Underwater glue

Glue and water don't really go together, yet PhD candidate Marco Dompé has managed to make an underwater adhesive. Thanks to the sandcastle worm.

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Glues don't stick to wet surfaces. Try mending a tyre that is still wet, or putting a plaster on damp skin. But adhering to things under water is not impossible. Mussels, for example, have no trouble sticking to a fixed surface. Barnacles can do it too. And some marine worms create entire shelters by sticking sand and other hard materials together under water.

This trick is what Marco Dompé, an Italian PhD student in Wageningen's Physical Chemistry and Soft Matter chair group, took as the starting point for his approach to developing a glue that does work under water.

As an adhesive, sandcastle worms use coacervates, viscous liquids made from two polymers that are water soluble. 'These polymers have opposite charges, stick together and form a liquid-like substance that doesn't mix with water,' explains Dompé. It then hardens in response to an external stimulus. The sandcastle worm's glue hardens when it comes into contact with seawater. Other coacervates might harden on contact with oxygen, when the acidity of the surroundings changes or when the temperature changes.

> 'Under water, the glue is 10 times stronger than adhesive tape'

TAKING TIPS FROM NATURE

Dompé used this principle to develop a glue. This scientific field is known as bio-inspired design: finding a design by taking tips from nature. 'The natural adhesives are based on complex proteins,' says Dompé. 'It would be far too difficult and time-consuming to replicate them precisely. What we do is use principles from nature to create something new.'

The external trigger for hardening the glue that Dompé has concentrated on is

Sandcastle worms build their homes by sticking grains of sand together under water.

temperature. The underwater glue that Dompé wants to make is intended for medical applications. So it should be a glue that can be applied at just the right spot in liquid form in the human body and then harden in response to the body temperature. Doctors would be able to use it to seal wounds or repair tissue.
As polymers, Dompé is using chains based on polyacrylate and polyacrylamide. 'We added poly(N-isopropylacrylamide) side chains to them. They are actually quite water soluble but when temperatures rise, they clump together and repel the surrounding water,' explains Dompé. The side chains clumping together makes sure the glue hardens as it should. This is an irreversible physical process. The glue hardens precisely in the temperature range of the human body.

STRENGTHENING

The glue worked exactly as envisaged on the drawing board. 'We've got the proof of concept, but the glue still has to be developed further,' says Dompé. 'Under water, the glue is 10 times stronger than adhesive tape. But I don't think that is quite strong enough for medical applications. The big plus points of this glue are its thermo-responsiveness and the strength of the electrostatic interactions of the polymers.'
Meanwhile, the chair group has applied for a patent on the process. So the principle does work. The rest is a question of pressing the right buttons. Different polymers and side chains result in different glue characteristics. For example, the salinity of the environment in which the glue is applied has an effect. Dompé: 'The materials you use have to be accepted by the body and must not be toxic. That also depends on the part of the body where you want to use the glue.' ■

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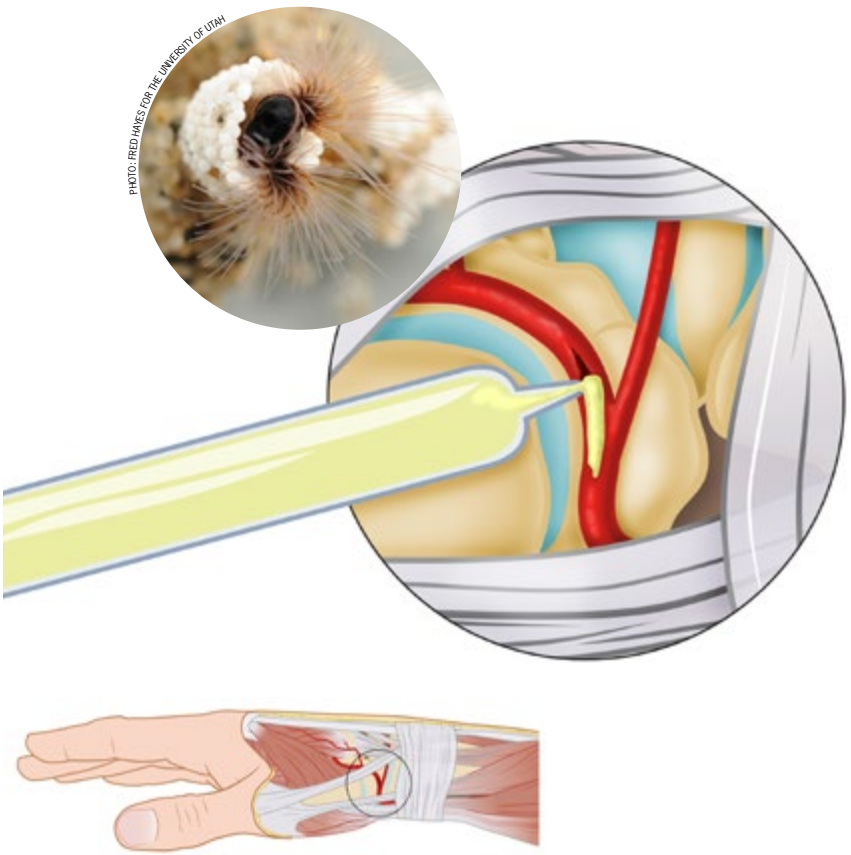

Marco Dompé used the same principle as the sandcastle worm to develop an adhesive that can stick wet surfaces together. The adhesive hardens at body temperature.

BIOSMARTTRAINEE

Marco Dompé (27, graduated with distinction in Industrial Chemistry at Turin) came to Wageningen through the BioSmartTrainee project, in which 10 universities and companies are collaborating on the development of adhesives that work on wet surfaces. The project is using nature as a source of inspiration. Dompé is one of 11 young researchers who are being trained in this area with money from the EU. Wageningen and Eindhoven University of Technology represent the Netherlands in the project.
Dompé joined the Physical Chemistry and Soft Matter group headed by Marleen Kamperman, who has since been appointed a professor at Groningen. Kamperman has spent her entire scientific career studying nature's chemical tricks and using them as inspiration. Dompé hopes to defend his thesis early next year.