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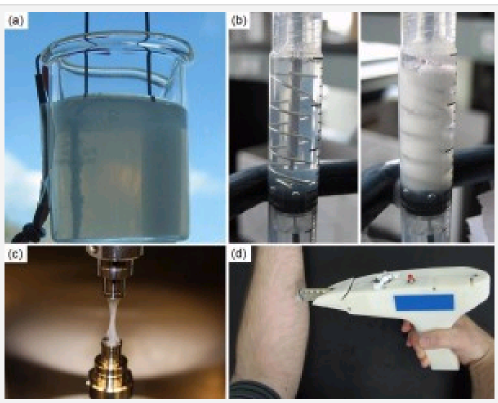
Silk-Based Adhesive Gel Provides Potential for In Situ and In Vivo Devices



Aspects of the silk electrogelation process: (a) basic process using 8% w/v silk solution with pencil lead electrodes (+ on the right); (b) syringe-based experiment with 8% silk solution and a spiral positive electrode; (c) demonstration of impressive adhesive qualities; and (d) prototype device to perform silk electrogelation and delivery for biomedical applications, such as burn treatment.

It's been a big year for silk. Researchers have been spinning new ways to employ silk for a variety of medical device applications in 2009, including using it as a base for nanoparticle composites, mimicking muscle, and employing it as a substrate for degradable electronics. Scientists at Tufts University (Medford, MA) are responsible for one of the latest developments: They've produced a novel, electrically mediated adhesive from silkworm silk that shows promise for future medical applications.

The Tufts researchers have yielded a highly viscous and tacky adhesive gel through a process called electrogelation, which means that the adhesive properties are controlled by electrical inputs. Beginning with electrodes immersed in an aqueous solution of silkworm silk protein, the researchers then applied 25 V dc to a pair of mechanical pencil leads for a 3-minute period. In response to these electric fields, gel formed on the electrode. Upon switching off the electric field, however, the electrogel (e-gel) remains stable. Thus, it is not dependent on an electrical field once formed.

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This particular project is unique for several reasons, according to the researchers. Although electrospinning of polymers has been performed at high voltages, the use of low dc voltages to generate a controlled volume of silk is a new development. Furthermore, the process is reversible, depending on voltage, time, and conditions. Atypical for silk-based systems, the reversal can be achieved using a reverse electrical process. The gel thus can be transformed from a solid state to the solution; this state change can be performed over multiple cycles.

Able to function on both hydrated and dry surfaces, the e-gel can also be applied to a variety of substrates. “E-gel displayed unique adhesion characteristics when compared to other bioadhesive systems,” according to an article written by the researchers for the journal Advanced Materials. “After the initial linear regime, the stress progressively increased, while the stress–strain curve showed sporadic fluctuations presumably due to an interplay between the decreasing e-gel/plate interface area, due to partial de-adhesion, and apparent stiffening of the e-gel, due to dehydration and elongational forces. Strains up to 2500% were recorded until failure upon complete de-adhesion.”

Because all biocompatible components were used in the development of the gel, it is potentially suited for a number of in vivo and in situ devices, the researchers note. They cite such possible applications as a handheld gel-forming and delivery device for burn treatment and a medical instrument that could navigate through the body and then temporarily adhere to a location in vivo.

Tags: Adhesives, Biomimetics, Silk

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