3.3.5 Alcohols

3.3.5.1 *Alcohol production: hydration of alkenes and fermentation. Biofuels. Carbon neutrality.*

Hydration of alkenes: ethene + steam, H_3PO_4 catalyst, 300°C, 60 atm. Fast, continuous, pure product — but uses non-renewable crude oil feedstock.

Fermentation: $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$ (yeast, 25–37°C, anaerobic). Batch process, slow, impure, needs distillation — but uses renewable feedstock.

Biofuel carbon neutrality claim: CO_2 released on burning = CO_2 absorbed during crop growth. Not truly carbon neutral (energy used in farming, transport, distillation).

3.3.5.2 *Oxidation of alcohols: primary → aldehyde/carboxylic acid, secondary → ketone, tertiary → no reaction. Tests for aldehydes.*

Oxidising agent: $K_2Cr_2O_7/H_2SO_4$ (acidified dichromate). Orange → green when oxidation occurs.

Primary alcohol:

Distil immediately → aldehyde (remove before further oxidation).

Reflux with excess oxidant → carboxylic acid.

Secondary alcohol → ketone (by distillation or reflux).

Tertiary alcohol → no reaction (no H on the C bearing OH).

Tests to distinguish aldehyde from ketone:

Fehling's/Benedict's: warm — brick-red precipitate with aldehyde; no change with ketone.

Tollens' reagent (ammoniacal $AgNO_3$): warm — silver mirror with aldehyde; no change with ketone.

3.3.5.3 *Elimination: acid-catalysed dehydration of alcohols to alkenes. Mechanism. Green chemistry link.*

Alcohol + conc. H_2SO_4 (or conc. H_3PO_4), heat → alkene + H_2O (dehydration/elimination).

Mechanism: H■ protonates the OH. Curly arrow from adjacent C–H bond to form C=C. H_2O leaves with the electrons from O.

Significance: alkenes from renewable alcohol (from fermentation) can make addition polymers without using crude oil. More sustainable route to plastics.

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Distillation of a Product from a Reaction (e.g. cyclohexene from cyclohexanol)

Method: Add cyclohexanol (~10 cm^3) + few drops conc. H_3PO_4 to round-bottomed flask with anti-bumping granules. Set up for distillation. Heat gently; collect distillate at ~83°C. Transfer to separating funnel. Wash with Na_2CO_3 solution (remove acid). Vent regularly. Separate organic layer (top). Wash with water. Dry with anhydrous $CaCl_2$. Filter off drying agent. Redistil if needed, collecting fraction at correct b.p. Record boiling point vs literature value.

Uncertainties: thermometer ±0.5°C; measuring cylinder ±0.5 cm^3.

Common errors: heating too strongly (charring); insufficient washing (acid impurities remain); incomplete drying (water contaminates); loss of volatile product.

Improvements: gentle, steady heat; wash until neutral; use sufficient drying agent; redistil for higher purity; compare b.p. with literature.