Wearable and flexible electrochemical sweat sensor consisting of a graphene-based polymer composite membrane

KEYWORDS

- ❑ WEARABLE SENSOR
- ❑ ELECTROCHEMICAL SENSOR
- ❑ GRAPHENE
- ❑ SWEAT SENSOR
- ❑ COMPOSITE MEMBRANE

AREA

- ❑ NANOTECHNOLOGIES & MATERIALS

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Patent for invention

Ownership
Sapienza University of Rome 100%

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Industrial & Commercial Reference
Medical/health/welfare and fitness sectors; continuous and minimally invasive real-time monitoring of sweat for PPE

Time to Market
The TRL is 3, which is a working prototype and tested in the laboratory in significant environments. The activation of an ethics committee is envisaged to proceed with tests on people

Availability
Research, Development and Experimentation

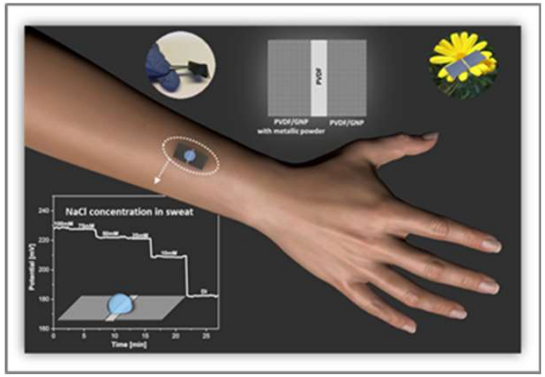


Fig. 1 Diagram of the electrochemical sweat sensor object of the present invention, consisting of a membrane in polymeric composite material containing graphene.

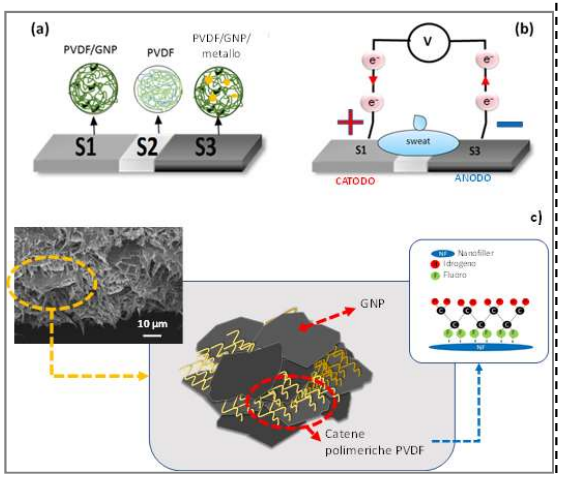


Fig. 2 Constitutive scheme of the sweat sensor that incorporates the three sectors S1, S2 and S3 (a), operating principle (b) and alignment effect of the PVDF polymer chains induced by the presence of the nanofiller (c).

Abstract
The invention concerns a wearable electrochemical sweat sensor consisting of a composite membrane with poly (vinylidene fluoride) (PVDF) and graphene. The membrane is self-standing and incorporates three different sectors: the first consists of PVDF and graphene, the second is electrically insulating and made with PVDF, the third is realized with a composite of PVDF, graphene and possibly metal elements. If wetted with drops of sweat or other electrolytic solution, the membrane electrochemically generates a voltage signal proportional to the salt content of the solution. It is therefore possible to detect the presence of sweat and to estimate the concentration of the ions present there, as shown in Fig.1..

Publications

- ❖ Bidsorkhi, H. C., Ballam, L. R., D'Al.oia, A. G., Tamburrano, A., De Bellis, G., & Sarto, M. S. (2020, July). Flexible graphene based polymeric electrodes for low energy applications. In 2020 IEEE 20th International Conference on Nanotechnology (IEEE-NANO) (pp. 263-266). IEEE

Wearable and flexible electrochemical sweat sensor consisting of a graphene-based polymer composite membrane

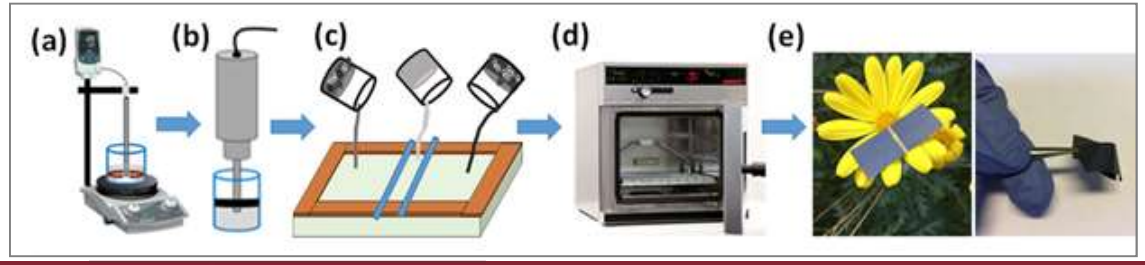
Technical Description

The sensor consists of a PVDF composite polymer thin membrane, containing graphene and possibly metal. The membrane is self-standing, light, flexible and incorporates three sectors:

- the first (S1) in PVDF and graphene;
- the second (S2) in PVDF;
- the third (S3) in PVDF and graphene, possibly with metal elements.

Sector S1, if placed in contact with sweat or other saline solutions, is the site of reduction reactions while sector S3 is the site of oxidation reactions, as shown in Fig. 2. Consequently, when both S1 and S3 are in contact even with small amounts of sweat, electrons pass through and therefore a voltage signal whose intensity depends on the concentration of ions in the sweat (or other saline solutions). The membrane production process is crucial..

Fig. 3 Manufacturing process of the sweat sensor consisting of the hybrid film with a polymer matrix of PVDF, partially loaded with graphene nanoplasty and containing metallic elements. (a): dissolution of PVDF; (b): sonication of mixtures; (c): pouring of the mixtures; (d): oven cure; (e): final product.



Technologies & Advantages

In summary, the invention is innovative compared to the state of the art in that:

- economic: it does not require the use of expensive reference electrodes;
- made with a simple process that leads to the production of a single polymeric membrane with 3 continuous sectors;
- easy to use and adaptable to various needs;
- flexible, wearable, washable, reusable;
- it does not require any external power supply because it is a device that is self-powered by electrochemical means in the presence of sweat;
- high sensitivity to small variations in electrolyte concentration thanks to the presence of graphene integrated in the PVDF matrix;
- biocompatible and with low bacterial proliferation;
- chemically resistant;
- allows easy monitoring of electrolyte concentration with immediate signal response to changes in ion concentration (such as K +, Na +, Cl).

Applications

The idea behind the present invention is to realize an electrochemical type wearable sweat sensor, easy to use, economical, usable several times and washable, consisting of a thin polymeric membrane which, once in contact with sweat, is it acts as an electrochemical cell, producing a voltage signal whose intensity depends on the saline concentration of the sweat itself. In order to demonstrate its feasibility and functionality, various sensors have been developed at a prototype level. These have been subjected to various tests designed to simulate different operating conditions, considering saline solutions and synthetic sweat containing different amounts of NaCl. Furthermore, it has been shown that the 3 sector membrane can also be used for low energy applications. In particular, by way of example, two prototypes of three-sector polymeric membrane have been created, characterized and studied. The first 1 cm × 2.1 cm sample was tested as a sweat sensor; the second sample, 5 cm × 9 cm in size, was immersed in saline solution and tested as an electrolytic cell.

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