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# Silk: The Super Biomaterial

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## Abstract

Silk is a biopolymer basically of insect origin. The structure and surface properties of silk endorses it as a high performance and cost efficient biomaterial. Its utility and promises are encompassed briefly in this article. Biomimetic approach for synthesizing silk-fibers and their composites may provide a "super biomaterial" with all the necessary attributes.



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## Editorial

The progress of human civilization is either based on unveiling the truths of nature or mimicking its vitality. Silk is such a material which has been attracting people from ancient times due to its diverse applications. It is a fibrous protein (fibroin) with hierarchical structure produced by spiders and silk worms. As stated in the literature, silk proteins consist of spacer regions, tight amino acid forming α- helices, elastic β-spirals, and crystalline β-sheets [1].

In India, Assam, Mysore, Kanchipuram, and Banarasi are the major silk producers. It is pertinent to mention that silk production and transportation renders occupations to a mass number of people all over the world. Hence, the utility of silk in biomaterials not only fulfills the criteria of sustainability and biocompatibility, but also provides livelihoods. A major concern is thus paid in recent times to develop silk-based-biomaterials. The unique mechanical attributes, biodegradability and favorable surface properties of fibroin endorse it as a promising material for tissue engineering.

Since the end of the 19th century, *Bombyx mori* silk fibers are used as surgical threads. This established the compatibility of silk based materials with physiological systems. However, processing technique dictates the extent of biocompatibility. Residual sericin causes immunogenic response to hosts as evident by Panilaitis et al. in 2003 [2]. It is further well established that silk fibers devoid of sericin could support the growth and proliferation of different cells. US Food and Drug Administration (FDA) has already approved a number of silk based biomaterials which include widely available meshes like Seriscaffold® and SeriACL™ [3].

With time silk based research found a special place in the domain of tissue engineering. Though spider silk exhibits tremendous strength, its abundance restricts commercial viability. Hence, fibers can be obtained in mass from silk worms. Recently material scientist tried to impart extraordinary properties to the silk fibers by feeding different nanomaterials to the worms. Graphene, fed worms spun fibers almost two fold stronger than the normal ones [4]. Besides, due to the inherent antimicrobial properties of graphene it is expected to restrict microbial fouling on silk based garments or surgical sutures or other biomaterials. Again, other carbon based nanomaterials like carbon nanotubes etc. have also been fed to such worms to attain added advantages. This motivated the researchers to think beyond conventional biomaterials and to design a tough, sustainable, biocompatible and biodegradable material with multifaceted attributes which can be regarded as "*super biomaterial*".

Consequently, investigations were started for obtaining synthetic silk fibers. In this quest, Lazaris et al. reported a biomimetic process for the production of recombinant silk in mammalian cells [5]. Renberg and co-workers also devised a microfluidic design to mimic silk production [6]. Recent research revealed that β-sheets structure is the 'trigger' to tailor the properties of silk. Kinahan and group utilized a microfluidic process for rapid and low-cost fabrication of fibers with controllable structure-property attributes [7]. In coming times, more explorations are expected in this domain.

Silk fibers found tremendous utility in the fabrication of textile, membranes, yarns, hydrogels, meshes, sponges etc. Besides, they show promises in tissue engineering research to regenerate a number of tissues which includes liver, skin, nerve, trachea, muscles, ligament, tendon, cartilage and bones. In most of the cases silk-composites were prepared with different polymers and nanomaterials. Collagen, chitosan, polylactic acid (PLA), chitin, polylactide, heparin, gelatin, hyaluronan are amongst the most widely used natural polymers in this context [8]. Table 1 briefly presents a few silk-composites based tissue scaffolds with their potential utility.

**Table 1:** A few silk based tissue scaffolds and their potential uses.

| Silk composition | Engineered tissue | Reference |
|---|---|---|
| Silk and chitosan | Hepatic, cartilage and bone tissues | [9] |
| Silk and collagen | Skin, hepatic, neural and ocular tissues | [10] |
| Silk and chitin | Skin tissues | [11] |
| Silk and hyaluronic acid | Neural and ligament tissues | [12] |
| Silk and PLA | Hepatic and neural tissues | [13] |
| Silk and gelatin | Vascular tissues | [14] |

Moreover, their biomedical applications also include drug delivery, cancer diagnostics and therapeutics, controlled release matrix for drugs, protein and growth factors etc [15]. Thus, it is the demand of the hour to opt for sophisticated techniques for obtaining high quality fibers with adequate abundance. This necessitates the understanding of traditional knowledge to rear silkworms and its modernization so that hybridized silk-fibers can be obtained within the process of spinning. The scientific fraternity is eagerly waiting for the silk based "*super-biomaterial*" with all necessary credentials.

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