Silk-Based Scaffolds for Tissue Engineering Applications

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Silk is a multifaceted natural polymer. Its morphological, mechanical, structural, optical and biological properties can be effectively optimized by varying protein molecular weight, secondary structure, and concentration [1]. Silks are unique proteins, exhibiting remarkable strength and toughness, as well as compressive strength and modulus, which exceed other commonly used degradable polymeric biomaterials. Silks are stabilized by beta sheet secondary structures, which are physical crosslinks formed via hydrogen bonding and hydrophobic interactions via inter- and intra-chain interactions. A summary of the mechanical and chemical features of silks include stability to: (a) organic solvents, (b) temperature, (c) acids/bases and water. In order to solubilize silk, either very strong salts (e.g., 50% LiBr, calcium nitrate salts), or concentrated acids are required. Current efforts are focused on implementing a standardized procedure with quality controls check points in the preparation of the regenerated silk aqueous solution. Thermally, silk materials are stable to above 200°C. In terms of optical properties, silk is optically as good as glass, transparent when prepared by water annealing process to control crystallization. Regenerated silk from aqueous solution can generate a wide platform of multifunctional materials due to the high versatile processing approaches. A range of scaffold material forms can be generated from silks through various processing into hydrogels, fibers, sponges, films, and other forms. The properties of these systems (e.g., mechanical, chemical, degradation profile, and optical clarity) can be tailored depending on the processing and then adapted to match native tissue parameters and also for functional devices, including nanoparticles, stabilization of enzymes and therapeutics, biophotonics, optoelectronics, and other technology applications [2]. In particular, silk in hydrogel form has been implemented for drug delivery for various applications, where the release profile can be controlled by tuning the protein physical and structural properties (e.g. molecular weight, protein concentration, secondary structure) and varying the processing technique and material format (e.g. hydrogel, particles, solution). Silk fibroin-based biomaterials will degrade within weeks to years depending on the processing form of the material. The *in vivo* degradability of silk scaffolds, as filler for soft tissue defects, showed the ability to regenerate adipose tissue in combination with lipoaspirate, while maintaining the original implanted volume. Furthermore, long term silk *in vivo* stability has been demonstrated for three dimensional structures implanted in rat models, which persisted beyond 1 year, and bladder tissue regeneration in larger animals. We have also recently shown the ability to control degradation of silk films in a rabbit cornea pocket model without significant adverse effects upon implantation [3]. These data all build upon the already FDA approved medical devices from silks.

References

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