

Condensation Polymerisation

A-Level Chemistry ■ Topic 35

A-Level Chemistry



What we will cover

- 1 Condensation polymerisation
- 2 Addition vs condensation
- 3 Finding the monomers
- 4 Degradable polymers



nylon, a polyamide



Condensation polymerisation



every new ester or amide link loses a small molecule (condensation)

In **condensation polymerisation**, monomers join **and** a small molecule is lost. Each monomer needs **two** reactive groups.

- **polyester** – ester links (diol + diacid)
- **polyamide** – amide links (diamine + diacid)

Addition vs condensation

addition polymerisation

- monomer has a **C=C**

- the double bond opens and the monomers join

- **nothing else** is lost

e.g. ethene → poly(ethene)

condensation polymerisation

- each monomer has **two** functional groups

- a **small molecule** (H₂O or HCl) is lost

- ester or amide links form

e.g. a polyester or polyamide

- **addition** – a C=C opens, **nothing** lost
- **condensation** – two-group monomers join, a small molecule **lost**

The two polymerisations, and the monomers each needs

addition polymerisation

monomers with a $C=C$ double bond join with **nothing lost**

condensation polymerisation

monomers join and a **small molecule** – usually water or HCl – is lost each time

a polyester needs

a **dicarboxylic acid** and a diol – **two** functional groups on each monomer

a polyamide needs

a dicarboxylic acid and a diamine

or one monomer

a single aminocarboxylic acid can polymerise with itself – as **amino acids** do, making proteins natural polyamides

finding the monomer

break the chain at the ester or amide link and **add back** the water that was lost

Two functional groups per monomer is what makes a chain possible at all. One group gives a dimer and stops.

Finding the monomers

polyester (ester links)



break each link; add back -OH and -H



diol

dicarboxylic acid

The **repeat unit** contains parts of **both** monomers.

To find the **monomers** ,
break the chain at each ester or amide link and add back —OH and —H to the cut ends.

Degradable polymers



- **poly(alkene)s** are inert (strong non-polar bonds) – hard to **biodegrade**
- polyesters & polyamides **are** biodegradable – their links **hydrolyse**

Exam tips

- **Condensation polymers** (polyesters, polyamides) form with **loss of a small molecule** (H_2O or HCl) – draw the repeat unit and the lost molecule.
- Identify the **monomers from the polymer** by breaking the ester or amide link – a common question.
- **Predict the type** from the monomers: a $\text{C} = \text{C}$ gives addition; two functional groups give condensation.
- Polyesters and polyamides are **hydrolysable** (more degradable); addition polymers are not.



Worked example – which polymerisation?

A polymer is made from 1,6-diaminohexane and hexanedioyl dichloride. Name the link and say why it is biodegradable.

- Each monomer has **two** functional groups, and a small molecule (HCl) is lost each time $\Rightarrow$ **condensation**.
- $\text{NH}_2 + \text{COCl}$ gives a $-\text{CONH}-$ **amide link** $\Rightarrow$ a polyamide (nylon-6,6).
- Amide links are **polar** and can be hydrolysed by water, acid or enzymes.
- So the chain breaks back to monomers $\Rightarrow$ **biodegradable**, unlike poly(alkene).

Two functional groups + a small molecule lost $\Rightarrow$ condensation. Addition polymers (all C–C) resist hydrolysis; polyesters and polyamides do not.

Topic 35 – key takeaways

1

Condensation

two-group monomers; a small molecule lost

2

Links

polyesters (ester) & polyamides (amide)

3

Monomers

break the links, add back -OH & -H

4

Degradable

condensation polymers hydrolyse & degrade

Check yourself

- 1 How many reactive groups does a condensation monomer need?
- 2 What link does a polyamide have?
- 3 What is lost in condensation but not addition?
- 4 Why do polyesters biodegrade?



Answers 1. two 2. an amide link 3. a small molecule (water/HCl) 4. their ester links hydrolyse