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The Secret Behind Strong Fighter Aircraft Bodies and Lightweight Bulletproof Vests

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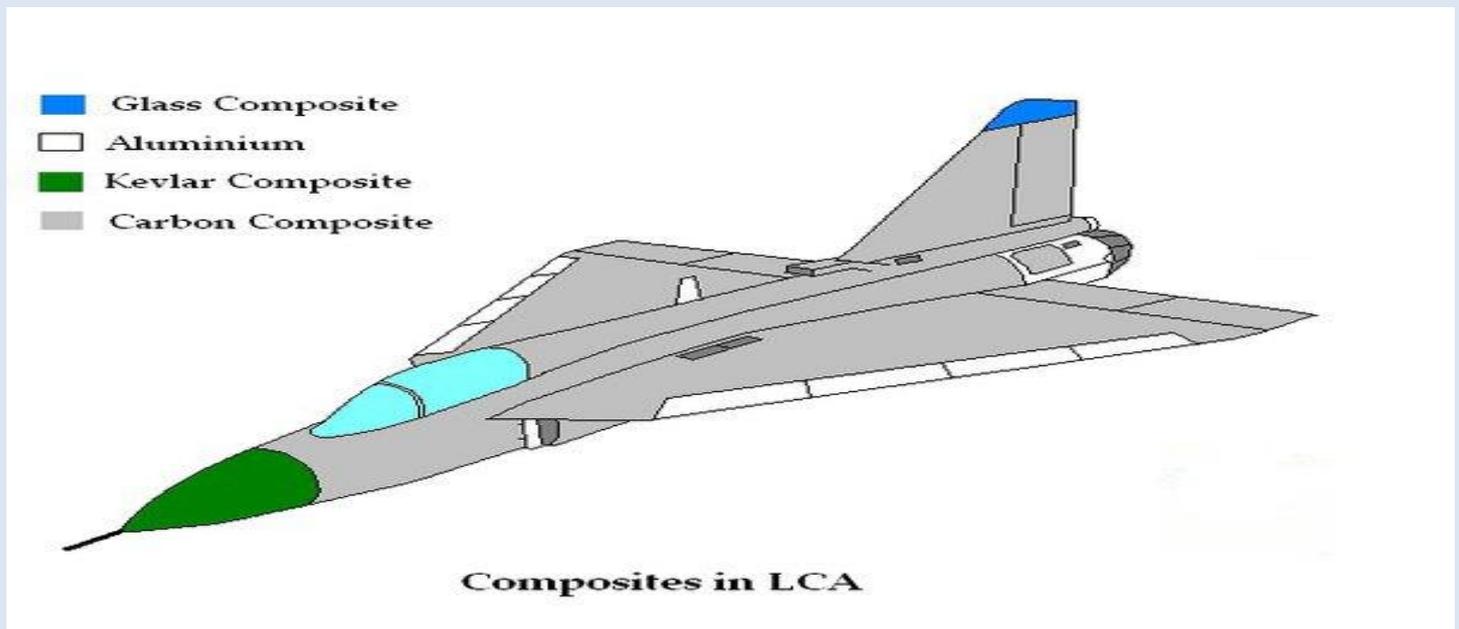


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In the wake of the American pullout from Afghanistan, there has been an influx of their arsenal into the Kashmir valley, in the hands of the terrorists. These deadly possessions also constitute armour-piercing bullets. This begs an astute analysis of the global military armour standards and where India stands. Owing to popular fiction, the average Joe's idea of armour is kevlar. However, there is more to life-saving military equipment than meets the eye.

Saving the Saviours: Kevlar and the Military

The kevlar fibre was discovered in the early 1960s by the US chemist Stephanie Kwolek at DuPont. It was introduced in 1971 and since then has become synonymous with properties such as high strength and toughness. Kevlar is a DuPont brand that has been popular for a reason. The material is a crucial requirement in the manufacturing of military equipment, such as aircraft bodies and bulletproof vests.¹

The fibre is formed by polymerising two compounds, para-phenylenediamine and terephthaloyl chloride. This combines to form poly-para-phenylene terephthalamide. Thus, kevlar, an aramid fibre, starts as a liquid. Fibres are made out of it and then woven into a textile material. The resultant material is extremely lightweight, strong, and corrosion and heat-resistant. It is often used in composites, where it is combined with other materials.

Even as a composite, kevlar outshines others in strength, and it is because of its structure. Kevlar forms small straight rods packed together closely. One can understand this by imagining new pencils stuffed in a box. The tiny rods create extra hydrogen bonds between each other, which is the source of their extra strength.²

Kevlar is a proprietary material made only by DuPont. The material has two main varieties: Kevlar 29 and Kevlar 49, with other lesser-known variants made for special applications.

Kevlar has several properties that make it worthwhile for the industry. The fibre offers a substantial amount of strength while also being lightweight. Both the main variants of kevlar also outshine steel wire in terms of tensile strength by over eight times. Tensile strength refers to the pulling power of a material. Kevlar is also great at withstanding high temperatures. Not only does it not melt (unlike plastic, etc.) during heatwaves, it also decomposes only at about 450°C.

Additionally, extremely low temperatures also do not affect kevlar. The fibre is also resistant to moisture and attacks from various chemicals. However, prolonged exposure to strong acids or bases will degrade it over time.

However, kevlar is hardly a steel replacement. It sacrifices compressive strength for high tensile strength. That is why kevlar is not used as the primary building material in constructing bridges, buildings, and other structures where compressive forces are routinely encountered.³

The Genius Behind Kevlar and Composites

The material is most well-known for its use in knife-proof body armour and bulletproof vests, as it takes tremendous energy for a knife or a bullet to pass through it. The tightly woven fibres of polymer molecules are unrelenting; considerable energy is required to separate them. Thus, a bullet's energy dissipates quickly as it tries to battle its way through.

Bullets vary in type, speed and weight. As a result, different bullets dissipate differing amounts of energy. Bigger and faster travelling bullets carry more kinetic energy than their smaller and slower counterparts. With tremendous kinetic energy comes the ability to penetrate further and cause more damage. Like bullets, kevlar too comes in different weights. One would require more layers of kevlar to stop the bigger and faster bullets. Bulletproof vests may have anywhere from 8–16 layers of kevlar to as many as 32–48 layers. Some vests also combine kevlar with other materials.⁴

However, kevlar finds its use in various industries. Kevlar is used as reinforcement in car tires, brakes, archery bowstrings, and the bodies of aircraft, cars, and boats. Kevlar and similar fibres can immensely increase the safety of military equipment. It is also extensively used in manufacturing panels and wings for fighter jets, including the Eurofighter Typhoon.⁵

Flying Safe and Sound: Kevlar in Military Aircraft

Kevlar 49 is considered an excellent material for reinforcement in a composite when producing aircraft components. It's lightweight, high tensile strength, inert state, and stiffness and resilience make it ideal for demanding tasks. Its material strength-to-weight ratio is high, far exceeding steel. The US Department of Defence added that the density is 40% lower than glass and 20% lower than commonly used carbon. In addition, it is also abrasion and impact-resistant.

The properties of Kevlar 49 make it a material choice not only in aircraft but also in other aspects of the aerospace industry. This includes air ducting, launch tube reinforcement, etc. Hindustan

Aeronautics Limited (HAL) has used kevlar on the HAL Rudra and the HAL Dhruv. For HAL Rudra, the cockpit is made of kevlar and carbon fibre composites, aiding in weight reduction while providing safety.⁶ The airframe of the HAL Dhruv uses a glass, carbon, and kevlar composite, which covers over 60 per cent of its surface area but only accounts for 29 per cent of the structural weight. This enables it to sustain vertical impacts of up to 30 feet per second.⁷

The India Way

Being a proprietary offering, kevlar goes against the grain of 'Make-In-India'. However, the domestic industry and academia have been working on an indigenous replacement. The Indian Army has showcased its indigenous bulletproof jacket, Shakti.⁸

Kevlar is a family of aramid fibres that all offer an excellent strength-to-weight ratio and heat resistance. The global players in the aramid fibres include DuPont, Contitech Ag, Teijin Limited, Yokohama Rubber Co., Ltd., Schaeffler Ag, Bando Chemical Industries Ltd., Hutchinson Sa, Toyobo Co. Ltd., Aramid Hpm, Fiberline, and Kolon Industries, Inc.

The use of aramid fibres has been increasing in the automotive sector, and hence, the rise of the small car market in India and China has propelled the demand for such fibres in the region.⁹ The hour's need is actively pursuing indigenous capability for formidable aramid fibre manufacturing. Already, India boasts of competent composite material manufacturers, many of whom offer aramid and kevlar fibre epoxies. With the government's hand-holding, India could enable a slew of industries, such as military reinforcement of aircraft, commercial aircraft components, etc.

NOTES:

¹ Lemelson-MIT, "Stephanie Kwolek", <https://lemelson.mit.edu/resources/stephanie-kwolek>, accessed on October 23, 2022.

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³ DuPont, "Kevlar Aramid Fibre: Technical Guide", https://www.dupont.com/content/dam/dupont/amer/us/en/safety/public/documents/en/Kevlar_Technical_Guide_0319.pdf, accessed on October 23, 2022.

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⁶ Army Technology, "HAL Rudra (ALH WSI) Attack Helicopter", <https://www.army-technology.com/projects/hal-rudra-attack-helicopter-india/>, accessed on October 23, 2022.

⁷ Army Technology, "Dhruv Advanced Light Helicopter (ALH), India", <https://www.army-technology.com/projects/dhruv-advanced-light-helicopter/>, accessed on October 23, 2022.

⁸ Times Now News.com, "Indian Army Major indigenously develops world's first universal bulletproof jacket 'Shakti'", <https://www.timesnownews.com/india/article/indian-army-major-indigenously-develops-world-s-first-universal-bulletproof-jacket-shakti-features/706772>, accessed on October 23, 2022.

⁹ Fortune Business Insights, "Aramid Fiber Market Size, Share | Global Industry Forecast [2027]", <https://www.fortunebusinessinsights.com/aramid-fiber-market-102183>, accessed on October 23, 2022.