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KÉMIA IDEGEN NYELVEN

Kémia angolul

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Előszóban:

Annyi érdekesség van, ami nem fér bele a középiskolás természettudományos órákba. Különösen igaz ez a több tantárgyon is alapuló esetekre. A ***The Complete Idiot's Guide to Organic Chemistry*** szerzőpárosa sajátos stílusban tárgyalja a szerves kémiát, messze nem középiskolás szinten. A spektroszkópiáról szóló fejezet bevezetőjének lefordítása a következő feladat. Hogyan kapcsolódik ez a szerves kémiához? A modern szerves kémia nem lenne ott, ahol most tart a spektrumok segítsége nélkül.

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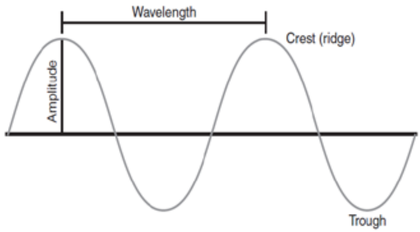
What Is Spectroscopy?

Spectroscopy is a method for identifying unknown compounds from their spectra. Unfortunately, a spectrum is the thing you get when you do spectroscopy, which makes this definition something less than handy. To really make sense, we'll have to go back and start from the beginning.

Wavelength, Frequency, and the Speed O' Light

You've hopefully heard at some point that light acts as both a particle and a wave. If you could see what this wave looks like, it would look something like this:



Light can often be thought of as being a wave, with the characteristics shown here.

In this drawing, the symbol λ (the lowercase Greek lambda) represents the wavelength of light. The wavelength is just the distance between two peaks or two troughs (the low parts) of the wave (measured in meters). Once we have this term, we can use the following equation to come up with lots of other neat stuff: $c = \nu \cdot \lambda$

Okay, I'll admit this equation doesn't look all that neat. However, there are a couple of terms that we need to familiarize ourselves with to make it neat.

- The speed of light is represented by the letter c. In a vacuum (and air is pretty close to being a vacuum, by light's standards), the speed of light is 3.00×10^8 m/sec.
- The frequency of light is represented by the symbol ν (the lowercase Greek letter nu). Frequency just tells us how many times the wave can do its wave thing in one second.

In essence, what this equation tells us is that there's a relationship between the speed of light, the wavelength of light, and the frequency. To put this in plain English (because I know that's all you really care about), the more times the wave does its wave thing in one second, the shorter each wave is. That's not too bad!

Light and Energy

Let's shift gears a second. Even without my saying so, you probably already know that light carries energy. Between the magic of solar power panels and the pain of sunburns, you know that if light shines on something, it adds energy to it.

The amount of energy that light can add to something depends on the color of the light. Light that's blue has lots and lots of energy, and light that's red has a lot less energy. There's even light out there that either has so much or so little energy that your eyes can't even detect it.

The color of light, in turn, has to do with things such as wavelength and frequency, which we were just talking about earlier. I know you can hardly wait to find out what the relationship is, so let's hit you with the equation: $E = h \cdot \nu$.

Let's explain these terms:

- E represents the energy of the light in Joules (J).
- h represents Planck's constant, which is nothing more than a number that some dude named Planck came up with to relate the energy of light to its frequency. The value of Planck's constant is 6.626×10^{-34} J × s. It doesn't exactly roll off the tongue, but there it is anyway.
- ν is the frequency of light, which we already talked about. Because we already know that $\nu \cdot \lambda = c$, we can restate the equation as: $E = h\left(\frac{c}{\lambda}\right)$.

As a result of all this messing around, we can now say (with confidence) the energy of light is related to its wavelength. Light with long wavelengths has low energy; light with short wavelengths has high energy. Seriously, that's what it says!

Colors and Energy

We just established that the color of light is related to its wavelength and frequency. In fact, if we were to be so crazy as to put the relationship between color, wavelength, and frequency on a chart, it would look something like the following.

The following chart represents the electromagnetic spectrum, which shows all of the different waves of light that exist. As you can see, only a very small part of the electromagnetic spectrum can actually be seen with the human eye—most of it has either too short or too high a frequency to be seen.

What Happens When You Add Electromagnetic Radiation to Something?

In the most general of terms, let's talk about what happens when electromagnetic radiation is added to a chemical compound in a process known as absorption spectroscopy. Here's a diagram with some explanation.

The process by which transmitted light is measured during absorption spectroscopy.

- The radiation comes into contact with the sample.
- The energy that has been added gets used by the sample to do something. What this "something" is depends on the energy of the radiation that was added to the sample in the first place. For example, if infrared radiation is used, some of the energy is used to make the bonds in molecules stretch and bend in various ways. If visible light is used, the energy is used to make electrons jump from one orbital to another. We'll talk more about each of these in the next few chapters.
- The light that doesn't get used by the sample to do something passes through the sample unchanged. Let's say we add three wavelengths of light. The first wavelength of the light is at just the right energy to make an electron in the sample jump from one place to another, while the second and third aren't the right wavelength to do anything at all. In such a scenario, the first wavelength of light will be absorbed and the second and third will pass through unchanged. Every compound has a completely unique pattern of light it absorbs for its various purposes.
- Something measures the light that passes through the sample. Once we know what wavelengths/colors/frequencies of light have

passed through the sample, we can tell what compound is present (because all compounds absorb unique patterns of light). The pattern of light that comes through the sample is called its spectrum, and all chemical compounds have unique spectra that allow them to be distinguished from all other compounds.

This whole process is called spectroscopy. And spectroscopy, as mentioned at the beginning of this chapter, is a method for identifying unknown compounds from their spectra. See, it's a piece of cake!

The process by which transmitted light is measured during absorption spectroscopy.

Because I know some of you may still have problems with the idea of spectroscopy, let's use an analogy to illustrate what I mean.

Let's say that (for some reason) you have started work in a factory that prints T-shirts. Your boss (who you suspect has huffed way too much paint in his time) tells you that in order to keep your job, you have to be able to tell the difference between three of the silk screens they use. One of them has a happy face on it, one of them has the slogan "sit on it," and the third is the album artwork from *What Makes a Man Start Fires?* by the Minutemen. The only problem: your boss has told you that you can't look directly at the screens.

Now, you could try to feel the screens with your hands, but all of them pretty much just feel like silk. You could ask a co-worker, but because they're all afraid of the boss they won't help either. It looks like you're screwed.

But wait! Remembering this book you think of a third idea. Placing each of the silk screens on a sheet of paper, you pour paint into each and look not at the screen but at the paper you placed under them. Because each silk screen lets a unique pattern of paint pass through, you now know that the first screen says "sit on it." Repeating the process with the other two screens, your job is now secure.

Types of Spectroscopy Used in Organic Chemistry

There are several different types of spectroscopy that organic chemists employ to figure out what the heck they are working with.

Infrared (IR) spectroscopy uses infrared light (wavelengths roughly between 750 nm and 1 mm) to identify organic compounds based on the bending and stretching of their bonds. We'll be discussing IR spectroscopy in Chapter 22.

Nuclear magnetic resonance (NMR) spectroscopy is used to identify a chemical compound based on the energy needed to flip the nuclear spin of various atoms within the compound (though hydrogen and carbon are the most common) in the presence of a magnetic field. NMR is somewhat different in concept than other forms of spectroscopy, but we'll worry about that in Chapter 23.

Why Spectroscopy Is Useful

Students sometimes wonder why we spend so much time talking about spectroscopy when there must be other ways of identifying chemical compounds. After all, people did chemistry before spectrometers were invented!

In answer to that question, here are some reasons why organic chemists like spectroscopy:

- You don't have to destroy the sample: Unlike methods such as combustion analysis or mass spectrometry, chemists can pull their samples out of the spectrometer and use them for some other purpose.
- You can perform spectroscopy on almost anything: Unlike X-ray crystallography or powder diffraction (both of which require that you have a solid sample), you can either dissolve your sample in a solvent or put it in the spectrometer in its pure state and it'll work. And, you only need a wee bit of sample.
- It gives very clear answers: Methods such as gas chromatography (GC or GLC) can separate mixtures of organic compounds but aren't very good at telling you what compounds are present. Spectroscopy can usually tell you what's in the beaker.

The Least You Need to Know

- The frequency, wavelength, energy, and color of light are all related to one another.
- You can get the absorption spectrum of an organic compound by shining light at it and measuring the wavelengths of light that pass through without being used.

- Because the spectra of all compounds are unique, spectroscopy can be used to identify them.
- There are many different types of spectroscopy, and they differ by the energies of light they use.
- Organic chemists use spectroscopy all the time to figure out what they've made.

Based on Chapter 21 "Introducing the Magical World of Spectroscopy" from ***The Complete Idiot's Guide to Organic Chemistry*** by Ian Guch and Kjirsten Wayman, Penguin, 2007