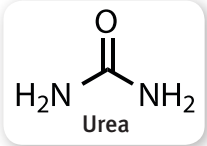
Magnificent molecules

Urea

Ian Le Guillou *finds out what skin creams, pretzels and fertilisers have in common*

Urea is used to add colour to pretzels

Urea was the first molecule from a living organism to be synthesised in a lab. The honour for this achievement goes to Friedrich Wöhler, who synthesised urea in Berlin in 1828 by reacting silver cyanate and ammonium chloride. As so often happens in these stories, Wöhler never intended to make urea, but was actually trying to make ammonium cyanate. However, the significance of his discovery was so great that he is now known as the father of organic chemistry.



Urea

A little accident

Before Wöhler, it was still possible to get hold of urea but it doesn't sound pleasant – Herman Boerhaave purified urea from urine 100 years earlier. Boerhaave's work on urea was somehow forgotten and 50 years later a method for purifying urea was rediscovered by French chemist Hilaire Rouelle. Unfortunately, as it took two hundred years until Boerhaave's work was uncovered, confusion about who first discovered urea persists, although Boerhaave is now slowly getting the recognition that he deserves.

The human body produces urea from ammonia and excess amino acids. Amino acids are usually used to make the proteins that we need to function. However, ammonia is toxic, so it is vital that the body has a way to get rid of it. Ammonia is produced naturally in the course of metabolising food, but if it is allowed to accumulate in cells it would raise the pH to toxic levels. Even though it costs energy to do so, ammonia is converted to urea, which is practically harmless and can be removed easily through urine and even a little through sweat!

Efficient fertilisers

Industrially, 100 million tons of urea is synthesised every year. So what is it all used for? Well, 90% goes into fertilisers, providing an essential source of nitrogen for crops to grow as quickly as possible. Urea has the highest percentage nitrogen content of solid fertilisers, which means less weight is required and it is cheaper to transport. The urea typically decomposes into ammonia, which can be absorbed by plants. However, ammonia tends to evaporate, reducing the amount of nitrogen available in the soil. To avoid this, particularly during the summer, farmers will spread the urea on fields just before it is due to rain.

The ammonia can also be oxidised by bacteria in the soil, creating nitrates. Nitrates are easily absorbed by plants, but can be carried away in rain water, running off into nearby lakes and rivers. This is a growing problem because it encourages the growth of plants in the water, which can disrupt the local ecosystem.

Modern synthesis

Since Wöhler, the method for synthesising urea has been adapted. The Bosch–Meiser process reacts ammonia and carbon dioxide, under high temperature and pressure, to form ammonium carbamate which then decomposes into urea and water. Even though this was first developed in 1922, it still remains the standard way of producing urea, thanks to the cheap reagents used.

Urea can be reacted with formaldehyde or nitric acid to create a range of other materials that can be used to make resins, plastics and explosives. However, it also has a wide range of uses including a skin softener in cosmetic creams and colouring for pretzels.

There are few molecules that have such an important place in chemical history. The story of urea is nearly 300 years old, from rather smelly origins through to fertilising the world's crops. Its synthesis may have been a lucky accident but it laid the foundations of modern-day organic chemistry.

Find out more

Learn more about the manufacture of urea, which uses just natural gas, air and water as starting materials: **http://bit.ly/VqqF7S** (PDF)