# 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

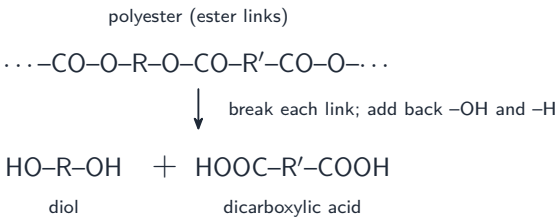
- **addition** 加成聚合 – a C=C opens, nothing lost
- **condensation** 缩合聚合 – two-group monomers join, a small molecule lost

# 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