7 Industrial Production of Poly(ethene)

Poly(ethene) is a polymer made from the monomer ethene. It is an odourless solid which is sold in pellet form. Poly(ethene) is easily processed to form a tough, flexible film or a firm container.

Poly(ethene) is very stable and inert. It resists attack by most chemicals, including most acids and bases, and is insoluble in water. It will, however, dissolve in some hydrocarbons when heated; also, some chemicals, such as detergents and oils, will cause stress cracking and discolouration.

This polymer was first made in 1933 when researchers studying the effects of pressure on ethene left some gas in a high pressure container over the weekend. Most poly(ethene) is now made at relatively low pressure in a fluidised bed reactor.

Ethene is pumped, under pressure, into the bottom of the **fluidised bed reactor**, which contains a bed of poly(ethene) powder suspended over a perforated plate. The ethene gas bubbles up through the powder, making it behave like a liquid (or fluid), rather like boiling water. A transition metal **catalyst** is added to allow the reaction to occur at the relatively low pressure of 20 atmospheres. The poly(ethene) molecules grow at the interface with this catalyst. As polymerisation is highly exothermic, the temperature of the reaction vessel must be monitored and maintained to prevent the polymer decomposing as it forms.

Transition metal catalysts are also called **Zeigler-Natta catalysts** after their inventors. These allow the production of linear, unbranched poly(ethene), which usually has molecular weights from 200 000 to 500 000. Poly(ethene) can also be made with ultra high molecular weights of 3 to 6 million and this is used to make bullet-proof vests and large sheets of artificial ice for skating rinks. Zeigler and Natta realised that the catalyst used could not only affect the rate of the polymerisation reaction and the conditions under which it took place (e.g. pressure and temperature), but also the arrangement of units attached to its main chain. This in turn could affect the polymer's properties, such as stability to heat, density and tensile strength.

Additives to the polymer allow it to have specific properties. Additives provide colour, make the polymer more stable, resist attack by fungi, reduce the friction of flexible film products and provide protection from UV light. Minerals such as silica are added to create a tiny air gap between surfaces so that plastic bags can open easily.

Quality control is essential in polymer production. Factors that must be controlled include molecular weight, density, type and amount of additives, contamination, the presence of defects such as lumps or streaks, and the size and shape of the pellets. There are standard tests for all of these; for example, the control of molecular weight is measured by the rate at which molten polymer can flow through a standard-sized hole. The viscosity of the polymer increases with increased molecular weight.

For You To Do

1. Use a flow chart to outline the steps in the production of poly(ethene).
2. In the low pressure industrial production of poly(ethene), a 'fluidised bed reactor' is used.
   (a) Describe the fluidised bed reactor, explaining why it is so named.
   (b) Identify the type of catalyst used in this reactor.
   (c) Outline an advantage of using a catalyst.
   (d) Outline what happens to any unreacted ethene.
   (e) Explain why it is necessary to monitor the temperature of the fluidised bed reactor.
3. Outline the importance of the discovery of transition metal catalysts to the development of the plastics industry.
4. Write an equation for the chemical process that occurs in an ethene fluidised bed reactor.
5. Use properties of poly(ethene) to evaluate its effectiveness as a cling wrap to cover food.
6. Identify three factors that can be varied in the production of poly(ethene) to change the properties of the finished product.
7. (a) Explain why quality control is essential.
   (b) Identify four characteristics of the final product checked during quality control.
   (c) When performing quality control testing of the molecular weight of a polymer, would you expect a polymer with low or high molecular weight to flow most rapidly through the standard hole?
8. Assess the impact of the discovery of polyethene on:
   (a) society
   (b) the environment.
9. Check your knowledge with this quick quiz.
   (a) Identify the catalyst used in the production of poly(ethene).
   (b) Name the type of reactor in which poly(ethene) is produced industrially.
   (c) Name two properties of poly(ethene) that make it useful as food containers.
   (d) When was poly(ethene) first made?
   (e) Identify two uses of poly(ethene) made with ultra high molecular weights.