

## Teaching ideas for Chapter 10, *Organic chemistry*

### Questions

Two worksheets of questions are provided:

- the first worksheet deals with the Standard Level part of the syllabus
- the second worksheet is for Higher Level only.

There are also a large number of questions available in the Coursebook and on the accompanying CD-ROM.

### Teaching ideas

- Crude oil:
  - the origins and processing of crude oil could be discussed
  - the environmental impact of the extraction and transportation of crude oil could be discussed with reference to the Amoco Cadiz, Sea Empress and Gulf of Mexico disasters, among others
  - the importance of the combustion of fossil fuels could be discussed, as well as the environmental problems associated with it
  - the importance of chemicals derived from crude oil (medicines, plastics, etc) can be discussed and it could be debated whether crude oil is too valuable to burn (this links in with Option C: *Chemistry in industry and technology*).
- Organic chemistry can be related to drug design using the resources available at: <http://www.rsc.org/Education/Teachers/Resources/Design.asp>  
this also links to Option D: *Medicines and drugs*.
- Students could research the use of biofuels and debate the advantages and disadvantages of using these. Details of a biodiesel synthesis can be found at: <http://greenchem.uoregon.edu/Pages/Overview.php?ID=87>
- Why might some countries be much keener on developing biofuels than others? What are the ethical arguments associated with using possible foodstuffs as fuels?
- Students can use molecular models to build isomers. If molecular model kits are not available they could build models using household materials.
- Molecule drawing programs such as ACD ChemsSketch (see below) are useful for visualising and naming isomers. The space-filling models can be used to illustrate how steric effects are important in  $S_N2$  mechanisms.
- Optical isomerism can be demonstrated using molecular models. Students could also be given samples of caraway seed and spearmint as examples of optical isomers.
- The importance of the hydrogenation reaction for alkenes can be discussed with regard to producing partially hydrogenated fats. The production of *trans* fats (relate to Section 10.10 in the Coursebook) can be discussed, as well as the health issues associated with them. Why have some countries banned partially hydrogenated fats/oils and others have not? This links to Option F: *Food chemistry*.
- Alternative methods of making ethanol could be discussed (fermentation and hydration of ethene), looking at the advantages and disadvantages of each process. Why some countries have introduced fuels containing ethanol could be discussed. Brazil is a prime example of a country where the addition of ethanol to gasoline is important.
- The advantages and disadvantages of using artificial polymers/plastics could be discussed. This can be related to Option E: *Environmental chemistry*. The legislation introduced by various countries to regulate packaging could be discussed. The pros and cons of recycling plastics could be discussed.
- The biochemical effect of ethanol could be discussed, along with the issues that arise from the over-consumption of alcoholic drinks. This links to Option D: *Medicines and drugs*.

- The economic importance of the production of esters and condensation polymers could be discussed.
- The role of esters in flavourings and odours could be discussed:  
<http://www.chm.bris.ac.uk/motm/ethylacetate/smells.htm>
- The importance of optical isomerism in everyday life could be researched/discussed. Students could look at the case of thalidomide.
- Students could research the nomenclature used for optical isomers (links to Option F: *Food chemistry*) and how enantiomers are separated.

## Practical activities

### Safety

Extreme care must be exercised when carrying out any practical activities in the classroom and a risk assessment should be conducted before carrying out the experiments.

### Demonstrations

- Wherever possible, students should be shown organic chemicals and their physical properties could then be demonstrated. For example, when each homologous series is introduced, students could be shown a sample of a compound and its solubility in water (or lack of it) demonstrated.
- Combustion reactions can be demonstrated by putting a few drops of the compound on a crucible lid and igniting. Students should notice different colour flames and smokier flames, which can be linked to incomplete combustion and the C : H ratio.
- The substitution reactions of alkanes can be demonstrated by adding a few drops of bromine (**Care!**) to, for example, hexane in a boiling tube. The sample is split into two: one portion is placed in a dark cupboard, whereas the other is put in sunlight. If it is not a particularly sunny day, a UV lamp can be used. The sample in sunlight will decolorise quickly whereas the other sample should remain unchanged.
- The addition reaction of alkenes with bromine water can be demonstrated by adding bromine water to, for example, hexene or cyclohexene and shaking. This can be compared to the lack of reaction with hexane/cyclohexane. Bromine water could also be shaken with a vegetable oil/margarine to illustrate the unsaturated nature of these fats (compare with butter/lard).
- The oxidation of alcohols can be investigated using simple test-tube reactions. Primary, secondary and tertiary alcohols can be heated with a mixture of potassium dichromate(VI) solution and dilute sulfuric acid (**Extreme care!**). This can be carried out by heating the reaction mixture in a Bunsen burner flame, but extreme care must be exercised as the mixture is likely to ignite or shoot out of the end of the tube. A safer way of carrying out the experiment is to heat in a water bath using an electric heater.
- Substitution reactions of halogenoalkanes and the relative rates depending on the nature of the halogenoalkane (primary, secondary or tertiary) and the type of halogen atom can be demonstrated.
  - Various test tubes containing about 2 cm<sup>3</sup> each of ethanol can be heated to about 50 °C in a water bath on a hot plate. A few drops of halogenoalkanes are added, followed by 1 cm<sup>3</sup> of silver nitrate solution. The rate of reaction can be compared by looking at the rate of formation of the silver halide precipitate.
  - The reactions for 1-bromobutane, 2-bromobutane and 2-bromo-2-methylpropane can be compared to illustrate the differences between S<sub>N</sub>1 and S<sub>N</sub>2 reactions.
  - Students could be asked to make a hypothesis about how the rate of reaction will vary between 1-chlorobutane, 1-bromobutane and 1-iodobutane. The two possible factors (bond polarity and bond strength) that are likely to affect the rate could be discussed and how an experiment is needed to test which is more important. The hypotheses could be tested by carrying out the reaction.

- Esterification can be illustrated by heating various alcohols and carboxylic acids with a couple of drops of concentrated sulfuric acid as a catalyst (**Extreme care!**). The resulting mixture can be poured into a beaker containing sodium carbonate solution before carefully smelling. This could also be carried out as a class laboratory practical. Pentyl ethanoate has a fruity smell.  
<http://www.practicalchemistry.org/experiments/making-esters-from-alcohols-and-acids,235,EX.html>
- Preparation of nylon can be demonstrated by putting 1,6-diaminohexane and decanedioyl dichloride in a small beaker and drawing a thread of nylon from the interface between the two liquids using tweezers. This is known as the 'Nylon Rope Trick'. This can also be carried out as a class practical. Consult the following websites for more detailed procedures:  
[http://www.chem.umn.edu/services/lecturedemo/info/Nylon\\_Rope\\_Trick.html](http://www.chem.umn.edu/services/lecturedemo/info/Nylon_Rope_Trick.html)  
<http://www.usm.edu/pattonresearchgroup/PSC341/jce.pdf>  
<http://media.rsc.org/Classic%20Chem%20Demos/CCD-64.pdf>
- The rotation of plane-polarised light can be demonstrated using a concentrated solution of one enantiomer of a sugar solution, e.g. D-glucose. An OHP is set up with a sheet of card with a round hole cut in it covering the surface. Crossed Polaroids are placed over the hole to demonstrate that no light can get through. The beaker containing the glucose solution is then placed between the Polaroids and some light does pass through. A filter can also be put on the OHP to produce monochromatic light.

### Student practicals

Experiments range from simple test-tube reactions to more complicated organic syntheses. Some of the experiments in the demonstration section can be carried out as class laboratory exercises.

- Examples of organic chemistry practicals can be found at:  
<http://www.practicalchemistry.org/experiments/advanced/organic-chemistry/topic-index.html>
- Limonene can be extracted from orange rind using steam distillation and subsequently tested with bromine water:  
<http://www.reading.ac.uk/web/FILES/chemistry/Limonene.pdf>
- Students could carry out test-tube reactions:
  - to look at the characteristic reactions of primary, secondary and tertiary alcohols (oxidation with acidified potassium dichromate(VI) and esterification)
  - to look at the characteristic reactions of aldehydes/ketones (reaction with 2,4-dinitrophenylhydrazine/Brady's reagent and oxidation)
  - to look at the characteristic reactions of carboxylic acids (reaction with indicators, magnesium, sodium carbonate, alcohols)
  - see **Practical 1 – Chapter 10: Alcohols**
  - see **Practical 2 – Chapter 10: Organic analysis**
- Students could then be asked to design a sequence of reactions to identify a set of unknown organic compounds. For example, students could be given a primary alcohol, a carboxylic acid, an ester, an aldehyde and a ketone and told to identify which is which using chemical tests.
- Students could investigate some factors that effect the rate of nucleophilic substitution reactions:  
<http://www.cerritos.edu/jbradbury/Chem.%20211%20lab/211%20Lab/Nucleophilic%20Substitution%20pt%202.pdf>  
<http://classes.kvcc.edu/chm220/nuc%20subst%20reaction-tech714.pdf>
- Esters can be made as described above, or using the following procedures:  
<http://www.chymist.com/Esters%20-%20Introduction.pdf>  
<http://www.hartnell.cc.ca.us/faculty/shovde/chem12b/esters.htm>  
<http://www.usna.edu/ChemDept/plebeChem/manual/Ex26G.pdf>
- The Royal Society of Chemistry book, *Aspirin*, which is available as a free download, provides a good introduction to some practical organic chemistry techniques:  
[http://www.rsc.org/images/Aspirin\\_tcm18-189278.pdf](http://www.rsc.org/images/Aspirin_tcm18-189278.pdf)

## Common problems

- Students often have difficulty with organic chemistry due to the volume of material that must be learnt. Organic flow diagrams that are either missing the reagents or the compounds will aid students in learning this material. There are six diagrams available on the website that can be used.
  - Standard level**
    - Complete reaction flow diagram, *Standard Level flow diagram 1*.
    - Flow diagram missing the reagents, *Standard Level flow diagram 2*.
    - Flow diagram missing the compounds, *Standard Level flow diagram 3*.
  - Higher level**
    - Complete reaction flow diagram, *Higher Level flow diagram 1*.
    - Flow diagram missing the reagents, *Higher Level flow diagram 2*.
    - Flow diagram missing the compounds, *Higher Level flow diagram 3*.
- Drawing isomers is something that students often find difficult. Wherever possible, molecular models can be used to aid students with visualising isomers.
- Balanced equations for organic reactions seem to be increasingly required in examinations. It is important that students learn how to balance these. This could include an overall balanced equation for the oxidation of alcohols using acidified dichromate(VI), which links to Chapter 9: *Redox*.

## ICT

There are many opportunities for using IT in this topic. Many sites offer visualisations of organic molecules or animations of reactions.

- Functional groups:  
<http://michele.usc.edu/105b/organic/group.htm>
- Isomers:  
<http://webhost.bridgew.edu/fgorga/Stereochem/default.htm>
- Nucleophilic substitution reactions:  
<http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/animationsindex.htm>
- There are various drawing programs available on the internet. ACD ChemsSketch allows you to draw molecules and name them and also to generate space-filling models:  
<http://www.acdlabs.com/resources/freeware/chemsketch/>
- IUPAC naming:  
<http://www.chem.qmul.ac.uk/iupac/>
- Demonstrations on video:  
[http://www.uni-regensburg.de/Fakultaeten/nat\\_Fak\\_IV/Organische\\_Chemie/Didaktik/Keusch/D-Video-e.htm](http://www.uni-regensburg.de/Fakultaeten/nat_Fak_IV/Organische_Chemie/Didaktik/Keusch/D-Video-e.htm)
- Organic experiments (in German):  
<http://www.versuchscheme.de/forum,41,-Organik.html>
- Viewing representations of organic molecules:  
<http://www.molsci.ucla.edu/pub/explorations.html#Crystalline%20Solids>
- Animations of structures and reactions:  
<http://www.chemtube3d.com/>  
<http://ochem.jsd.claremont.edu/tutorials.htm#>
- Organic synthesis reaction pathways:  
<http://synthesisexplorer.rsc.org/>
- Organic practical techniques;  
<http://www.rsc.org/Education/Teachers/Resources/practical/>
- Using curly arrows:  
<http://www.abdn.ac.uk/curly-arrows/>



- Isomerism of butenedioic acid:  
[http://www.uni-regensburg.de/Fakultaeten/nat\\_Fak\\_IV/Organische\\_Chemie/Didaktik/Keusch/D-Mal\\_Isom-e.htm](http://www.uni-regensburg.de/Fakultaeten/nat_Fak_IV/Organische_Chemie/Didaktik/Keusch/D-Mal_Isom-e.htm)

### **Theory of knowledge (TOK)**

The different ways of representing organic molecules could be discussed. Are any of them a true representation of reality?

Inductive reasoning is being used when we assume that just because one primary alcohol reacts in a particular way, then all primary alcohols react in the same way.

The use of systematic names could be discussed. Why is it important that everyone agrees on a set of rules for this? Why aren't unambiguous incorrect names accepted?

The use of reasoning to deduce, from the existence of optical isomers, that carbon has tetrahedral geometry when singly bonded could be discussed.