Chest strap for the heart

An Empa team developed a chest strap for the long-term monitoring of cardiovascular patients. What makes the belt that displays the electrocardiogram (ECG) so special: It keeps itself moist – which is crucial to detect a signal reliably. This makes it just the ticket for the elderly who often perspire a lot less.

TEXT: Martina Peter / PICTURES: Empa, iStockphoto

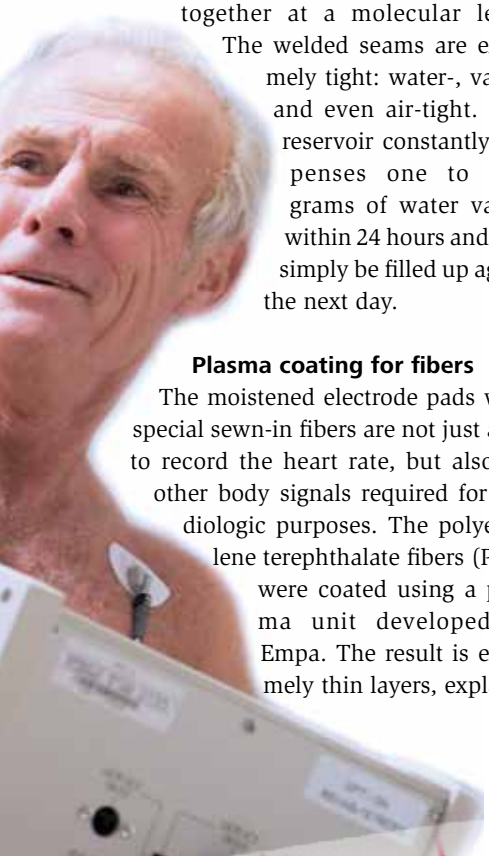
The demand for ECG measuring devices is on the rise: it is not just hospitals and rehabilitation centers that are interested in reliable, skin-friendly devices for the long-term monitoring of cardiovascular patients. The trend towards collecting and monitoring personal health data is booming. The problem: so far, gel electrodes were used for reliable, long-term ECGs. After 24 hours at the latest, however, they dry out and stop emitting reliable signals. This makes them of limited suitability for elderly people who often perspire less and are not as mobile.

The idea of developing an ECG belt for long-term use with wettable electrodes is nothing new, explains Markus Weder from Empa's Laboratory for Protection and Physiology and head of the project funded by the Commission for Technology and Innovation (CTI). "Originally, the idea came from clinical practice where long-term ECGs are customary for monitoring stress in high-risk patients. Nobody wants to stick new gel electrodes on their skin every day." Weder soon realized that such a product only stood a chance if it was easy to use and didn't bother the wearer too much. "The solution as to how we could wet electrodes in a dosed way came from a very different project, where we developed cooling clothing for multiple sclerosis patients using the very same technology," he says.

Artificial perspiration from a "reservoir"

The wetting was necessary, Weder explains, to preserve electrodes' electrical conductivity. At the same time, this should reduce artifacts that form when the electrode rubs against the skin ever so slightly. For the metallic sensors to be able to accurately register the body signals and reliably transfer them there needs to be moisture between the electrode and the skin – much like when we sweat. In order to generate a kind of "perspiration", Weder's team developed flexible moistening elements that can be filled with around 30 milliliters of water and ensure that the skin remains permanently moist.

The "reservoir" is a cavity between a watertight membrane and a vapor-permeable textile layer. Instead of sewing the layers together, the scientists welded them together with a laser technique they had perfected recently. A diode laser beam heats up the layers with such precision that they melt point by point and the polymer chains bind together at a molecular level. The welded seams are extremely tight: water-, vapor- and even air-tight. The reservoir constantly dispenses one to two grams of water vapor within 24 hours and can simply be filled up again the next day.



Plasma coating for fibers

The moistened electrode pads with special sewn-in fibers are not just able to record the heart rate, but also all other body signals required for cardiologic purposes. The polyethylene terephthalate fibers (PET) were coated using a plasma unit developed at Empa. The result is extremely thin layers, explains Dirk Hegemann, a specialist in functional textile coatings at Empa's Laboratory of Advanced Fibers. This enables the coated fibers to retain their properties – their textile haptics – and gain new ones: the roughly 100-nanometer-thin silver layer ensures that the electric impulses are transmitted and that microorganisms cannot take hold.

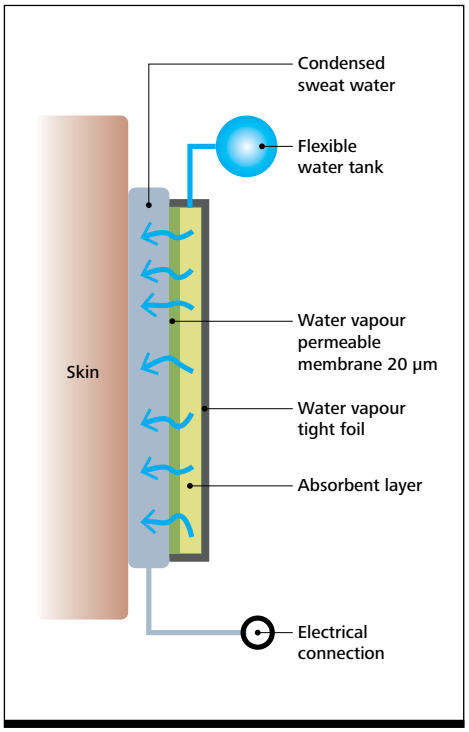
The overlying four to six-nanometer-thin layer made of titanium guarantees stable signals and prevents skin irritations from developing or silver particles from being released. "We already made an attempt with titanium some years ago," says Weder. "But the layer was too thick and the titanium came off." The researchers have now succeeded in applying a considerably thinner layer, which does not peel off when the thread is embroidered.

Strict requirements

Two embroidered sensor pads that are directly connected to a data logger are incorporated into each ECG belt. The recorded signals are sent to a database or standard monitoring device. As the data logger is secured with snaps, the wearer can remove and wash it – one of the strict requirements for the system to be cleared for use as a long-term medical ECG device.

The device has already been tested successfully in well over 100 trials with volunteers. Weder himself as well as his team have also worn the belt extensively. The device could be worn for up to ten days as, compared to reference measurements, the values provided also proved to be extremely accurate after long-term use.

However, it will be some time before the device hits the market. The next step will be clinical trials as part of a CTI follow-up project with the University Hospital Basel and various industrial partners (Unico Swiss Tex GmbH, Forster Rohner, Serge Ferrari SA, xotox and Zietromec). In order to be able to produce the special fibers in large quantities, stable plasma processes that enable layer thicknesses to be set with nanometer precision are also needed. The scientists are currently working on this. Moreover, the researchers are already considering the extent to which the electrodes could be used for other purposes – such as to stimulate muscles in pain therapy or reactivate the colonic function in bedridden patients using interference wave therapy, for instance. //



Function diagram: Thanks to a water reservoir, the electrode always remains moist and yields reliable data.

The prototype of the EKG chest strap was tested on various test subjects in more than 100 experiments.