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

1 Condensation

Condensation polymerisation

polyester: -C(=O)-OH + H-O- → -C(=O)-O- + H_2O

polyamide: -C(=O)-OH + H-N(H)- → -C(=O)-NH- + H_2O

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

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

- **polyester** 聚酯 – ester links (diol + diacid)
- **polyamide** 聚酰胺 – 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** (H_2O or HCl) is lost
- ester or amide links form

e.g. a polyester or polyamide

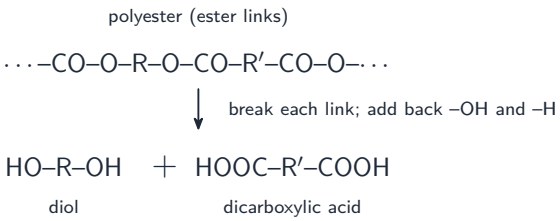
- **addition** 加成聚合 – a C=C opens, nothing lost
- **condensation** 缩合聚合 – two-group monomers join, a small molecule lost

The two polymerisations, and the monomers each needs

addition polymerisation 加成聚合	monomers with a C=C double bond join with nothing lost
condensation 缩合 polymerisation	monomers join and a small molecule – usually water or HCl – is lost each time
a polyester needs	a **dicarboxylic acid** 二元羧酸 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** 氨基酸 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



The **repeat unit** 重复单元 contains parts of both monomers.

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

Degradable polymers



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

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 C = C gives addition; two functional groups give condensation.
- Polyesters and polyamides are **hydrolysable** (more degradable); addition polymers are not.

2 Recap

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 ⇒ condensation.
- NH_2 + COCl gives a −CONH− **amide link** 酰胺键 ⇒ 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 ⇒ biodegradable, unlike poly(alkene).

Two functional groups + a small molecule lost ⇒ 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