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

polyester (ester links)

$$\cdots\text{–CO–O–R–O–CO–R′–CO–O–}\cdots$$

↓ break each link; add back –OH and –H

$$\text{HO–R–OH} \quad + \quad \text{HOOC–R′–COOH}$$

diol — dicarboxylic acid

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