teflon, PTFE	tetrafluoroethene $\text{CF}_2=\text{CF}_2$	non-stick surface withstand high temperature	non-stick frying pans non-stick taps
Polystyrene(PS) Polyphenylethene	phenylethene(styrene) $\text{C}_6\text{H}_5\text{CH}=\text{CH}_2$	light, poor conductor of heat	insulation packaging(foam)

C11.04 Condensation polymerisation

1. Nylon

Wallace Carother - made synthetic fiber, Nylon

- first formed - solid
- can be melted and forced through small holes
- not only made into fibres
- very versatile material, moduled into strong plastic items such as gear wheels
- contains characteristic of polymer molecule
 - Long filament colls - fibres produced are stretched to align the polymer molecules -dried
 - fibres- can be woven into fabric to make shirts, ties, sheets
- copolymer of two different monomer - diamine & dicarboxylic acid
- each monomer consists of a chain of carbon atoms



- **condensation polymer** - amide link is formed during polymerisation
- nylon - **polyamide**

2. Comparing synthetic addition and condensation polymers

Additional polymerisation

Condensation polymerisation

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Monomers used	Usually many molecules of a single monomer	Molecules of two monomers usually used
	monomer is unsaturated, contains C=C bond	Monomers contain reactive functional groups, at ends of molecule
Reaction taking place	addition reaction - monomers join together by opening C=C double bond	Condensation reaction with loss of a small molecule(usually water) each time a monomer joins a chain
Nature of product	Only a single product- the polymer	Two products- the polymer plus water(some other small molecule)
	non-biodegradable(자연 분해성 x)	biodegradable(자연 분해성 o)
	resistant to acids	hydrolysed by acids