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WEARABLE SENSOR FOR REAL TIME pH DETERMINATION IN SWEAT

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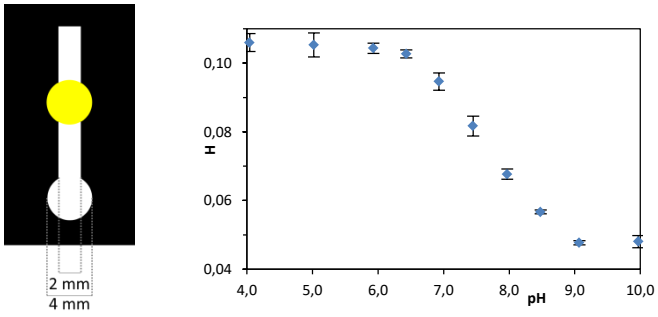
Nowadays, it is more and more common to find devices that permits to everybody carry out analysis of different analytes of interest as glucose in blood or creatinine in urine by themselves, thanks to the development of the Point-of-Care (POC) devices. POC's permit the in situ analysis of the samples, in an easy way, quickly and by the use of a small amount of sample in the sampling area of the device, obtaining result with no need of instrumentation or by the use of a very simple one. In order to match these objectives and make the device useful for everybody in any condition, the WHO has described the ASSURED guidelines for the POC devices[1].
In the recent years, and thanks to the capillary properties of different materials as paper, thread or cloth, the development of the POC devices are turning to a new strategy that implies the inclusion of the POC devices in t-shirts, bracelets or patches obtaining in this way wearables sensors. In this kind of sensor, instead of the addition of the sample in the sampling area, it moves through the device arriving to recognition/transduction area were the property of the sensor changes and can be measured and related to the concentration of the analyte.
In this work, we present a wearable POC that permits the real-time determination of the pH in sweat. For this purpose, we have developed a µCAD (Figure) that contains a pH indicator (4-[4-(2-hydroxyethanesulfonyl)-phenylazo]-2,6-dimethoxyphenol (GJM-534) [2]) covalently immobilized on cotton cloth, which color is going to change from yellow (pH around 6) to pink (pH around 9) depending on the pH. The size and shape of the µCAD (see Figure) was designed taking into account the low flow rate of sweat generated in the wrist when sweating (0.01 µL/min) including a superabsorbent material working as passive pump to avoid the saturation of sample of the µCAD.
The colorimetric device was calibrated using the H parameter from the HSV color space as analytical parameter, obtaining the calibration function and analytical parameters of the device, the reversibility of the µCAD, response time and stability.
Finally, the µCAD was integrated into a bracelet that includes a color detector and a microprocessor that registered the color of the µCAD in real-time and send the information via Bluetooth to a smartphone, obtaining and registering the pH of the sweat while doing exercise.



Bibliography:

[1] M.M. Erenas, Biosens. Bioelectron. 136 (2019) 47–52.
[2] P. Kassal, Sensors Actuators, B Chem. 246 (2017) 455–460.

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WEARABLE DEVICE FOR REAL TIME pH MEASUREMENT IN SWEAT

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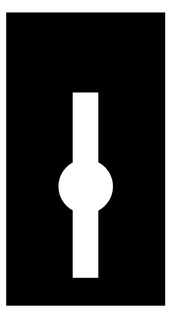
INTRODUCTION

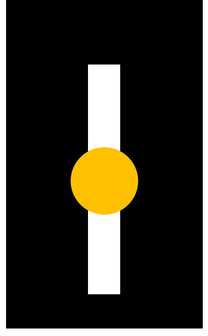
In the recent years, and thanks to the capillary properties of different materials as paper, thread or cloth, the development of the POC devices are turning into a new strategy that implies the inclusion of the POC devices in t-shirts, bracelets or patches obtaining in this way wearables sensors. In this kind of sensor, the sample moves through the device arriving to recognition/transduction area where the property of the sensor changes and it can be measured and related to the concentration of the analyte.
In this work, we present a wearable POC that permits the real-time measurement of the pH in sweat using a pH indicator, synthetized by us, covalently immobilized on cotton cloth, which color is going to change depending on the pH. The size and shape of the µCAD was designed taking into account the low flow rate of sweat generated in the wrist when sweating (0.01 µL/min) including a superabsorbent material working as passive pump to avoid the saturation of sample of the µCAD.

µCAD fabrication

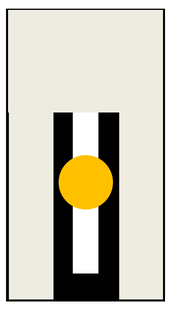
Screen-printing black Plastisol ink

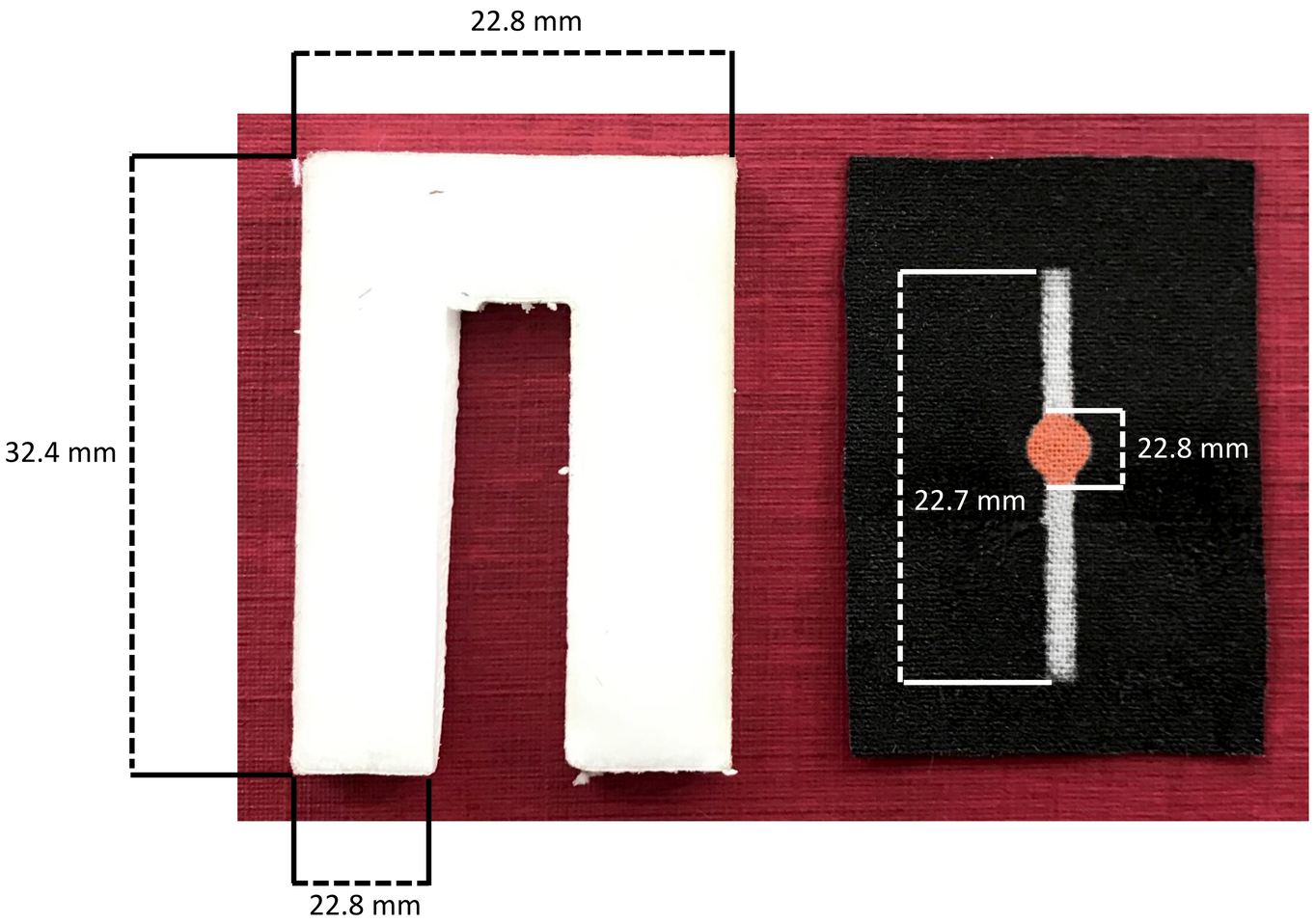


pH indicator immobilization by divinylsulfone chemistry

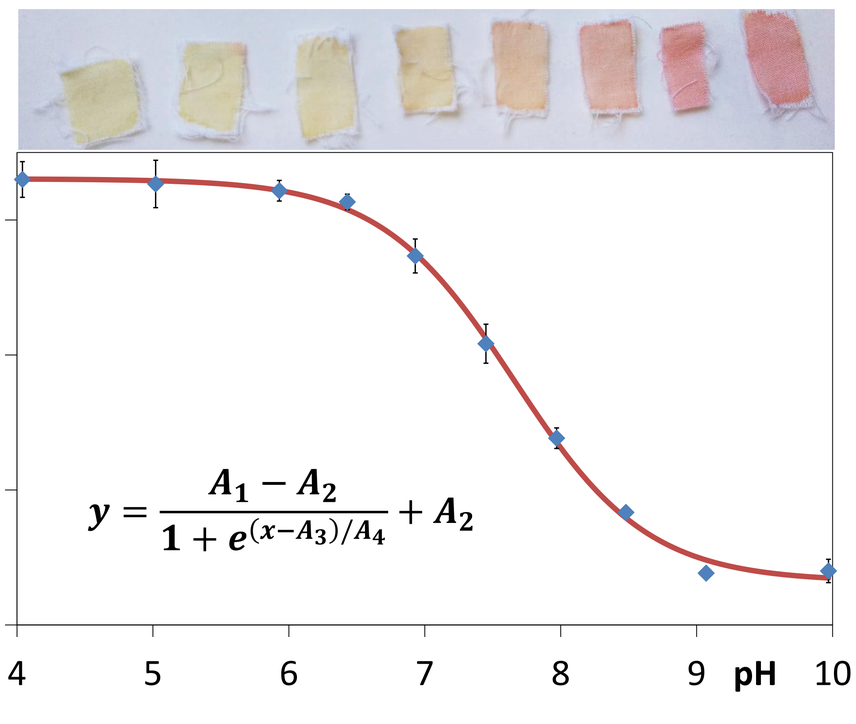


Passive pump



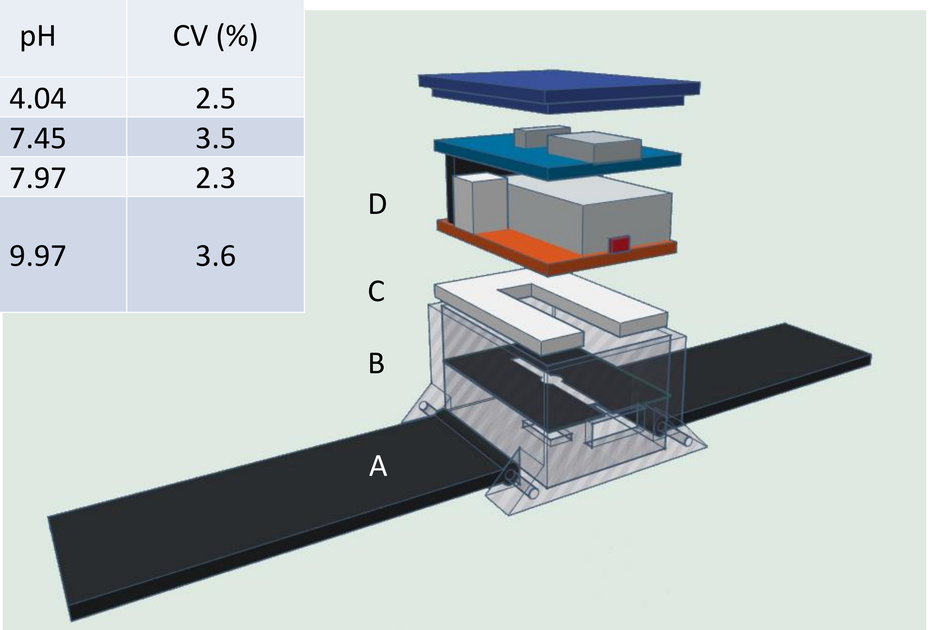


µCAD calibration and measurement



Analytical parameters			
A_1	0.106	Precision	
A_2	0.046	pH	CV (%)
A_3	7.657		
A_4	0.492	4.04	2.5
R^2	0.997	7.45	3.5
LOD	6.6	7.97	2.3
Range	6.6-10.0	9.97	3.6

A Bracelet
B Patch
C Passive pump
D PCB designed



CONCLUSIONS

- A pH indicator derived from 2,6-dimethoxyphenol (GJM-534) has been synthetized by us, has been and covalently immobilized on a cotton cloth.
- A µCAD that works with a flow rate of sample of 0.01 µL/min (similar to sweating rate) has been designed.
- A wristband were included in the µCAD and a PCB that is able to register during 4 hours and send to a phone the evolution of sweat pH, by analyzing the color of the pH indicator bonded on the cotton cloth.

REFERENCES

M.M. Erenas et al. Biosens. Bioelectron. 136 (2019) 47–52.
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