Drug Analysis by NMR

Target Audience
Students studying A2 Chemistry who are interested in modern analytical techniques, chemical structures, molecular biology and forensic science.

Key Concepts
Chemical structures, symmetry, NMR spectroscopy, analysis, drugs, medicinal chemistry

The Activity
NMR spectroscopy, both proton NMR and carbon-13 NMR, is routinely used by chemists worldwide to determine the structures of new compounds that they prepare. What are the active ingredients in a typical non-steroidal pain reliever, such as Anadin Extra®? What are the chemical structures of these compounds? How can carbon-13 NMR spectroscopy be used to distinguish between these ingredients?

Background Knowledge
A detailed knowledge of the theory of NMR spectroscopy is not required to tackle this activity. All that is required is a basic knowledge of how to interpret a \( ^{13} \text{C} \) NMR spectrum in terms of the numbers of peaks, and the different regions of the spectrum that signals occur in. You will be able to develop the skills you need using the resources suggested below.

Resources
It should be relatively easy to find the active ingredients in Anadin Extra®, and their chemical structures. A useful introduction to the use of \( ^{13} \text{C} \) NMR spectroscopy may be found at this [webpage]¹. The [Spectral Database for Organic Compounds]² gives detailed spectral information for many compounds and may be of assistance in understanding how to interpret \( ^{13} \text{C} \) NMR spectra.

Outcomes
This activity has many possible outcomes, for example, a report, display, or presentation. How far you develop the ideas depend on you and your intended audience. For example, how far do you need to analyse the spectrum – just the numbers of peaks, or also some prediction of exactly where in the spectrum these peaks occur?

Helpful hints
- There are different ways of representing molecular structures – which way is the most convenient for your purposes?
- Make models of the compounds to help identify which carbon atoms are equivalent to help predict the numbers of peaks in the \( ^{13} \text{C} \) NMR spectrum.
- It might be useful to consider the \( ^{13} \text{C} \) NMR spectra of some simple compounds, such as benzene and methyl benzene, before looking at those of your drugs.
- How are the chemical shifts of the signals in the NMR spectra affected by double bonds, or by electronegative groups that are attached to carbon atoms?

Going further
You could give a presentation on the \( ^{13} \text{C} \) NMR of other drugs too. Currently, the world's best selling drug is Pfizer's drug cholesterol-lowering drug Lipitor which has sales exceeding $10 billion per year. What would you predict the spectrum for this drug to look like?

¹ [http://www.chemguide.co.uk/analysis/nmr/backgroundc13.html#top]
² [http://riodb01.ibase.aist.go.jp/sdbs/cgi-bin/direct_frame_top.cgi]