Permanganate oxidation of alcohols

The oxidation of alcohols is commonly carried out on a test-tube (or spotting tile) scale to demonstrate to pupils the different properties of primary, secondary and tertiary alcohols.

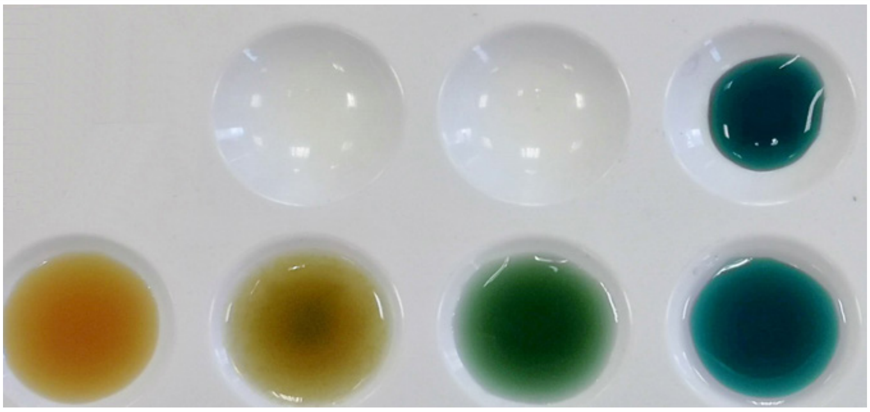

Figure 1 - Top row: control. Bottom row(left to right): Ethanol, propan-1-ol, propan-2-ol and 2-methyl-propan-2-ol.

It is normally carried out using acidified potassium dichromate. This reagent is an effective oxidant and has the advantage of an inherent colour change (from yellow to green) that allows the progress of the reaction to be easily observed.

However, chromium(VI) compounds, such as dichromates, are toxic, corrosive, carcinogenic, mutagenic, sensitisers and extremely hazardous to the environment. Where possible they are best avoided.

Other methods have been suggested, most notably by using a solution of acidified permanganate in which the primary, secondary and tertiary alcohols can be distinguished by the rate of change of the colour from purple to yellowish brown as the manganese VII is reduced to manganese IV. The colour changes are not all that clear, though, and the experiment takes some time.

As an alternative, we have developed an improved method which uses an **alkaline** permanganate solution. This gives an initial colour change (where oxidation happens) to the bright green manganese VI followed (in some cases) by a slow change to yellow/brown manganese IV. (The blue V state is very unstable and rapidly decomposes).

Alkaline permanganate is not as stable as the acidified solution and so will be reduced in air to the blue/green colour (possible a mix of Mn VI and VII) but it is significantly different from the green produced if there is any reaction.

As can be seen in Figure 1 above, the colour changes are clear and this method has the great advantage of not being hazardous (for technicians either).

The permanganate solution is very dilute (0.006 mol l^{-1}) and so the solution can, after either neutralisation or further dilution simply be washed to waste. (The hazard of this solution is solely from the sodium hydroxide)

The experiment

You will need:

- **Alkaline manganate VII solution**
  Dissolve 0.1 g of potassium manganate VII in 100 cm^3 of 0.4 mol l^{-1} sodium hydroxide.
- **Spotting tile**
- **Alcohols to test**
  A good selection would be ethanol, propan-1-ol, propan-2-ol and 2-methyl-propan-2-ol but others can be tried.
- **Pasteur pipettes**
  It may be preferable to have the alcohols in dropping bottles. In either case, the alcohols have a tendency to flood out of the pipette/bottle rather more rapidly than water so students should take care and preferably have some practice at handling them

Method

1) Take your spotting tile and add 10 drops of your alkaline manganate VII solution to each of 5 wells (4 alcohols and a control)

2) Use Pasteur pipettes or dropping bottles to add 2 drops of ethanol to the first well, propan-1-ol to the second, propan-2-ol to the third and 2-methyl-propan-2-ol to the fourth.

3) Observe the changes over the next few minutes.

Results

The figure below shows the colours obtained from some common alcohols after leaving for about 5-6 minutes.

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Ethanol - an immediate green colour which then slowly (over 5 minutes or more becomes yellower).

Propan-1-ol - the same as ethanol but it is very slightly slower.

Propan-2-ol - A slightly slower green colour (a couple of seconds) followed by a slower yellowing. It will end up green rather than yellow.

2-methyl-propan-2-ol - the solution rapidly goes a dark, slightly bluish green but then stays that colour.

Control - this slowly changes colour to end up the same dark bluish green as the tertiary alcohol.

Extensions

1) Ketones - The only ketone we tested here was **propanone**. This goes the same colour as the primary alcohols only faster. Within about 1 minute the solution is yellow. To be certain, test the propanone with an acidic permanganate solution - there will be no reaction and the solution will remain purple.

2) Methanol - This undergoes the same changes as ethanol but is a little slower

3) Butan-1-ol - again the same changes as ethanol but it needs stirring a little at the start to encourage mixing. The reaction is also noticeably slower.

4) Aromatic alcohols - we tested **phenylmethanol** and **cyclohexanol**. Both needed some stirring to encourage the reaction to start but they turned green after about 15 seconds and began to show a yellowish tinge after about 3 minutes.

5) Diols and triols - we tried **ethane-1,2-diol**, **propane-1,2-diol** and **propane-1,2,3-triol**. All three (after a little stirring to mix) rapidly went orange.

Guide to practical physics

'Send the teachers on this!' commented a technician who attended our Introductory Physics course. It got us thinking about our own experiences as newly-qualified teachers and the guidance available when it came to setting up equipment. We decided to take the notes we had created for both Introductory and Intermediate Physics and put together a document we hope will be of use to technicians, science teachers who are not physicists but who teach physics at BGE, and to early-career physics teachers.

The result is the *Guide to practical physics*. This can be downloaded from our website [1] but you will need to log in to do so as it has a substantial amount of health and safety content. Such material is password protected. SSERC Bulletin 265 [2] tells you all you need to know about getting a password.

Guidance ranges from the very basic - which sockets to use when measuring current with a multimeter - to more complicated issues such as using the correct UV light source to demonstrate the photoelectric effect and indeed doing so safely. We have made videos to support some of the content [3].

When we first ran the Introductory Physics for Technicians course, we asked delegates for their ideas regarding content of an Intermediate course. We took these ideas onboard. In a similar spirit, we would like to hear your ideas for the content of the *Guide to practical physics*. We hope that it will be an ever-evolving document. Comments, please, to gregor@sserc.scot.

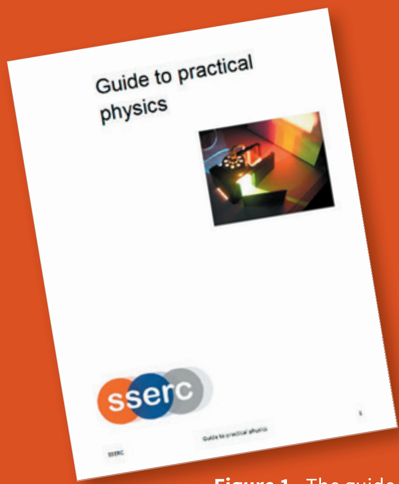

Figure 1 - The guide.

References[

[1] www.sserc.org.uk/subject-areas/physics/physics-other-resources/guide-to-practical-physics/ (accessed August 2019).

[2] www.sserc.org.uk/wp-content/uploads/Publications/Bulletins/265/SSERC-bulletin-265-p7_8.pdf (accessed August 2019).

[3] www.sserc.org.uk/subject-areas/physics/physics-other-resources/how-to-videos/ (accessed August 2019).