Three isomeric alcohols

Time

1–1.5 h.

Curriculum links

Reactions of primary, secondary and tertiary alcohols. Reactions of aldehydes and ketones.

Group size

1–2.

Materials and equipment

Materials per group

- 2 cm^3 samples of butan-2-ol (Flammable, eye and respiratory irritant), 2-methylpropan-2-ol (Highly flammable, eye and respiratory irritant, harmful if swallowed), and 2-methylpropan-1-ol (flammable, causes eye damage, skin and respiratory irritant) labelled as different unknowns
- iodine solution (10% I_2 in KI(aq)) [dissolve 10 g iodine and 20 g of potassium iodide in deionised water and make up to 100 cm^3]
- 2 mol dm^{-3} sodium hydroxide solution. (Corrosive to skin and eyes)
- 1 mol dm^{-3} dilute sulphuric acid (Irritant to skin and eyes)
- 0.1 mol dm^{-3} potassium dichromate(VI) solution [dissolve 2.9 g of potassium dichromate(VI) in deionised water and make up to 100 cm^3]. (carcinogen, mutagen, reproductive toxin, skin/respiratory sensitiser, is a skin irritant, harmful if inhaled and hazardous to the aquatic environment. - wear gloves and goggles).

These reagents are used to perform the iodoform test and to carry out the oxidation of the alcohols.

Equipment per group

- test-tubes
- test-tube rack
- boiling tubes
- 250 cm^3 beaker
- Bunsen burner, tripod, gauze and bench mat
- safety glasses.

Safety

Eye protection (Goggles to BS EN166 3) must be worn.

Keep away from sources of ignition.

Students must get their methods checked before they start any practical work. The use of fume cupboards is encouraged.

Disposal: Any dichromate that has not gone green should be reduced (probably easiest to use one of the alcohols that works) then test tube contents can be washed to waste.

Risk assessment

It is the responsibility of the teacher to carry out a suitable risk assessment.

This is an open-ended problem solving activity, so the guidance given here is necessarily incomplete. Teachers need to be particularly vigilant, and a higher degree of supervision is needed than in

activities which have more closed outcomes. Students must be encouraged to take a responsible attitude towards safety, both their own and that of others. In planning an activity students should always include safety as a factor to be considered. Plans should be checked by the teacher before implementing them.

You must always comply with your employer's procedures and in some cases may decide that a particular activity is inappropriate in your situation. Further information on Health and Safety should be obtained from reputable sources such as CLEAPSS [*http://science.cleapss.org.uk/*] in England, Wales and Northern Ireland and, in Scotland, SSERC [*https://www.sserc.org.uk/*].

Commentary

This is an exercise in traditional organic chemistry. A structured approach would be to ask the students to work through the following questions and activities:

(a) Write out the structural formulae of the three possible alcohols.
(b) Classify the alcohols as primary, secondary or tertiary.
(c) Examine the structures and predict which compounds will undergo reactions such as the iodoform reaction or oxidation reactions. There are, of course, other possible reactions. In the case of the two mentioned above you could then ask the students which isomer undergoes: (i) both the oxidation and the iodoform reaction; (ii) the oxidation, but not the iodoform reaction; and (iii) neither reaction.
(d) Carry out the reactions, entering your observations in the following table.

Observations

Alcohol	Iodoform test	Oxidation test
A B C		

(e) From your observations in (d) give the identity of A, B and C.

Procedures

The following procedures were found to work particularly well in trialling.

Iodomethane reaction
Place six drops of an alcohol in a test-tube. Add 1 cm^3 of iodine in potassium iodide solution followed by sodium hydroxide solution drop by drop until the brown colour of the iodine just disappears (about 2 cm^3). The test is positive if a yellow precipitate (triiodomethane) is produced.

Oxidation reaction
Place dilute sulphuric acid in a boiling tube to a depth of 1 cm. Add three drops of potassium dichromate(VI) solution and then five drops of alcohol. Warm the mixture gently and note if the orange colour of the dichromate(VI) is replaced by the green colour. If this occurs then the alcohol has been oxidised.

Extension

This problem is capable of extension in a variety of ways. During trialling some institutions used different functional group isomers – *eg* $C_3H_6O_2$ ethyl methanoate, methyl ethanoate, propanoic acid; or the three isomers of C_4H_9Cl.

Acknowledgement

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Credits

Health & safety checked May 2018

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