# Colorimetric temporary tattoo-based sweat pH sensor


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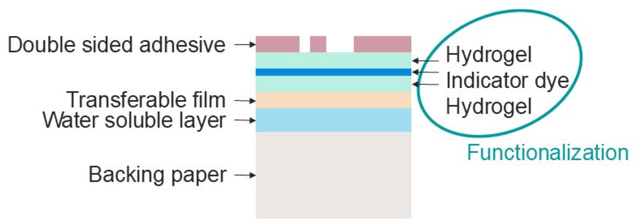
## Introduction

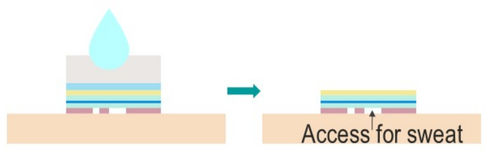
Temporary tattoo-based sensors have attracted considerable attention in the expanding field of tracking sweat biomarkers. Thanks to their ultra-conformal adhesion to the skin combined with excellent water vapor permeability, tattoo sensors can react to even minimal sweat production but can also cope with large amounts of sweat. One major advantage of a tattoo sensor of providing a skin-alike sensation can get compromised with electroanalytical components. Therefore, we present for the first time a colorimetric temporary tattoo-based pH sensor.

## Concept

Commercially available temporary tattoo paper is functionalized (by spin coating) with a pH indicator dye embedded between hydrogel layers. The hydrogel traps the dye and at the same time serves to collect and transport sweat. A cut-out double-sided adhesive provides the necessary adhesion to the skin and access for sweat.

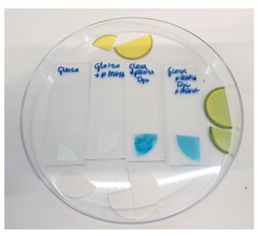


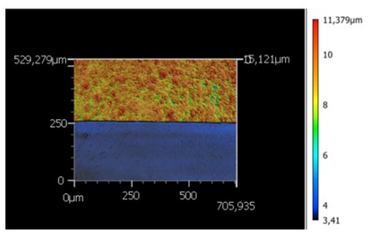

The ultra-thin sensor can be transferred to the epidermis using a water slide technique.

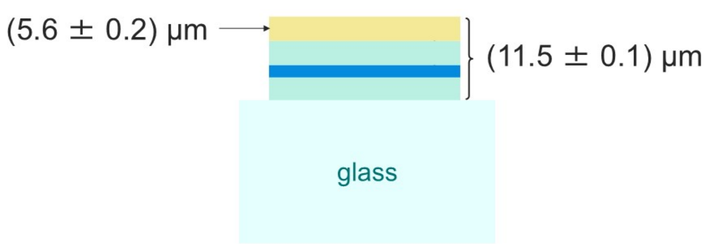



## Thickness of Layers

Via laser confocal microscopy topographical features such as the layer thickness were extracted.



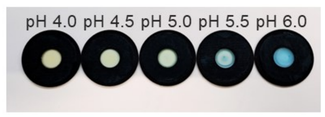


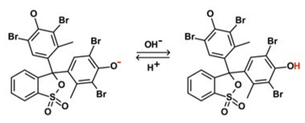

The thickness of the sensor is about 12 µm. In comparison, typical features of the epidermis are 10 - 100 µm.

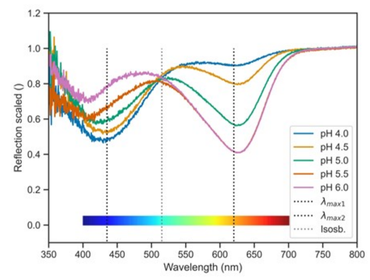
## Color Response

The tattoo sweat pH sensor is transferred on a carrier ring and exposed to artificial sweat of different pH.

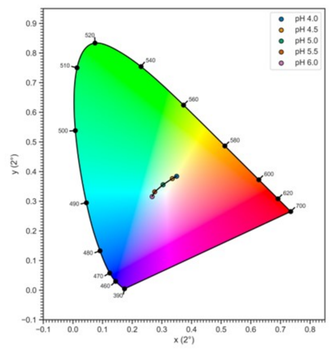



The visible spectrum at different pH reveals the expected monoanionic (yellow) and dianionic (blue) form of the used bromocresol green.



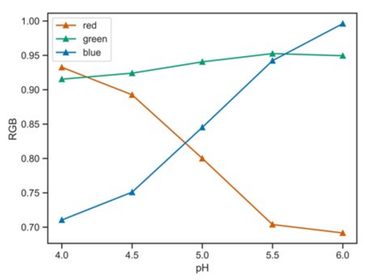

For visual inspection, a color scale was calculated according to the CIE 1931 color space. The colors are distinguishable, but the intensity is reduced. The requirement for an ultra-thin responsive layer is at the expense of color brightness.





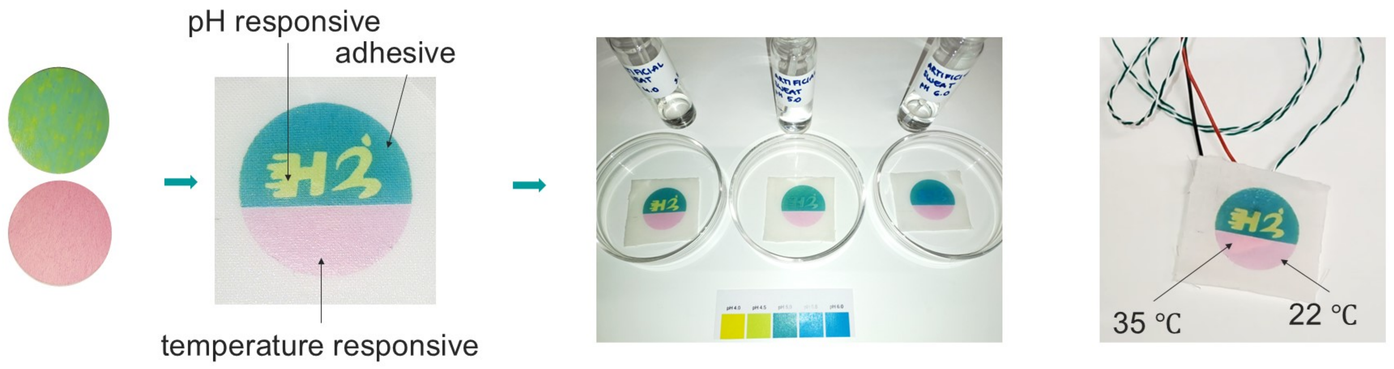


For inspection via rgb camera the sRGB intensities were extracted revealing a clear trend of the expected red and blue intensity versus the pH.




## Technology Demonstrator

The technology demonstrator consists of a pH-sensitive tattoo, a temperature-sensitive colorimetric tattoo (for calibration reason) and the double-sided adhesive with the H2TRAIN project logo cut-out. The demonstrator was applied on cotton fabric which was soaked in artificial sweat of different pH and exposed to different temperatures. The change of color represents well the pH and the temperature.




## Conformality on Skin

A major challenge of wearable sweat sensors is to cope with minimal sweat rates of 0.02 nL/gland/min (sedated patients). The great advantage of the tattoo sensor is a combined collection, transport and measurement layer that is in close contact with the skin and thus minimizes the required sweat sample volume.


## Funding

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