Materials for applications of your imagination – Futuristic material/ Materials of science fiction

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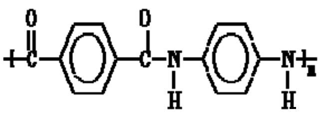
Kevlar

Kevlar was first synthesized in 1964 by Stephanie Kwolek at the Dupont laboratories in Wilmington, Delaware in the United States.

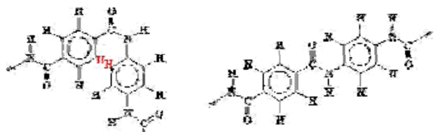
Originally Kevlar was designed for use as a replacement for steel in radial tyres but now has seemingly unlimited uses, from chord on the airbags of the mars pathfinder; to shrapnel resistant shielding in jet aircraft to protect passengers in the event of an explosion; to lightweight, small diameter ropes used to moor large naval ship and super tankers; to lighter stronger sports equipment like tennis racquets and skis. And undoubtedly the range of uses will continue to expand as new pursuits and the need for lightweight materials increases.

Kevlar is a polymer; this means that it is made up of a large number of the same basic unit, called a monomer, which are attached to each other to form a long chain. The monomer in this case is made up of an amide group and a phenyl group.

Kevlar is a polyamide, a type of synthetic polymer, in which the amide groups are separated by para phenylene groups, meaning that the amide groups are attached to each other on opposite sides of the phenyl group (i.e. carbons 1 and 4).



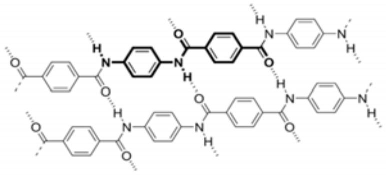
The large phenyl groups separating the amides cause the polymer of Kevlar to nearly always form the trans conformation, where the phenyl groups arrange themselves so that they are on opposite sides of the rigid amide bond:

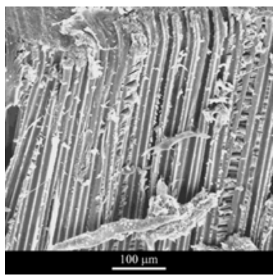


In the cis configuration, the hydrogen atoms are too close for stability.

The strength of Kevlar comes from its unusually regular internal structure; this has implications for the Hydrogen bonding which occurs between the electron dense oxygen atom and the electron deficient hydrogen. The all trans configuration, giving long straight chains, means that the hydrogen bonding can occur very regularly to form a very strong lattice, similar to those formed in crystals.

The fibres consequently have very few flaws and so are very difficult to break up.





Dragline Spider Silk

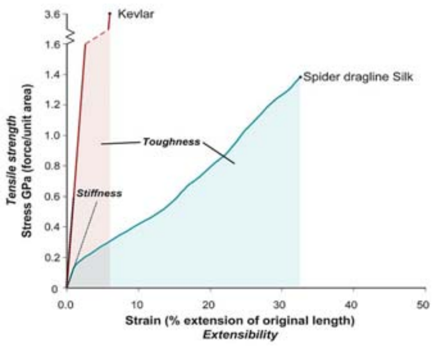
Dragline silk is a composite material comprised of two different proteins, each containing three types of regions with distinct properties. One of these forms an amorphous (noncrystalline) matrix that is stretchable, giving the silk elasticity. When an insect strikes the web, the stretching of the matrix enables the web to absorb the kinetic energy of the insects flight.

Embedded in the amorphous portions of both proteins are two kinds of crystalline regions that toughen the silk. Although both kinds of crystalline regions are tightly pleated and resist stretching, one of them is rigid. It is thought that the pleats of the less rigid crystalline regions not only fit into the pleats in the rigid crystals but that they also interact with the amorphous areas in the proteins, thus anchoring the rigid crystals to the matrix. The resulting composite is strong, tough, and yet elastic.

	Material Toughness [3]	Tensile Strength [4]	Weight [5]
Dragline spider silk	120,000-160,000	1,100-2,900	1.18-1.36
Kevlar®	30,000-50,000	2,600-4,100	1.44
Steel	2,000-6,000	300-2,000	7.84

Kraig Biocraft Laboratories, based in Lansing, Michigan, genetically engineered silkworms to produce spider silk, and has used the material to create gloves that will soon undergo strength testing.

Mass manufacture will help law enforcers do their job since it provides flexibility as well as strength and toughness. This is an important illustration of how a composite can be used to selectively incorporate beneficial properties of multiple materials.



Video for spider silk here

Vantablack

The name comes from the term "**V**ertically **A**ligned **N**ano **T**ube **A**rrays".

Vantablack is composed of a forest of vertical tubes which are "grown". When light strikes vantablack, instead of bouncing off, it becomes trapped and is continually deflected among the tubes, eventually becoming absorbed and dissipating into heat

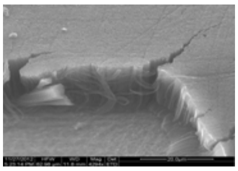
- Vantablack was an improvement over previous similar substances developed at the time. Vantablack absorbs 99.965% of visible light. Also, this new material can be created at 400 °C (752 °F);
- This substance has many potential applications, including preventing stray light from entering telescopes, and improving the performance of infrared cameras both on Earth and in space Ben Jensen, Chief Technology Officer, Surrey Nano Systems, has explained: "For example, it reduces stray-light, improving the ability of sensitive telescopes to see the faintest stars... Its ultra-low reflectance improves the sensitivity of terrestrial, space and air-borne instrumentation."
- Vantablack may also increase the absorption of heat in materials used in concentrated solar power technology, as well as military applications such as thermal camouflage. The emissivity of Vantablack and scalability support a wide range of applications.
- The material is being used creatively by artist Anish Kapoor who said, "It's effectively like a paint... Imagine a space that's so dark that you walk in you lose all sense of where you are, what you are, and especially all sense of time." The colour was exclusively licensed to Kapoor's studio for artistic use,

Vantablack is a free-space coating consisting of a 'forest' of aligned and equally spaced, high aspect-ratio carbon nanotubes (CNTs).

The CNT array is patterned and spaced to allow photons to enter. Most of the light, or radiation arriving at the surface enters the space between the CNTs, and is repeatedly reflected between tubes until it is absorbed and converted to heat. This heat (largely undetectable in most applications) is conducted to the substrate and dissipated. The Vantablack array is very largely free-space; the volume of CNTs only makes up about 0.05% of the coating. Consequently, only a miniscule proportion of the incident radiation is able to hit the tip of a CNT, explaining why such a small amount is reflected back to the observer.

CNTs are hollow structures with one-or-more walls formed from atom-thick sheets of carbon. Each nanotube is around one fiftieth of one millionth (!) of a metre in diameter, making it an appropriately-sized building-block for engineering structures that exhibit low-reflectivity and high-emissivity across a wide-range of frequencies. In addition to incredible light absorption, the CNT array also has many other highly attractive properties:

1. The high proportion of free-space within Vantablack (>99%) makes it extremely light. The height of a Vantablack coating is typically around 20 to 30 microns. One square metre of coating weighs around 2.5g (for a typical coating - growth parameters are varied to suit the application).
2. The CNTs have an exceptionally high modulus of elasticity and will flex and bend, making them very robust in environments subject to extreme shock and vibration.
3. The strength of the CNTs' bond to the substrate is high, making it difficult to remove the forest through thermal cycling, shock or vibration, even though the coating's characteristic's can be compromised through direct abrasion.



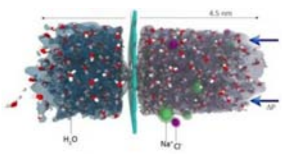
What is Graphene?

Graphene is a two dimensional mesh of carbon atoms arranged in the form of a honeycomb lattice. It has earned the title "miracle material" thanks to a startlingly large collection of incredible attributes - this thin, one atom thick substance (it is so thin in fact, that you'll need to stack around three million layers of it to make a 1mm thick sheet!) is the lightest, strongest, thinnest, best heat-and-electricity conducting material ever discovered, and the list does not end there. Graphene is the subject of relentless research and is thought to be able to revolutionize whole industries, as researchers work on many different kinds of graphene-based materials, each one with unique qualities and designation.

Graphene Water Treatment

Among graphene's host of remarkable traits, its hydrophobia is probably one of the traits most useful for water treatment. Graphene naturally repels water, but when narrow pores are made in it, rapid water permeation is allowed. This sparked ideas regarding the use of graphene for water filtration and desalination, especially once the technology for making these micro-pores has been achieved. Graphene sheets (perforated with miniature holes) are studied as a method of water filtration, because they are able to let water molecules pass but block the passage of contaminants and substances. Graphene's small weight and size can contribute to making a lightweight, energy-efficient and environmentally friendly generation of water filters and desalinators.

It has been discovered that thin membranes made from graphene oxide are impermeable to all gases and vapors, besides water, and further research revealed that an accurate mesh can be made to allow ultrafast separation of atomic species that are very similar in size - enabling super-efficient filtering. This opens the door to the possibility of using seawater as a drinking water resource, in a fast and relatively simple way.



Video for graphene here