Wearable and fully printed microfluidic nanosensor for sweat rate, conductivity, and copper detection with healthcare applications

Vernalyn Abarintos [a,b]
Qiuyue Yang [a,c], Giulio Rosati [a], Miguel Angel Aroca [d,e], Johann F. Osma [d], and Arben Merkoçi [a,f,*]
[a]*Catalan Institute of Nanoscience and Nanotechnology (ICN2), Campus UAB, 08193, Bellaterra, Barcelona, Spain*
[b]*Universitat Autonoma de Barcelona, Department of Biotechnology, Campus de la UAB, 08193, Barcelona, Spain*
[c]*Universitat Autonoma de Barcelona, Department of Material Science, Campus de la UAB, 08193, Barcelona, Spain*
[d]*Dept. of Electrical and Electronic Engineering, Universidad de los Andes, Cra 1 Nº 18A – 12, 111711, Bogota, Colombia*
[e]*Office of Information and Communication Technologies. Gov. of Cesar. Calle 16 # 12 - 120, Valledupar, Colombia*
[f]*Catalan Institution for Research and Advanced Studies (ICREA), Pg. de Lluís Companys, 23, 08010, Barcelona, Spain*
*arben.merkoci@icn2.cat; vernalyn.abarintos@icn2.cat

Wearable sensors and biosensors, also known as wearables, have been of great interest due to their applications in sports, well-being, and health monitoring. A wearable is ideally non-invasive and one of the most common samples is sweat, being the simplest in composition, abundant, and containing many biomarkers for pathologies and the general well-being of the subject [1]. Amongst the many biomarkers in sweat, heavy metals (HMs) such as copper have an important role as a biomarker of rheumatoid arthritis, coronary heart disease, Wilson's disease, and liver cirrhosis [2,3]. Nevertheless, several issues such as sampling conditions, sweat rate normalization, reliable continuous monitoring, and typically expensive fabrication methods still need to be addressed in sweat analysis with wearables. In this work, we propose an all-printed wearable system composed of: a) an inkjet-printed microfluidic part for the active sampling by reverse iontophoresis and measurement of the sweat volume/rate, b) a screen-printed carbon electrode (SPCE) for the copper electrochemical detection and its concentration normalization with the sweat rate, and c) a flexible wearable potentiostat transmitting the data wirelessly to a smartphone. The copper sensor showed a limit of detection of 396 ppb, a linear range up to 2500 ppb, a sensitivity of 2.3 nA/ppb, and resilience to interference tested in artificial sweat. Furthermore, the conductivity and volume integrated sensors allow for the normalization of the copper concentration on the base of the sweat rate. Lastly, the sweat absorption by a sponge in contact with air at the outlet of the device allows to empty of the microchannel (with the sweat in the sponge evaporating); thus, permitting the reuse of the device over time, pursuing the continuous monitoring concept.

References

[1] Bariya, M., Nyein, H.Y.Y., Javey, A. Nat. Electron. 1 (2018) 160–171.
[2] Bakulski, K.M., Seo, Y.A., Hickman, R.C., Brandt, D., Vadari, H.S., Hu, H., Park, S.K. J Alzheimers Dis. 4 (2020) 1215–1242.
[3] Yu, L., Liou, I.W., Biggins, S.W., Yeh, M., Jalikis, F., Chan, L.N., Burkhead, J. Hepatol. Commun. 8 (2019) 1159–1165.

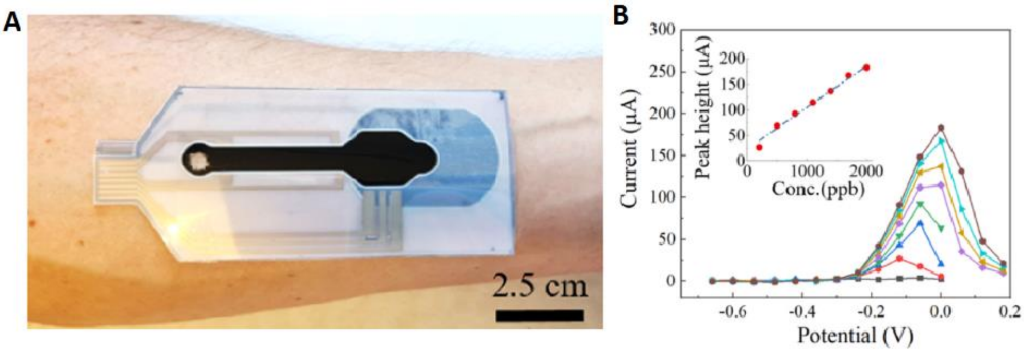

Figure 1: A) The assembled device applied on the forearm of the skin and **B)** the voltammograms of the printed microfluidic device on the flexible potentiostat and mobile phone system