IJRBAT, Issue (VI), Vol. II, May 2018: 74-76 (10) 2011-18 e-ISSN 2347 – 517X 35

INTERNATIONAL JOURNAL OF RESEARCHES IN BIOSCIENCES, AGRICULTURE AND TECHNOLOGY
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www.ijrbat.in

TECHNOLOGICAL ADVANCES OF SYNTHETIC SPIDER SILK AS A BIOMATERIAL

S.V.Ghonmode
S.S.E.S.Amt'sShivaji Science College, Congress Nagar, Nagpur-440012 (M.S.)
sharyu.ghonmode@gmail.com

ABSTRACT:
Everyone is much aware about the applications of the silk produced from the silkworm. Recently the researchersare trying to develop new materials that are stronger, lighter, and tougher than materials which the people are using presently. Spider silk is captivating material with low density and biodegradability. Spider silk is considered as the ideal biomaterial. However, there are certain issues, as the spider silk is not produced in sufficient quantities one may find it to be a difficult task. This material has high ability to absorb energy, due to combination of strength and extensibility it has ascribed ability to stop bleeding. This research paper will describe the biomedical applications of spider silk.

Keywords: Health hazards, Spider silk.

INTRODUCTION:

Spider is placed in class Arachnida. It produces silk called as Spider silk which is nature's high performance fibre. Spider silk is also known as gossamer (Fig.1). If the weight is considered then the spider silk is stronger than steel. It has unprecedented ability to absorb energy. It bears the mechanical properties of low density and biodegradability. Because of this properties spider silk has several medical applications and used as a biomaterial. Spider avails its silk for different uses like constructing their webs, laying eggs and production of egg sacs, wrapping in their prey and many more. Mechanical properties of spider silk have been studied by Gosline et al., 1999. Spiders are territorial and hence produces low amount of silk which cannot be employed for industrial silk production (Anna Rising et al., 2005).

Fig. 1a) A garden spider spinning its web (Photo-From Wikipedia, the free encyclopedia)

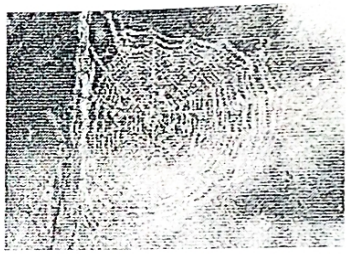

Fig. 1b) A garden spider spinning its web (Photo-Atomic news)

Structure of spider silk gland -

Fig.-2 Schematic of a generalized gland of a Golden silk orb-weaver(*Lefèvre, T.*, 2008)

Physical properties of Gossamer (Gosline et al., 1986)

1. Length is continuous.
2. Most of the fibers are few microns in diameter and are very fine.

3. Spider silk is very tough and stronger in weight which is equal to that of commercial polyaramid (aromatic nylon) filaments (Tanveer Malik, 2011).
4. Its elastic properties show that this silk is highly elastic and breaks at 2-4 times its length.
5. Spider silk is highly ductile as it is able to stretch upto 40% of its length without breaking
6. Thermal properties shows that the spider silk keep its strength below -40°C(Plaza, Gustavo R, 2006).
7. Mechanical properties depend on ambient conditions like humidity and temperature (Plaza, Gustavo R, 2006).
8. The energy density of dragline spider silk is roughly 1.2×10^8 J/m^3(Porter, D, 2005).

Macroscopic Structure of Spider silk-

The dragline silk is composed of two similar proteins (Spidroin) namely majorampullateSpidroin (MaSp) 1 and (MaSp) 2 (Hinman and Lewis, 1992). These proteins have approximately 3500 amino acids residues and can be encoded by several gene loci (Ayoub et al., 2007; Rising et al., 2007). They mostly constitute the repetitive blocks of glycine and alanine (Hinman, M. B et al., 1992; Simmons, A. H., 1996). The short side chained alanine is mainly found in the crystalline domains (beta sheets) of the nanofibril and glycine is mostly found in the amorphous matrix consisting of helical and beta turn structures (Van Beek, J. D, 2002; Simmons, A. H., 1996).

Biomedical applications of spider silk-

Spider silk has many biomedical applications. It is used as a biomaterial. This has the abilities to stop bleeding and promote wound healing (Bon, 1710-1712: Newman and Newman, 1995). The spider silk has the antiseptic properties facilitates healing and also helps to connect the wound (Heimer, S. 1988). As the spider silk is rich in vitamin K it helps in blood clotting (Jackson, Robert R. (1974). The main benefit is in medicine. Here the strands are used as biodegradable sutures for internal wounds (www.fibre2fashion.com). They are used for making artificial tendons and ligaments for supporting weak blood vessels. They are used for making bandages and surgical threads

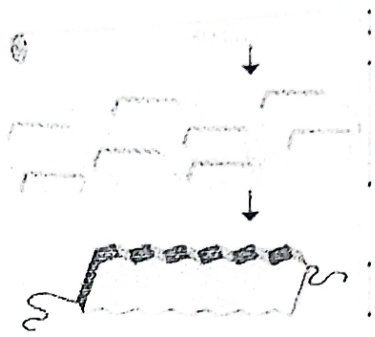

Fig. 3. Structure of spider silk. Inside a typical fibre there are crystalline regions separated by amorphous linkages. The crystals are beta-sheets that have assembled together.(From Wikimedia Commons, the free media repository).

Types of Spider silk –

Silk	Use
major-ampullate (dragline) silk	Used for the web's outer rim and spokes and also for the lifeline. Can be as strong per unit weight as steel, but much tougher.
capture-spiral (flagelliform) silk	Used for the capturing lines of the web. Sticky, extremely stretchy and tough. The capture spiral is sticky due to droplets of aggregate (a spider glue) that is placed on the spiral. The elasticity of flagelliform allows for enough time for the aggregate to adhere to the aerial prey flying into the web.
tubiliform (a.k.a. cylindriform) silk	Used for protective egg sacs. Stiffest silk.
aciniform silk	Used to wrap and secure freshly captured prey. Two to three times as tough as the other silks, including dragline.
minor-ampullate silk	Used for temporary scaffolding during web construction.
Piriform (pyriform)	Piriform serves as the attachment disk to dragline silk. Piriform is used in attaching spider silks together to construct a stable web.

Table-1: Source: From Wikipedia, the free encyclopedia

CONCLUSION :

Spider silk one of the Biomaterials is one of the outstanding fibrous biomaterial which consists almost entirely of large proteins. Silk fibers have tensile strengths comparable to steel and some silks are nearly as elastic as rubber. In combining these two properties, silks reveal a toughness that is two to three times that of synthetic fibers like Nylon or Kevlar. Spider silk is also antimicrobial, hypoallergenic and completely biodegradable. Apart from medical applications spider silk has many other non- medical applications. Thus from the above study it is concluded that spider silk cannot be produced on large scale like that of the silkworm but the spider silk has tremendous application in medical terms as the spider silk is much more tougher and elastic in nature.

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