Sensors for the monitoring of analytes in the sweat

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In the last decade, can be found an exceptional growth in research activity relating to the development of wearable devices, capable of continuously monitoring the health conditions of the wearer by analyzing body fluids such as blood, urine, saliva, tears and sweat. Among the body fluids available, sweat is a biofluid of particular interest, as it allows a non-invasive, continuous and comfortable collection. Human sweat contains useful information on the health of an individual and therefore is an excellent biofluid for the detection of specific analytes. The most abundant ions in the sweat are Na^+ and Cl^- (10 - 100 mM), and their monitoring is useful in patients with cystic fibrosis. Other constituents are Ca^{2+}, K^+, ascorbic acid, glucose (0.1-10 µM) related to osteoporosis, hypoaldosteronism, scurvy and diabetes disease. The sweat pH is in the range 3 to 8 [1] [2] and indicates the level of metabolism and homeostasis of the body.
Wearable sensor needs to be flexible, compact and easily applicable. It must also offer a stable response, with high sensitivity and selectivity towards specific analytes [3]. Over the years, many wearable sensors for sweat monitoring have been developed, combining different form factors, substrates and sensing mechanism. In this work, electrochemical sensors based on polyaniline (PANi), which is pH sensitive, were studied. First, the best conditions of electrochemical deposition of PANi were studied [4], using as flexible substrate polyethylene terephthalate coated with indium-tin oxide (ITO-PET). In order to improve the sensor performance electrodes were also modified by electrochemical deposition of reduced graphene oxide (rGO). All samples were characterized by XRD, SEM and EDS analysis in order to study morphology and evaluate the crystalline phases of the deposited PANi. The electrodes were tested as pH sensors using different buffer solutions, from 2 to 8, by Open Circuit Potential (OCP) technique. The ITO-PET/rGO/PANi electrodes show good behavior in terms of sensitivity (62.3 mV/pH), very close to Nernstian response of 59 mV/pH and reproducibility of 3.8%. Flexibility and mechanical stability tests were carried out on the sensor to evaluate both the wearability and mechanical resistance. In addition, interference tests, in the presence of competing ions such as Na^+, Cl^-, K^+, NH_4^+, aimed to verify the selectivity were also performed.

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[1] M. J. Patterson, S. D. R. Galloway, e M. A. Nimmo, «Variations in Regional Sweat Composition in Normal Human Males», *Exp. Physiol.*, vol. 85, n. 6, pagg. 869–875, nov. 2000.
[2] M. Bariya, H. Y. Y. Nyein, e A. Javey, «Wearable sweat sensors», *Nat. Electron.*, vol. 1, n. 3, pagg. 160–171, mar. 2018.
[3] C. Legner, U. Kalwa, V. Patel, A. Chesmore, e S. Pandey, «Sweat sensing in the smart wearables era: Towards integrative, multifunctional and body-compliant perspiration analysis», *Sens. Actuators Phys.*, vol. 296, pagg. 200–221, set. 2019.
[4] D. M. Wirth, L. J. Waldman, M. Petty, e G. LeBlanc, «Communication—Polyaniline Electrodeposition on Flexible ITO Substrates and the Effect of Curved Electrochemical Conditions», *J. Electrochem. Soc.*, vol. 166, n. 13, pagg. D635–D637, 2019