3.3.4 Alkenes

3.3.4.1 *Alkenes: C=C double bond, sigma and pi bonds. Electrophilic character. E/Z isomerism.*

General formula: CnH2n. Unsaturated: contain a C=C double bond (region of high electron density).

C=C consists of: a σ-bond (head-on orbital overlap) and a π-bond (sideways p-orbital overlap above and below the bond).

The π-bond is a region of high electron density — attracts electrophiles.

Restricted rotation about C=C → E/Z isomerism when each C has two different substituents.

3.3.4.2 *Electrophilic addition: HBr, H2SO4, Br2. Mechanisms. Markovnikov's rule. Bromine test.*

With HBr: alkene + HBr → halogenoalkane. Markovnikov's rule: H adds to C with more H's, giving the more stable (tertiary > secondary > primary) carbocation intermediate → major product.

With H2SO4: alkene + H2SO4 → alkyl hydrogen sulfate; hydrolysis with water → alcohol (industrial route to ethanol).

With Br2 (bromine water): orange → colourless. Test for unsaturation. Product = dibromoalkane.

Mechanism: curly arrow from C=C π-bond to δ+H (or δ+Br). Heterolytic fission of H–Br. Carbocation intermediate formed. Then Br■ attacks (nucleophile).

3.3.4.3 *Addition polymers from alkenes. Repeat units. PVC and plasticisers.*

Addition polymerisation: C=C opens; monomers join to form C–C backbone. No by-products (100% atom economy).

Repeat unit: draw monomer with double bond opened and continuation bonds at each end.

Poly(chloroethene) = PVC: rigid. Plasticisers (small molecules between chains) reduce intermolecular forces → more flexible.

Addition polymers are non-biodegradable: strong C–C backbone, no polar functional groups → resistant to chemical attack and hydrolysis.

★ RPRP7 Synthesis of a Halogenoalkane (e.g. 1-bromobutane from butan-1-ol)

Method: Add butan-1-ol, NaBr and conc. H2SO4 to a round-bottomed flask with anti-bumping granules. Heat under reflux for 30–45 min. Allow to cool. Transfer to a separating funnel. Wash with water, then NaHCO3 solution (to remove acid), then water. Separate organic layer (bottom for 1-bromobutane). Dry with anhydrous MgSO4. Filter and distil. Collect fraction at 101°C.

Uncertainties: thermometer ±0.5°C; balance ±0.001 g; measuring cylinder ±0.5 cm³.

Common errors: incomplete reaction (insufficient heating); impure product (insufficient washing); loss during distillation; acid not removed (gives acidic product).

Improvements: heat under reflux for full time; wash with NaHCO3 until no further gas evolved; anhydrous drying agent; distil and collect fraction at correct b.p.