Simon Cotton

Image breakers

'Soundbite' molecules – all you need to know about a chemical – on an A4 sheet.

THE LACK OF A chemical David Bellamy or a Patrick Moore, who can popularise chemistry for the man in the street, is frequently deplored. This is not just a British problem as a recent article by Rudy Baum in *Chemical and Engineering News* reported.[1] Baum's central theses are:

- ❖ chemistry is a practical science where chemists' work is directed to making a particular material or molecule; it is fun to do but harder to read about;
- ❖ chemistry keeps losing some of its most interesting areas to other disciplines, *eg* biotechnology developed from the manipulation of DNA;
- ❖ chemistry is the most rigorous science, being grounded in 'the unforgiving rigor of what is real'. Physicists, on the one hand, admit that they cannot find 90 per cent of the matter that their theories predict should exist in the universe, and most biologists (except molecular biologists who are really chemical biologists) deal with such complicated systems that they only have a very basic understanding of how they work. Chemists 'precisely manipulate matter, which is real. Their theories must conform to experimental reality';
- ❖ chemistry is hierarchical;
- ❖ the wonder of chemistry is largely in the details, which fascinate chemists, but few others.

There is no doubt that people generally want to know about those chemicals which are in the news and those relating to their experience of life. It is important to be positive yet honest about chemicals. In recent times, 'chemical' has too often meant 'artificial', 'toxic', and 'additive'. John Emsley, a science writer, has commented on how difficult it is to use the word in a neutral way, meaning 'substance'.[2] Chemistry's image is such that people are surprised to learn that the most lethal poisons known are not dioxins and the nerve gases but natural toxins – botulinum, tetanus, diphtheria *etc.*[3]

Reclaiming chemistry

We can reclaim chemistry from other disciplines by making clear the true meaning of the term chemical, pointing out the natural substances in the world around us; we need to remember that 'chemistry is all around'. One approach to this has been the *Chemistry trail* popularised by Peter Borrows,[4] while the same author has used sources like newspaper articles and labels on bottles and packets to raise students' awareness of chemistry in their lives.[5]

I have found a different approach, based on a popular broadsheet style, to be profitable. I prepare a one-page presentation on a compound or group of related chemical substances, if possible with a catchy title. The first broadsheet was stimulated by the almost simultaneous publication of two articles, one on the chemistry of love, the other on the chemistry of chocolate,[6] both of which mentioned 2-phenylethylamine, reportedly an aphrodisiacal chemical in people. A Valentine's Day edition of the broadsheet entitled *The love drug* (*Fig 1*), revealed some interesting facts, including the presence of 2-phenylethylamine in chocolate.

The sheets were originally aimed at UK A-level students. Additionally, A3 versions have been posted on noticeboards and attract younger students and teachers alike.

My inspiration for the broadsheets comes from various avenues. Questions asked in the course of classroom discussion are a good starting point. One's own colleagues also make pertinent enquiries; thus the high pollutant levels in the late spring of 1995 prompted *Ozone.* Newspaper articles referring to articles in the original literature can serve as a stimulus; thus a short article on the front page of *The Times,* relating to the discovery of a huge ethanol cloud in outer space, not only drew a large correspondence in the pages of that paper, but provoked me to put together *Chemistry in space.* The almost simultaneous appearance of two articles on the large number of organochlorine compounds in nature[7] was serendipitous and almost demanded a sheet with the polemical title *Ban chlorine.* Books devoted to consumer (and other) chemistry have been invaluable.[2, 3, 8, 9] Atkins' book *Molecules* has been irreplaceable as a source of information on specific important substances,[10] while more esoteric molecules can be accessed through dictionaries.[11] Finding information rapidly on topical stories can be difficult. Recently *Chemical and Engineering News* provided useful coverage of both the Tokyo nerve gas attack and the Oklahoma City bombing.[12] Other magazines like *Chemistry in Britain* and *Chemistry and Industry* are also valuable.

Textbooks can also be a useful source of information, but be careful and watch out for errors. For instance, it is now known that the smell of putrescine (1,4-diaminobutane) arises

1. The love drug

Why drag sex into chemistry?

It happens that a romantic reaction to another human being sets off a chemical reaction in the body. It is no accident that we talk about sexual chemistry because the substances produced in the body are closely related to the amphetamine drugs. They include dopamine, norepinephrine and particularly 2-phenylethylamine (PEA).

Does the body go on producing these drugs?

Yes, but unfortunately the body builds up a resistance to PEA and, after a couple of years or so, its effects wear off.

Is this the end of love?

By no means.

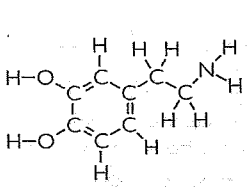
Why?

Emotional reactions are produced by other chemicals. Long-term attachment leads to morphine analogues called endorphins being produced by the brain and produce morphine-like symptoms – relaxation, peace *etc.* The pituitary gland in the brain secretes oxytocin, a nerve stimulant implicated in sensations during lovemaking (oxytocin levels rise during intercourse). It also appears to be involved in the mother–child relationship; it helps uterine contraction in birth and production of milk.

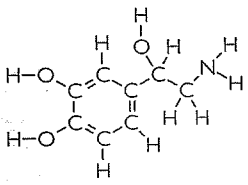
Can we make someone fall in love with us by spiking their drinks with chemicals like PEA?

Funny you should say that; chocolate is rich in PEA. A 100 g bar contains up to 660 mg of it (as well as other stimulants such as methylxanthine and theobromine). However, it is poorly absorbed by the body and therefore chocolate isn't an aphrodisiac. The body has to manufacture its own PEA.

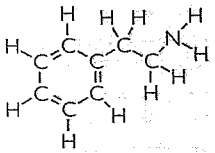
So the lady may love M— T—, but not for the apparent reason.



Dopamine



Norepinephrine



2-phenylethylamine (PEA)

from the presence of traces of the cyclic Schiff base, 1-pyrroline,[13] while the smell of the skunk, often reported to be caused by 1-butanethiol, actually arises from 3-methyl-1-butanethiol.[14] Smells are in fact a popular byway to explore. The sheet *Fruity* explains how changing the structure of an ester affects the smell of the molecule. *No sweat man* explored which chemicals have sweaty smells and why each person has an individual sweat discernible by tracker dogs.

Some ground rules

Here are some tips for preparing a broadsheet.

1. An eye catching title to indicate the key issue and arouse attention. The first sentence of the text should expand on this perhaps by asking a topical question, *eg* What killed all those people in the Tokyo subway?

2. Stick to one page – the concentration soundbite. Turning the page can turn the reader off.

3. Try not to crowd the page by putting too much information in.

4. Break up the text with graphics – clipart and molecular structures – and equations. Even if the reader doesn't have the technical appreciation of much that the equation communicates, it is still better than a whole page of text. The amateur, though impervious to a molecular formula, can take in the connections in a structural formula.

5. Find the right level and don't patronise the reader. Use straightforward English and deal in facts. Don't use scientific language unless you have to; explain unfamiliar words.

6. Try to include some dialogue. I use an informal question and answer style, using questions that the public might sensibly ask.

7. Use a couple of different fonts – I admit to using far too many – to discriminate and separate text (*eg* question and answer).

8. Be human. A little bit of dramatic understatement can go down well, but use humour sparingly. I often signal one-liners or highlights in italics.

I don't use a desktop publishing program (though that would be an improvement). I do, however, have a certain amount of clipart as well as ChemWindow, a Windows package for drawing structures that can be inserted in the text (this is not essential, structures can be hand drawn, but it improves the appearance). ChemDraw is an alternative drawing program. Both are available in PC and Mac versions.[15]

These sheets have provided opportunities to clear up misconceptions and put right some media fallacies. Thus *Ban chlorine* was a chance to point out that both inorganic and organic chlorine compounds are widely spread in nature (0.045 per cent of the Earth's crust, 1.9 per cent of sea water) and thus could not be 'banned'. Further, introducing chlorine into phenol actually makes the molecule safer. The occurrence of all three dichlorophenols in nature provides a starting point for revising isomerism. The subtitle of the sheet, *Frustrate the Lone Star Tick*, reflects the use of 2,6-dichlorophenol by the Lone Star Tick as its sex pheromone.

The love drug led to a class discussion on the chemistry of amines – could 2-phenylethylamine be turned into azo dyes? The sheet *Ozone* provoked discussion of the bonding and shape of O_3, along with other triatomics such as CO_2, NO_2, NO_2^-, NO_2^+ and SO_2.

2. Nerve gas

What killed those people in the Tokyo subway?

Experts aren't sure yet (or else they aren't saying). In 1994, however, two groups of Japanese commuters were poisoned with an organophosphorus compound called sarin.

Why did they die?

Assuming that the poison was sarin, their deaths were caused by a build-up of the neurotransmitter acetylcholine.

Pardon?

Acetylcholine helps transmit signals from one nerve cell to another, or from a nerve cell to a muscle cell. Sarin inhibits the enzyme cholinesterase. This is the substance that breaks down acetylcholine. If acetylcholine levels are not controlled, its build-up paralyses the respiratory system and causes the lungs to fill with water.

Is there an antidote?

The antidote is atropine, accompanied by oxygen. Sarin can kill you in minutes if you inhale the vapour or get a drop on your skin.

What is sarin like?

It is an odourless, colourless liquid not unlike water in appearance. The terrorists seem to have used a solution in acetonitrile.

Is sarin easy to make?

No, it is difficult. But it can be made by more than one route, for example Scheme 1. $SOCl_2$ is a rather unpleasant liquid to use and HF is downright nasty – it dissolves glass. This means that sophisticated apparatus has to be used. Filling a nerve-gas 'bomb' is a perilous undertaking. American nerve-gas shells contain difluor and isopropanol separately; they are only mixed when the shell is fired.

Who is known to have stocks of sarin?

The US and Russia admit to holding stocks, which they will be destroying under the Chemical Warfare Treaty. Other countries like Iraq don't admit to it.

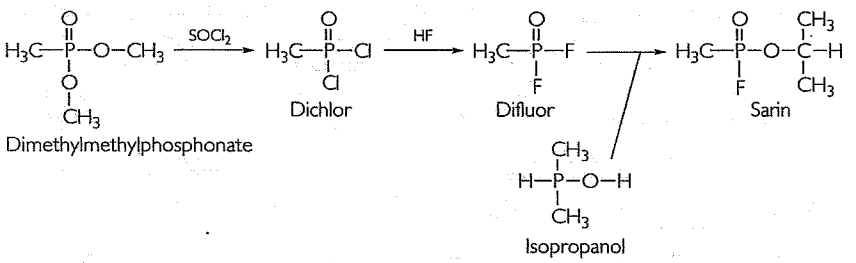
So sarin is a brand new poison, right?

Wrong. German scientists researching new insecticides hit upon it during the 1930s. The Nazis made it for use as a secret weapon, but did not use it; the Americans and Russians developed it too. Since then, Saddam Hussein used it against the Kurds in 1988.

Are there any similar compounds?

Similar compounds but without fluorine, such as malathion and parathion, are used as pesticides. Other organophosphorus compounds are used in 'sheep dips'. A number of farm workers have developed illnesses that may be related to these.

Scheme 1



Pheromones have provided an opportunity for cross-curricular links with biology;[16] their need for volatility has been a good reinforcing point about properties of covalent substances. Another opening for the ionic/covalent comparison was provided by *Crack*, a sheet inspired by an article in the literature,[17] explaining why crack cocaine was more dangerous than its hydrochloride.

The paradigm of the 1980s has been 'chemicals are bad'. We need to redefine the paradigm for the rest of the 1990s and on into the 21st century to 'chemistry is great'. Chemistry has made more positive contributions to the everyday life of the public than any other science. We owe it to them to tell them about it.

Simon Cotton is a chemistry teacher and a regular contributor to Education in Chemistry. *Look out for his new series,* Soundbite molecules, *in Column, starting this September.*

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