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TOPIC 11.6: MACROMOLECULES

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THE ABOUT

CHAPTER ANALYSIS

MASTERY

- Key component of Organic Chemistry
- Commonly tested, especially Section A & B

EXAM

- Know how the **difference** between **'Addition Polymerisation'** & **'Condensation Polymerisation'**
- Know your **ester linkage** & **amide linkage**

WEIGHTAGE

- **Heavy** overall weightage
- Entire Organic Chemistry portion accounts for **15-20%** of each year's Chemistry paper

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KEY CONCEPT

MACROMOLECULES
POLYMERISATION
ADDITION POLYMERISATION
CONDENSATION POLYMERISATION

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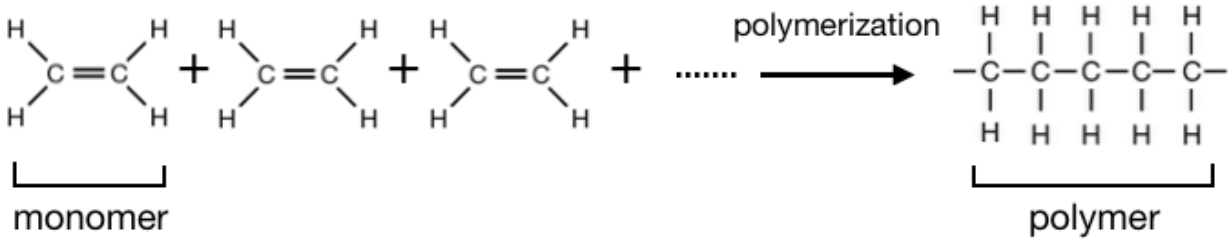
MACROMOLECULES

A macromolecule is a large molecule that is formed from many smaller molecules.

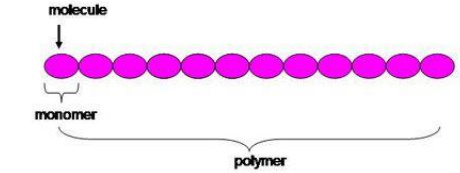
Different macromolecules usually contains different smaller units and linkages.

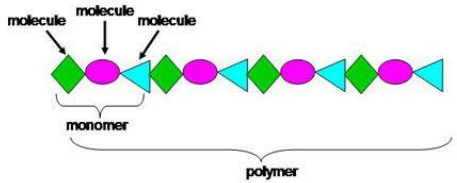


POLYMERISATION

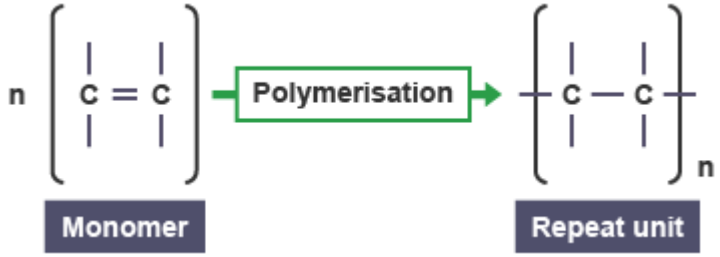
When polymerisation occurs, small molecules known as **monomers** are linked together to form a **long-chain macromolecule known as a polymer**.

Polymerisation is defined as the process where **small molecules (monomers) chemically combined together to form one large chainlike molecule (polymer).**





The **repeating unit** of a polymer is the smallest portion of the polymer, that when repeated multiple times, would form the entire polymer.



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ADDITION POLYMERISATION

ADDITION POLYMERISATION

Addition polymerisation is the process where **small molecules (monomers) are linked together to form a polymer without any other by-products.**

APPLICATION

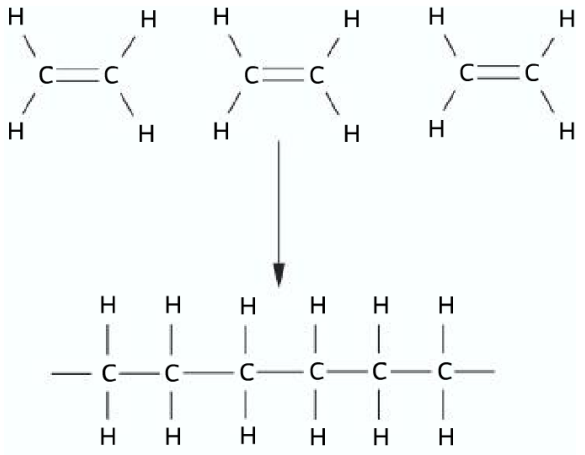
Poly(ethene) is the most **widely used plastic** because of its resistance to many different chemicals, and that it is not soluble in water at room temperature.

It is present in plastic products such as plastic bags, plastic bottles and used as water pipes.

POLY(ETHENE)

Poly(ethene) is an example of a polymer that is formed using addition polymerisation of ethene monomers.

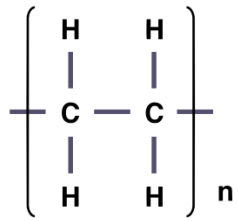
During addition polymerisation, the **C=C double bond is broken.**



The equation for the addition polymerisation of ethene monomers to form poly(ethene) is:

$$n(CH_2 = CH_2) \rightarrow -(- CH_2 - CH_2 -)-_n$$

The **repeating unit** of poly(ethene) is:



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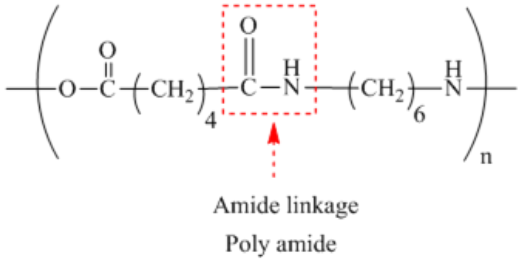
CONDENSATION POLYMERISATION

CONDENSATION POLYMERISATION

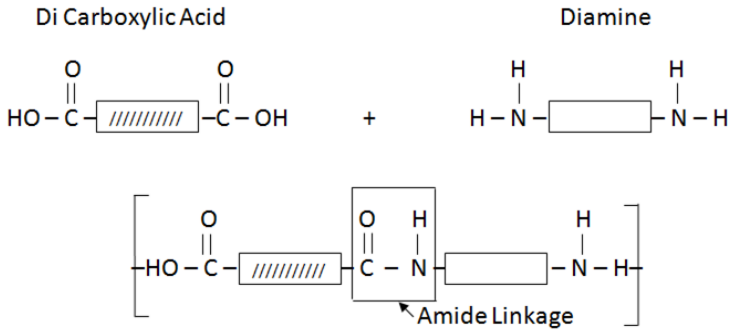
Condensation polymerisation is the process where **two different monomers are chemically combined to form a polymer. The process produces by-products such as water.**

The repeat unit of nylon contains the **-CONH- amide linkage**. The polymer is made up of monomers linked by the amide linkages, hence it's called **polyamide**.

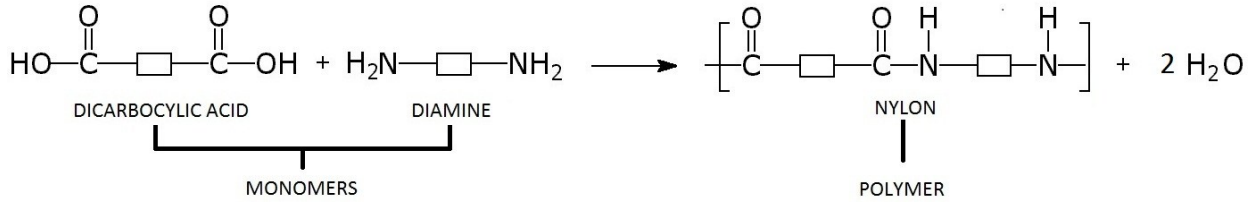


NYLON

Nylon is a synthetic polymer formed through condensation polymerisation of **dicarboxylic acid and diamine**, one containing the carboxylic acid functional group and the other containing the amine functional group.



During the condensation reaction process**, water molecules are formed as by-products and removed**:



Nylon is **light, strong, and has high stretchable**. Hence, this man-made fibre is used to make **clothing, fishing lines, parachutes and sleeping bags.**

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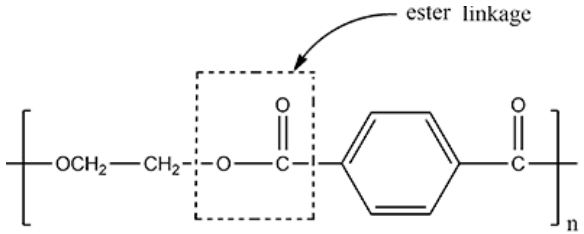
CONDENSATION POLYMERISATION

CONDENSATION POLYMERISATION

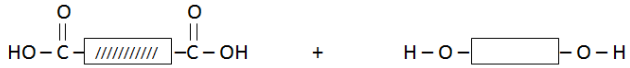
Condensation polymerisation is the process where **two different monomers are chemically combined to form a polymer. The process produces by-products such as water.**

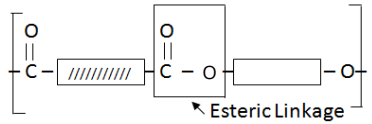
The repeat unit of terylene contains the **-COO- ester linkage**. The polymer is made up of monomers linked by the ester linkages, hence it's called **polyester**.



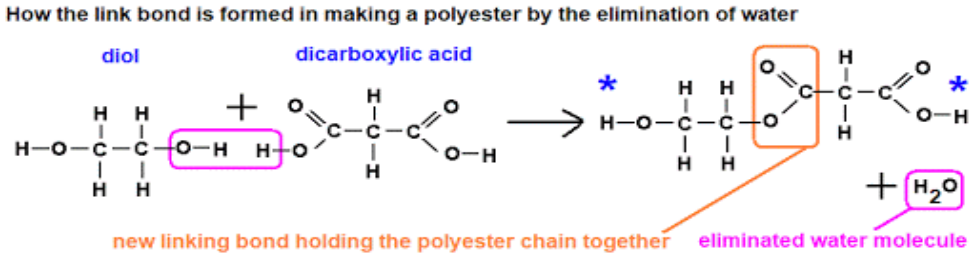
TERYLENE

Terylene is a polymer formed through condensation polymerisation of **dicarboxylic acid and diol**, one containing the carboxylic acid functional group and the other containing the alcohol functional group.





During the condensation reaction process**, water molecules are formed as by-products and removed**:



Man-made fibres like terylene lasts longer, would not decompose, and has the ability to maintain their shape under humid conditions.

Some uses of terylene are also used to make sails of boats and clothes.

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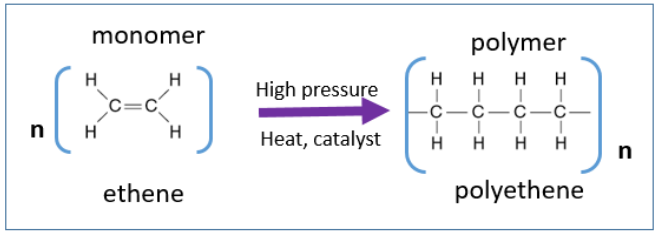
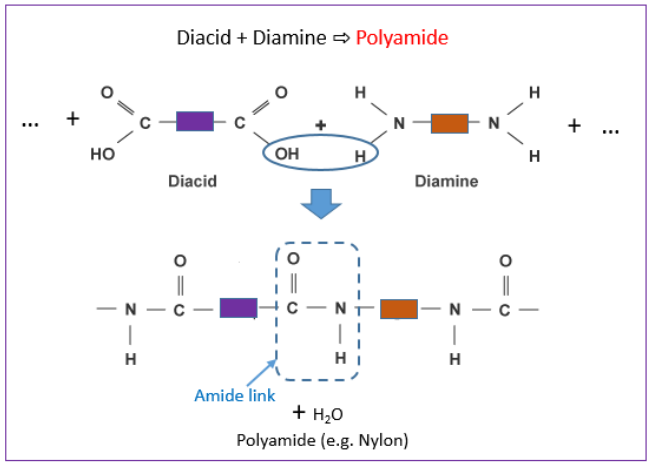
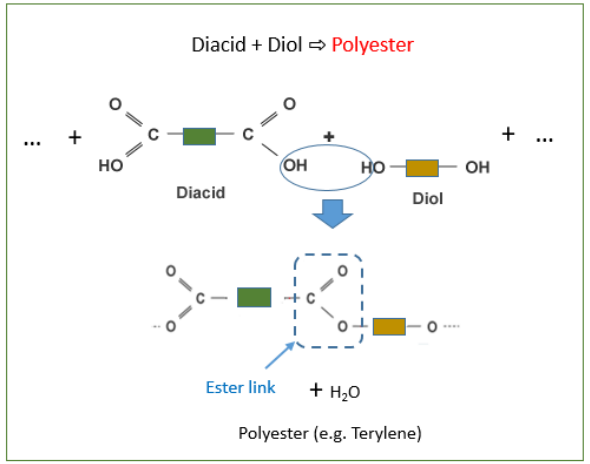
SUMMARY

Addition Polymerisation



Condensation Polymerisation





Addition polymerisation	Condensation polymerisation
Monomers must contain a **double bond (e.g. alkenes)**	Monomers must have **two functional groups at the two ends**
No by-products is produced	By-products like **water are produced**
Example: **polyethene**	Example: **nylon** & **terylene**

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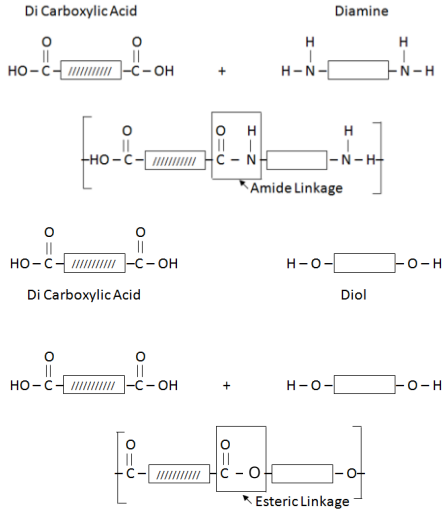
POLYMER

Condensation Polymerisation
(elimination of water)



LONG CHAIN ALKANE

H_2 gas
(For Haber process)

Catalytic Cracking
(Al_2O_3 & SiO_2, 600 °C)

Addition Polymerisation
(High temp & pressure)

SUGAR

$C_6H_{12}O_6 \longrightarrow 2\ C_2H_5OH + 2\ CO_2$

Fermentation
(37°C, yeast & no O_2)

Oxidation
(acidified aqueous potassium manganate(VII) / exposed to air)

Hydration
(300 °C & 60 atm, Phosphoric(V) acid)

ALKANE
C - C

Hydrogenation
(200 °C & nickel)

# ALKENE
C = C

ALCOHOL
-OH

CARBOXYLIC ACID
-COOH

Substitution
(UV light)

Bromination
(Test for C=C bonds)

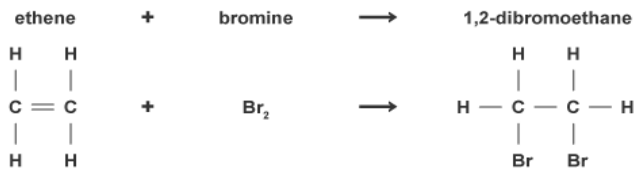
Esterification
(warm, sulfuric acid)

Prefix

Meth- 1
Eth- 2
Prop- 3
But- 4
Pent- 5
Hex- 6
Hep- 7
Oct- 8
Non- 9
Dec- 10

$CH_4\,(g) + Br_2\,(g) \longrightarrow CH_3Br\,(g) + HBr\,(g)$

$C_2H_4\,(g) + Br_2\,(aq) \longrightarrow C_2H_4Br_2\,(aq)$



ESTER + H_2O
-COO-

ALL ORGANIC COMPOUNDS
Complete Combustion

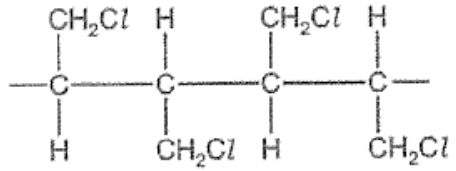
$X + O_2\,(g) \longrightarrow CO_2\,(g) + 2H_2O\,(l)$

Incomplete Combustion

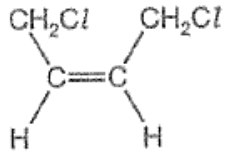
$X + O_2\,(g) \longrightarrow CO\,(g) + 2H_2O\,(l)$

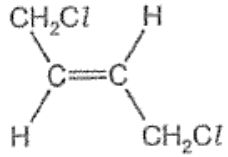
Try it yourself! (TYS Question)

12. The diagram shows the partial structure of a polymer.



Which statement about this polymer is correct? (N2019/P1/Q40)

A It could be made by addition polymerisation of 

B It could be made by condensation polymerisation of 

C Its monomer has the empirical formula $C_4H_6Cl_2$.

D Its monomer could be made by the reaction of an alkane with chlorine. ( )

Answer:

12. **A**
This polymer is made from addition polymerisation.

Try it yourself! (TYS Question)

13. Two compounds, X and Y, react together to form the polymer nylon.

X	Y
$H_2N–(CH_2)_6–NH_2$	$HOOC–(CH_2)_4–COOH$

What is the formula of the partial structure which repeats within the polymer?

(N2020/P1/Q40)

A $C_{10}H_{22}N_2O_2$ **B** $C_{12}H_{22}N_2O_2$

C $C_{10}H_{20}N_2O_4$ **D** $C_{12}H_{20}N_2O_4$ ( )

Answer:

13. **B**
X and Y will react to produce H_2O as a side product. Hence, the formula of the partial structure can be derived by adding the C atoms in X and Y together (since the number of C atoms remains unchanged) and removing 2 H atoms and 2 OH atoms for the formation of the side product.

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