Lab: Reactions of the Hydroxyl Group

Introduction

All members of the alcohol family are represented by the general formula R – OH. Reactions of an alcohol involve either the fission of the O – H bond or the C – O bond.

With oxidizing agents, such as acidified potassium dichromate, a primary alcohol produces first an aldehyde and eventually a carboxylic acid. a secondary alcohol will produce a ketone, and a tertiary alcohol will be inert.

Apparatus & Materials

test tubes, test tube rack, forceps, universal indicator solution, moist blue litmus paper, hot-water bath, 0.1 M acidified $KMnO_{4(aq)}$, 0.1 M acidified $Na_2Cr_2O_{7(aq)}$, Na metal, , conc. H_2SO_4, glacial acetic acid (CH_3COOH)
CH_3OH,
C_2H_5OH,
butanol: $CH_3CH_2CH_2CH_2OH$, a primary alcohol
propan-2-ol : $(CH_3)_2$ CHOH, a secondary alcohol
butan-2-ol: $CH_3CH_2CH(OH)CH_3$, a secondary alcohol, (sec-butyl alcohol)
2-methyl-2-propanol: $(CH_3)_3COH$, a tertiary alcohol, (tert-butyl alcohol)
cyclohexanol

Safety

Alcohols are flammable and poisonous. Do not use them near an open flame or breathe the vapours. Glacial acetic acid emits a strong odour, has dangerous fumes and burns the skin. Conc. H_2SO_4 is very corrosive and reacts violently with water. $KMnO_{4(aq)}$ stains the skin. $Na_2Cr_2O_{7(aq)}$ is a powerful oxidant and can damage the skin.

Aim

The purpose of this experiment is to study some of the reactions of the different classes of alcohols.

Procedure

1. Solubility in water

Pour ~ 1 cm^3 of distilled water into a test-tube, add a few drops of universal indicator and shake gently. Add ~ 1 cm^3 of methanol and shake the mixture. Note results into a Data Table, whether the addition of the alcohol has any effect on the colour of U.I , and record observations on the solubility of the alcohol. Repeat with each of the other alcohols in turn.

2. Reaction with Oxidizing Agents

a) Add 2 cm^3 of each of the alcohols to 5 cm^3 of acidified $KMnO_{4(aq)}$ in a tt. Heat the mixture in a hot water bath for 5 minutes. Test the vapour generated with moist litmus paper, and note the odour. Record all the changes.

b) Repeat the above procedure with acidified $Na_2Cr_2O_{7(aq)}$ instead of acidified $KMnO_{4(aq)}$ with each of the alcohols.

3. Reaction with Sodium Metal

Pour ~ 1 cm^3 of the alcohol into a tt. Using forceps, pick up a 1 mm cube of sodium and remove the oil from its surface on filter paper. Drop the sodium into the alcohol. Test the gas with a lighted splint. Pour a little of the product formed onto a watch glass, leave in the fume cupboard and allow to evaporate. Describe what remains. Repeat with each of the alcohols.

4. Reaction with Ethanoic Acid

Into a tt, pour 2 cm^3 of the alcohol and 1 cm^3 of glacial ethanoic acid. **With care**, add 2 - 3 drops of conc. H_2SO_4. Heat the mixture in a hot water bath fro several minutes. Pour the product carefully into a beaker containing sodium carbonate solution. Stir and smell. Note your observation. Repeat using each of the alcohols.

Data Collection

Prepare a suitable table to record the reactions observed above with each of the alcohols.

Questions

1. Explain the solubility observed in reaction 1 above in terms of the structure of the alcohol.
2.a) What relationship exists between the structure of the alcohols and their reactivities towards an oxidizing agent.

b) In reaction 2 above, ethanol produced an acidic compound, name the compound, what is the name of the intermediate compound in this reaction?

3. In the reaction with sodium, what type of fission has taken place in the alcohol molecule - is it C – OH or CO – H fission? Explain.
4. What conditions and relative proportions of reactants are used in Reaction 4 above, to increase the yield of the product.
5. What would be the safest method of disposing of a large piece of material suspected to contain potassium metal?
6. 'Breathalysers' used by the police to detect high levels of alcohol in blood are used, based on one the chemical reaction observed by you above. Describe this test.
7. Write the name and formula of the hydroxy compound which is used as antifreeze and in the manufacture of Terylene.
8. Why have methanol and ethanol recently attracted the interest of the liquid fuels market?
9. Propane-1,2,3-triol (glycerol) is used widely for the manufacture of propane-1,2,3-triyl nitrate by the reaction with nitric acid in the presence of sulphuric acid.

a) This product is more commonly, though incorrectly, known by another name. What is it and why is it incorrect?

b) What is this compound used for?

10. The following sequence shows a method of preparing cyclohexene from cyclohexane:

cyclohexane ----≫ chlorocyclohexane -----≫ cyclohexanol -----≫ cyclohexene

From your knowledge of chemistry, suggest a reagent and conditions for carrying out each step on a laboratory scale.

Alcoholic drinks consist of water and ethanol. Effects of long term use include: increased risk of strokes, liver disease, high blood pressure, infertility and diseases of the nervous system. Withdrawal after heavy alcohol use can involve delirium which may be fatal. Meths drinkers drink methanol which is much more toxic than ethanol and can result in blindness. Pyridine added to the meths causes sterility.