A life in science

Stephanie Kwolek *Polymer chemist*

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Have you seen the nylon rope trick? It's a common school demonstration showing how a nylon fibre can be made from two liquids. But what is the connection with the bullet proof vests used by the United Nations peacekeeping forces?

The answer is that the same woman, Stephanie Kwolek, developed both the nylon demonstration and the material Kevlar which is the key lightweight polymer used in bullet proof vests. Born in the United States to parents who were Polish immigrants, she studied chemistry at university and hoped to become a doctor. In order to fund her studies she took a temporary job as a research chemist and enjoyed it so much that she stayed and never did study medicine.

Stephanie Kwolek worked for the chemical company DuPont. DuPont were responsible for the invention of many different polymers during the twentieth century. These included neoprene used in wetsuits, Teflon used as a non-stick coating for saucepans, and Lycra used to make clothes stretchy and fit better. They also discovered and manufactured nylon, one of the first widely available polymers used in clothing.

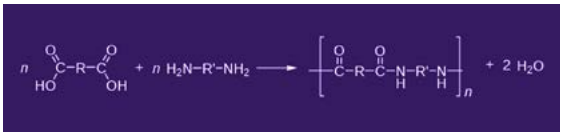
A polymer is a long molecule made of lots of smaller molecules, called monomers, joined together.

A bullet proof vest, part of a United Nations peacekeeper's body armour

Polymer names: Kevlar, Teflon and Lycra are trade names of polymers so are written with a capital letter.

Making nylon

Nylon is a co-polymer, a polymer made from two different monomers joined together. As the monomers join, a small molecule is formed along with the polymer. This can sometimes be water so these are called condensation polymers.

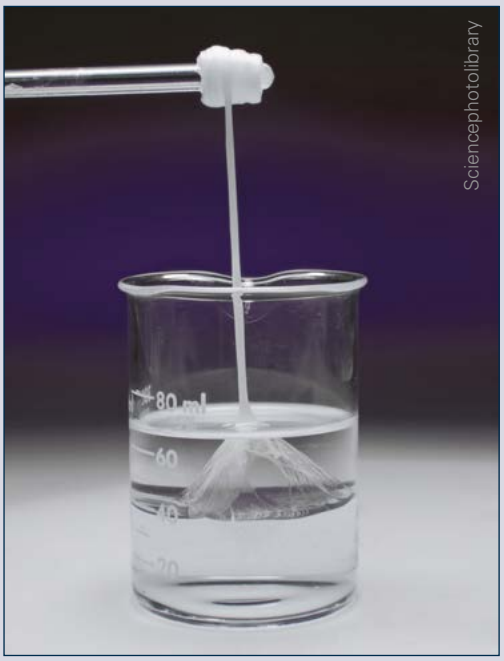


This equation shows the formation of nylon. The n represents any number of the molecules; R represents a chain of carbon and hydrogen atoms joined together.

The first molecule has a carboxylic acid group, COOH, at each end and second has an amine group, NH_2, at each end. They react with each other producing a polymer which has the monomers in an ABABAB pattern.

The nylon rope trick

In the 1950s Stephanie Kwolek developed a method for demonstrating the production of nylon in the classroom which is still used today. The two monomers needed to make nylon are dissolved in two solvents which do not mix. The solutions are poured into a beaker where one floats on the other. You can see the two separate layers in the photo. They react at the interface where they meet, forming a film of nylon. This can be pulled upwards to form a fibre.

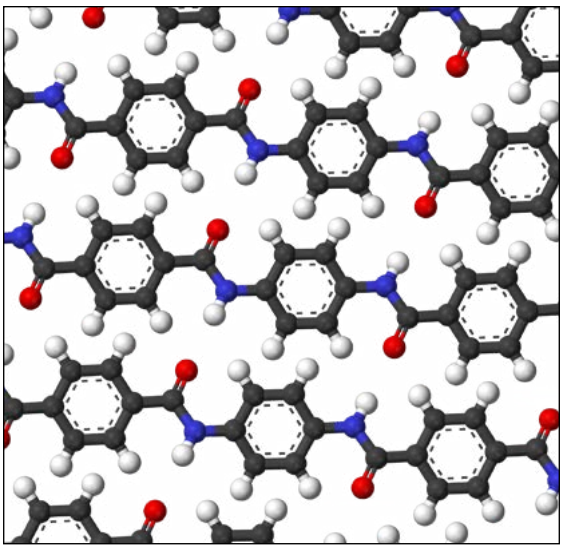


The nylon rope trick is used to demonstrate making nylon in the classroom

How Kevlar was found

In the 1960s, Stephanie Kwolek was working to produce an alternative material for making tyres. She was working with polymers and had produced a thin, cloudy solution which didn't look very promising. Usually it would be thrown away but Kwolek persuaded the technician who ran the 'spinneret', which tested if a polymer could be spun, to put her uninteresting solution through the machine. She and the other scientists were amazed to find that not only could it be spun, it didn't break. Further investigation showed that when it was spun, the polymer molecules all lined up in the same direction, making it incredibly strong. The new polymer was named 'Kevlar.'

Kevlar fibres – each fibre is about 10 micrometres thick.



When Kevlar is spun, the polymer chains line up. This gives the material its strength.

When interviewed in 2007 about her discovery, Stephanie Kwolek said, "The company management didn't fool around. They immediately assigned a whole group to work on different aspects ... It was very exciting, let me tell you."

Kevlar at work

Kevlar is very light and very strong. It is used for a wide range of applications including sporting equipment – canoes, sails, bicycle tyres, tennis rackets, sporting shoes. It is used for drum heads, ropes and brake discs. The most famous use for Kevlar, though, is in bullet proof vests.

Most police forces and military personnel now have body armour made of Kevlar as it is light and strong. There are thousands of people alive today because of the protection they got from Stephanie Kwolek's invention.

Stephanie Kwolek shows off work gloves with Kevlar pads.

Stephanie Kwolek died in June 2014, aged 90. The day before she died, DuPont announced that a million bullet-proof vests have been sold using the latest version of Kevlar.

In an interview a few years before she died, Kwolek was pleased with what she had achieved. She said: "At least I hope I'm saving lives. There are very few people in their careers that have the opportunity to do something to benefit mankind."

Vicky Wong is Chemistry editor of Catalyst.

Kevlar is used for sports equipment such as canoes