A2 Chemistry: F324- Rings, Polymers, and Analysis.  
**Addition Polymers and Poly(esters).**

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<th>Learning Outcomes:</th>
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<tr>
<td><strong>All (E)</strong></td>
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<td>• State the two types of polymerisation reactions.</td>
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<td>• State and draw the monomers used to make Terylene and poly(lactic acid)</td>
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<td><strong>Most (C)</strong></td>
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<td>• Draw the repeating unit given the structure of a polymer</td>
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<td>• Identify the monomers given a section of a polymer</td>
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<td><strong>Some (A)</strong></td>
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<td>• Write an equation to show the polymerisation of Terylene and poly(lactic acid)</td>
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Polymerisation – a reaction in which small molecules called monomers join together to make large molecules consisting of repeating units.

There are two general types of polymerisation, **addition** and **condensation**.

**Addition Polymerisation.**

Involves an alkene where the \(\pi\) bond is broken enabling connecting covalent bonds to be formed. Addition polymerisation involves no loss of atoms/molecules.

![Polymerisation Reaction](image)

The formation of poly(ethene) from its monomer ethene.

The repeating unit of poly(ethene) is:

![Repeating Unit](image)

Draw a polymerisation reaction of poly(propene) showing one repeating unit.
Draw the repeating unit in the following polymers:

a. Poly(chloroethene)

b. Poly(tetrafluoroethene)

c. Poly(phenylethene)/poly(styrene)

**Condensation Polymerisation.**

A reaction in which two small molecules react together to form a larger molecules, with the elimination of a small molecules such as water or HCl.

- Condensation polymerisation requires two monomers that have different functional groups, where the different functional groups bond together or one monomer that contains two different functional groups.
  - Condensation polymerisation monomers are bifunctional (contain two functional groups e.g. amino acid) or are different.
- Polyester and polyamides are common condensation polymers.

**Polyesters**

Polyesters are made from monomers that contain a **dicarboxylic group** and an **diol group**. The reaction is the same as forming esters which you have covered earlier in the unit. The two common types of polyesters are:

1. Polyesters made by reacting two different types of monomers units
   - One monomer is a dicarboxylic acid (two -COOH groups)
   - One monomer is a diol (two –OH groups)

2. Polyesters made by reacting just one type of monomer unit containing both –OH groups and -COOH
Draw the general equations for the formation of the two different types of poly(ester)

**Formation of polyester from two monomers one containing a diol and the other containing a dicarboxylic acid**

**Formation of polyester from one monomer (hydroxycarboxylic acid)**

**Condensation Polymerisation Reaction to Form Terylene (a polyester).**

This is an example of forming a polymer from two different monomers. The reaction is a condensation polymerisation reaction where the hydroxyl group of one monomer forms an ester link with the carboxylic acid group of the other monomer. Water is eliminated during the reaction.

**The monomers are:**

1. Benzene-1,4-dicarboxylic acid
2. Ethane-1,2-diol

![Ethan-1,2-diol](image1)

![Benzene-1,4-dicarboxylic acid](image2)

The formation of polyester (Terylene) is made from two monomers as shown above. When these two monomers react the alcohol group will lose a hydrogen and the carboxylic acid group will lose an hydroxyl group to form an ester link and water is eliminated.
Poly(esters) are strong fibres which are inelastic and are resistant to shrinking and chemical attack, but they are easily combustible.

**Uses of Terylene:**

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3. ..................................................................................................................................................
4. ..................................................................................................................................................

**Properties of Terylene:**

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2. ..................................................................................................................................................
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Condensation Polymerisation Reaction to Form Poly(lactic acid) – a polyester.

This is an example of forming a polymer from one monomer 2-hydroxypropanoic acid (lactic acid). Poly(lactic acid) is the polymer that makes clear plastic cups and is made from polymer lactic acid (2-hydroxypropanoic acid).

Poly(lactic acid) is biodegradable so is becoming widely used in drinks and food containers. During the condensation reaction an ester bond (-COO-) forms between the hydroxyl group on one monomer and the dicarboxylic group on the other monomer. Water is eliminated during the reaction.

**Monomer**

2-hydroxyproanoic Acid

![Monomer Structure](image)

**Questions.**

1. Short sections of the molecular structures of two polymers are shown below.

![Polymers C and D](image)
(a) (i) Circle, on the diagrams above, the simplest repeat unit in each polymer. [2]

(ii) In the boxes below, draw the displayed formulae of the two monomers that could be used to prepare polymer D.

[2]

(b) Chemists have developed degradable polymers to reduce the quantity of plastic waste being disposed of in landfill sites. Polymer D is more likely to be a ‘degradable polymer’ than polymer C.

Suggest two reasons why.

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................................................................................................................ [2]

[Total 6 marks]

2. Poly(phenylethene) is one of the most versatile and successful polymers.

The 3-D skeletal formula of a section of atactic poly(phenylethene) is shown in the diagram below.

(i) State the type of polymerisation used to make poly(phenylethene).

.................................................................................................................... [1]
(ii) Draw a skeletal or displayed formula to show the monomer used to make poly(phenylethene).

(iii) Outline how the polymer is formed from the monomer molecules. (You do not need to give any details of the catalyst or conditions involved.)

Tell me two things....

...that you have done well today
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Notes.

Further Information.

   http://bit.ly/RCL0g

2. Chemguide – Terylene

3. You Tube Addition Polymerisation video

4. Knock Hardy Notes.
   http://bit.ly/rho0KY


Download the Layer app for iPhone or Android to access the interactive material where every you see the icon.