Mussels Inspire Innovative New Adhesive For Surgery

Mussels can be a mouthwatering meal, but the chemistry that lets mussels stick to underwater surfaces may also provide a highly adhesive wound closure and more effective healing from surgery.

In recent decades bioahesives, tissue sealants and hemostatic agents became the favored products to control bleeding and promote tissue healing after surgery. However, many of them have side effects or other problems, including an inability to perform well on wet tissue.
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"To solve this medical problem, we looked at nature," said Jian Yang, associate professor of bioengineering at Penn State. "There are sea creatures, like the mussel, that can stick on rocks and on ships in the ocean. They can hold on tightly without getting flushed away by the waves because the mussel can make a very powerful adhesive protein. We looked at the chemical structure of that kind of adhesive protein."

Yang, along with University of Texas-Arlington researchers Mohammadreza Mehdizadeh, Hong Weng, Dipendra Gyawali and Liping Tang, took the biological information and developed a wholly synthetic family of adhesives. They incorporated the chemical structure from the mussel's adhesive protein into the design of an injectable synthetic polymer. The bioahesives, called iCMBAs, adhere well in wet environments, have controlled degradability, improved biocompatibility and lower manufacturing costs, putting them a step above current products such as fibrin glue and cyanoacrylate adhesives.

Fibrin glues are fast acting and biodegradable but have relatively poor adhesion strength. They may also carry risk of blood-borne disease transmission and have the potential for allergic reactions due to animal-based ingredients. Cyanoacrylate adhesives -- super glues -- offer strong adhesion, rapid setting time and strong adhesion to tissue, but they degrade slowly and may cause toxicity, often limiting their use to external applications.

Additionally, neither product is effective when used on wet tissue, a requirement of internal organ surgery, nor are there any current commercially available tissue adhesives or sealants appropriate for both external and internal use.

The researchers tested the newly developed iCMBAs on rats, using the adhesive and finger clamping to close three wounds for two minutes. Three other wounds were closed using sutures. The researchers reported their findings in a recent issue of Biomaterials.

The iCMBAs provided 2.5 to 8.0 times stronger adhesion in wet tissue conditions compared to fibrin glue. They also stopped bleeding instantly, facilitated wound healing, closed wounds without the use of sutures and offered controllable degradation.

"If you want the material to stay there for one week, we can control the polymer to degrade in one week," said Yang. "If you want the material to stay in the wound for more than a month, we can control the synthesis to make the materials degrade in one month."

The iCMBAs are also non-toxic, and because they are fully synthetic, they are unlikely to cause allergic reactions. Side effects were limited to mild inflammation.

"If you put any synthetic materials into your body," said Yang, "the body will generate some inflammation."

The researchers are now working on improving the formula.

"We are still optimizing our formulation," said Yang. "We are still trying to make the adhesion strength even stronger" to expand its use for things like broken bones where strong adhesion is tremendously important.

The researchers are also looking at adding in components that could control infection.

"We can introduce another component with anti-microbial properties, so it can do two functions at once," said Yang.

The iCMBAs could eventually be used in a wide range of surgical disciplines from suture and staple replacement to tissue grafts to treat hernias, ulcers and burns.

"There are so many applications that you can use this glue for to help in surgery," said Yang.

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