Simulating the Flow of Native Silk Feedstocks in Vivo

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Abstract

Silk is one of the longest used and most recognizable textiles that we, as a society, use regularly. We see it as a luxury good, worn as an indicator of success and value. However, despite mankind having domesticated and farmed silkworms for millennia, we still know relatively little about the natural production process - spinning - which is responsible for the fibers we are so familiar with. Commercial silk is most commonly harvested from the cocoons of the Chinese silkworm Bombyx mori, which is farmed on an industrial scale. However, there are many other arthropods, including insects, myriapods and arachnids, which produce silks. Of these, it is the dragline silk produced by orb-weaving spiders which has received the most attention due to its high strength and toughness, both of which are desirable properties, especially in a biodegradable fiber which can be produced in ambient conditions.[1]

Increased understanding of the processing conditions which silk spinning animals employ will help in our search for tailor-made bio-sourced fibers. In nature, silk is stored in the animal as a liquid which can be converted on demand into a solid fiber with bespoke material properties. Whilst there is evidence that silks undergo this phase transition primarily via shear and extensional flows created by the geometry of the spinning duct in which it travels, alongside a concurrent reduction in pH, we know little of the details of this process and thus there is a gap in our knowledge [2].

Previous research has hinted at the shape of the duct and combined with our increasingly accurate unique rheological data from the Natural Materials Group [3] we are now in a position to explore these structures and determine relationships between the rheological, geometric and mechanical properties in greater detail than ever before [4-7].

The use of COMSOL's parametric analysis and LiveLink will allow us to explore Ridley's statement that evolutionary systems are only energetically optimized as they need to be, not necessarily can be [8]. We shall achieve this by comparing the differences between different sets of published rheological data for both spiders and silkworms against different duct geometries, with the eventual aim of producing a series of dies optimized for the creation of fibers with radically or subtly distinct properties. In doing so, we will gain valuable insight into the evolution of this fascinating process and take one more step down the path to producing synthetic silk fibers with properties tailored to specific applications.

Reference

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