A newly developed sensor that measures the blood sugar through skin contact could render blood samples a thing of the past. "Glucolight" is initially to be used on premature babies.

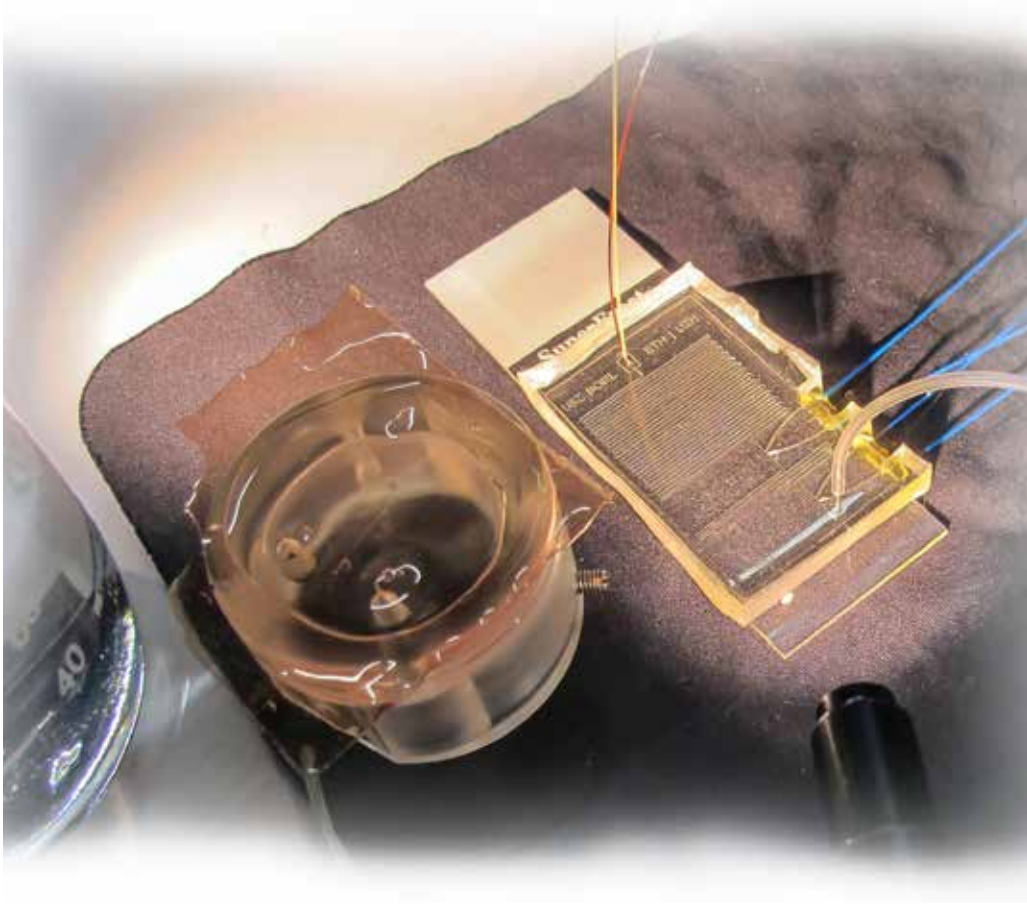
TEXT: Anemone Seger / PICTURES: Empa

One in twelve babies is born prematurely in Switzerland. The blood sugar levels need to be monitored closely in these premature babies, also known as “preemies”, as prolonged hypoglycemia can affect brain development. Until now, this monitoring inevitably meant taking blood samples. If the blood sugar is at a critical level, doctors even have to take blood every hour, which causes blood loss, pain and stress. To address this issue, Empa teamed up with the University Hospital Zurich on a five-year project funded by the Swiss National Science Foundation (SNSF) to develop the “Glucolight” sensor, which gages the blood sugar level through the skin, without taking any blood. “As preemies lack the top layer of skin, theirs is permeable for glucose, which is why you can measure the blood sugar level very well via the skin,” explains project leader Martin Wolf from the Department of Neonatology at the University of Zurich.

Although skin sensors already exist, they have to be calibrated before use. And this means that the skin’s permeability value needs to be known, which depends on the area of the skin, the temperature and the pH value. In order to establish this, the blood sugar level has to be determined via a blood sample and the glucose concentration on the skin measured. Based on these two readings, the permeability can then be calculated and the sensor calibrated.

Doctoral student Damien de Courten, a member of Martin Wolf´s team, presents the measuring head with the "smart" membrane in the lab at the University Hospital

Light replaces the needle



Initially, glucose molecules diffuse through the membrane from the skin (left) before enzymes are added and the solution is pumped through the microfluidics chip (right). By means of fluorescence measurement the glucose concentration in the blood can be calculated.

An intelligent membrane

Glucolight spares the premature babies blood samples and enables the blood sugar level to be monitored permanently thanks to the sensor's novel measuring technology, which comprises several parts: a microdialysis measuring head, which was developed at the University Hospital Zurich, with a "smart" membrane developed at Empa; light sources; a pump; and a microfluidics chip with a fluorometer, which was also developed at the University Hospital Zurich.

"The smart membrane contains special dye molecules, known as spiropyrans," explains Luciano Boesel from Empa's Laboratory for Protection and Physiology in St. Gallen. If UV light is beamed onto these spiropyran molecules, they alter their chemical structure and become charged (polar). When irradiated with visible light, they revert to their original, neutral structure. As a result, the membrane "opens" when irradiated with UV light and glucose molecules from the skin diffuse relatively easily through the membrane. If irradiated with visible light, considerably fewer glucose molecules pass through the membrane.

The measurement involves sticking the measuring head, which is around three centimeters in size, to the baby's skin and irradiating it with visible light. Some glucose molecules diffuse through the membrane. On the other side of the membrane, the glucose is mixed with a fluid and pumped through the microfluidics chip, while enzymes are added to trigger a chemical reaction. The reaction leads to a fluorescence, which can be measured by a fluorometer; finally, the computer uses the reading to calculate the glucose concentration. The process is then repeated with UV light. The computer then uses the two different readings to calculate the premature baby's blood sugar level.

Next step: clinical trials

The researchers filed a patent application for Glucolight in mid-2014. "We hope to be able to test Glucolight for the first time in clinical trials at the University Hospital Zurich in the course of 2015," says Wolf. However, it could be years before the use of Glucolight becomes standard practics. Empa and the University Hospital Zurich are currently in negotiations with partners for the industrial production of the sensor. For the future, the researchers also envisage the use of Glucolight in other fields, such as diabetes.

In the course of the project, the researchers discovered another potential application for the membrane. Its "switchable" permeability can also be used in the opposite direction: in a drug-loaded plaster. Instead of a measuring head, there is a drug depot behind the membrane. If irradiated with UV light, the membrane becomes more permeable and the drug is gently administered through the skin over several hours. In the absence of irradiation, the membrane keeps the drug in the depot. Empa and the University Hospital Zurich developed a caffeine plaster to combat respiratory arrest, which is common in premature babies. (See also Empa News No. 47) //

Video
"Intelligent materials take care of premature infants"

https://youtu.be/GPCws_lHtDM