BIODEGRADABLE MATS FOR THE DESIGN OF BIFUNCTIONAL BIOSENSORS FOR GLUCOSE DETECTION IN URINE

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Introduction

- Diabetes mellitus reaches about 422 million in the word
- The commercial glucometer is a indispensable tool used to detect glucose levels in blood samples
- There is a crescent demand for less invasive glucose tests using biofluids e.g saliva, sweat and urine samples.
- Besides that strips made with substrates that are more of eco-friendly, biodegradable and sustainable materials are need now

Aim

- We proposed a bifunctional support of polylactic acid (PLA) and polyethylene glycol (PEG) prepared by the solution-blow spinning technique to design an electrochemical biosensor.

Methods

i Printing the flexible biosensors in PLA :PEG substrate

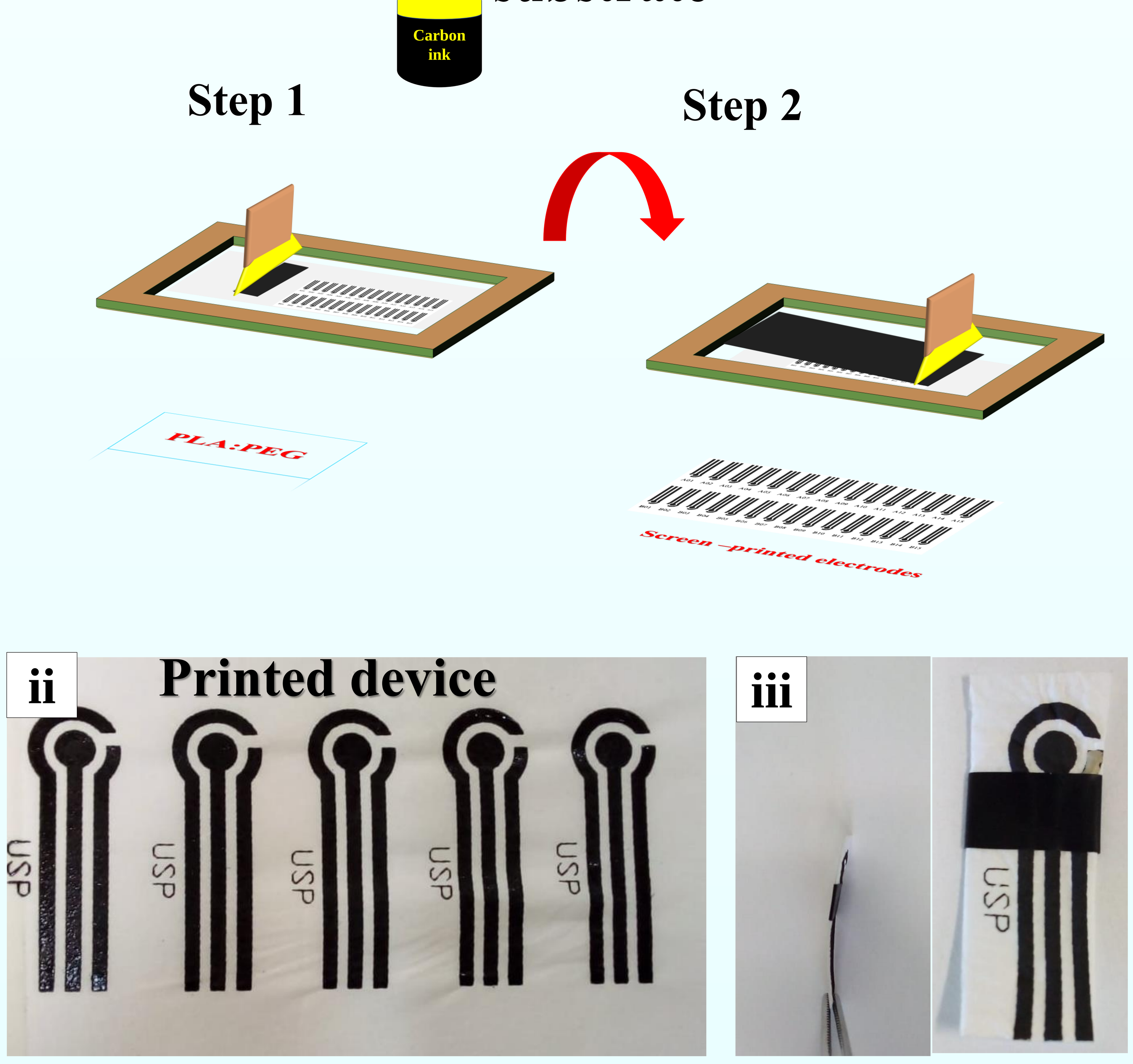

Fig 1. Scheme of the screen printing protocol in i. Photo of the PLA/PEG electrodes in ii and ii

Bifunctional surface based on PLA:PEG preparation

Fig 2. Fabrication principle of the bifunctional surface.

Results and Discussion

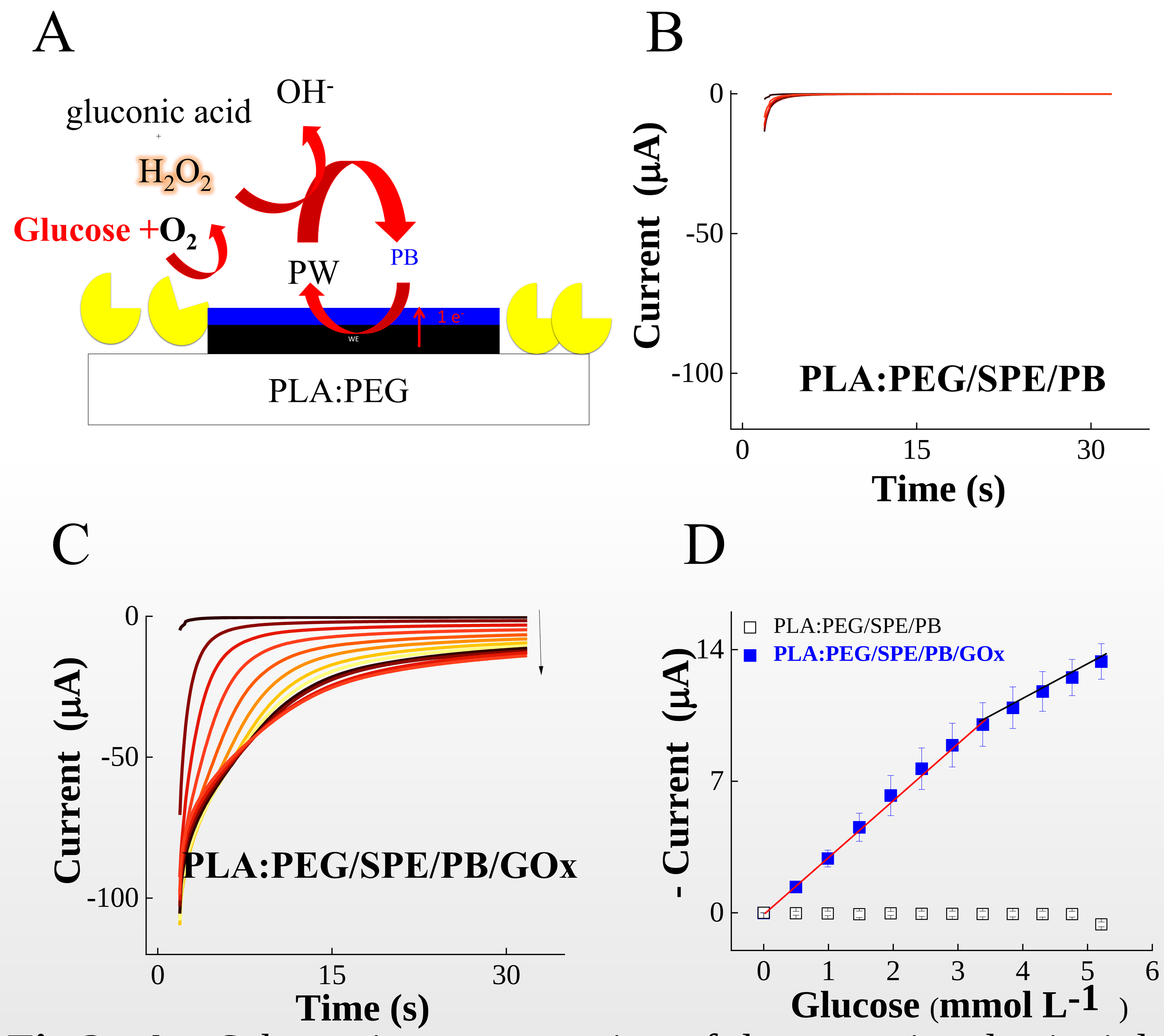

Fig 3 . A – Schematic representation of the operational principle of bifunctional surface based on PLA/PEG mat. Chronoamperograms obtained for increasing glucose concentration between 0.5 and 5.24 mM using PLA/PEG/SPE/PB (without GOx enzyme) in **B** and biosensor in **C**. **D** – The resulting calibration curve from the surfaces

The current response using biosensor was proportional to glucose concentration, resulting in two linear calibrations curves expressed as I (A) = $-5.93 \times 10^{-9} + 0.003\, C_{glucose}$ (M), $R^2 = 0.998$ and I (A) = $3.91 \times 10^{-6} + 0.0018\, C_{glucose}$ (M), $R^2 = 0.999$. The detection limit was estimated with Miller & Miller method yielding a value of 0.197 mM.

Conclusions

- We offered a bifunctional surface based on PLA/PEG mats used as support for printing flexible sensors and as matrix for glucose oxidase immobilization.
- The design allowed the modification of WE with PB nanoparticles to be free from biofouling effects and improve the efficiency of the biodevice for detecting hydrogen peroxide at low potential (0 V vs Ag/AgCl).

Acknowledgments:

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O. Gomes, N.; T. Paschoalin, R.; Bilatto, S.; R. Sorigotti, A.; S. Farinas, C.; Henrique C. Mattoso, L.; A. S. Machado, S.; N. Oliveira Jr., O.; A. Raymundo-Pereira, P. Flexible, Bifunctional Sensing Platform Made with Biodegradable Mats for Detecting Glucose in Urine. *ACS Sustain. Chem. & Eng.* **2023**, *11*, 2209–2218, doi:10.1021/acssuschemeng.2c05438.

Miller, J.N. Basic Statistical Methods for Analytical Chemistry. Part 2. Calibration and Regression Methods. A Review. *Analyst* **1991**

Biodegradable Mats for the design of bifunctional biosensors for Glucose detection in urine

Authors: Nathalia O. Gomes, Rafaella T. Paschoalin, Stanley Bilatto, Amanda R. Sorigotti, Cristiane S. Farinas, Luiz H. C. Mattoso, Sergio A. S. Machado, Osvaldo N. Oliveira Jr. , Paulo A. Raymundo-Pereira

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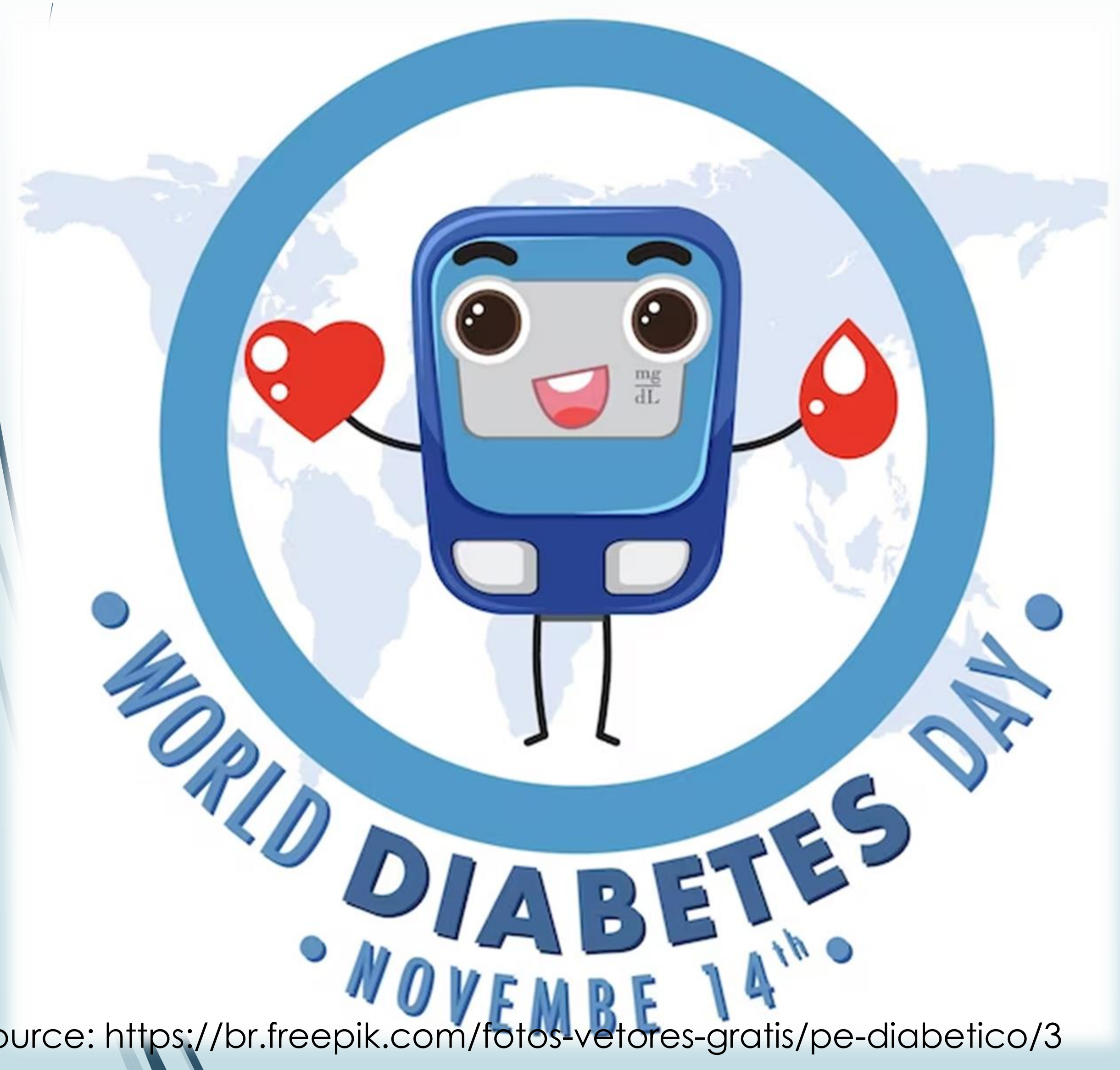
MOTIVATION



Source: https://br.freepik.com/fotos-vetores-gratis/pe-diabetico/3

Diabetes mellitus is a severe disease reaching about 422 million people in the world and is still a cause of death

MOTIVATION

The commercial glucometer are used to measure the glucose levels using blood samples

Analysis

- Invasive analysis;
- Painful;
- Risk of contamination;
- Uncomfortable;

Source:https://controllab.com/programa/saliva/https://pt.dreamstime.com/foto-de-stock-pele-e-suor-humanos-image77230784

MOTIVATION

Demand

Less invasive tests

Noninvasive biofluids

Sweat

Saliva

Urine

Source:https://controllab.com/programa/saliva/https://pt.dreamstime.com/foto-de-stock-pele-e-suor-humanos-image77230784

MOTIVATION

Electrochemical sensors

Substrates

- polyimide,
- polyethylene terephthalate (PET),
- polyvinyl chloride (PVC),
- polyurethane (PU),
- polydimethylsiloxane (PDMS)

While the commercial strips of glucose are made of plastic

Source:https://owell.com/products/glucomate-ht100-blood-glucose-test-strips

MOTIVATION

The materials used as support for design of eletrochemical biosensors

They are not easily degradable and can become a serious environment issue

Source: https://www.exchangewire.com/blog/2022/01/21/predictions-2022-the-environmental-impact-of-digital-advertising/

MOTIVATION

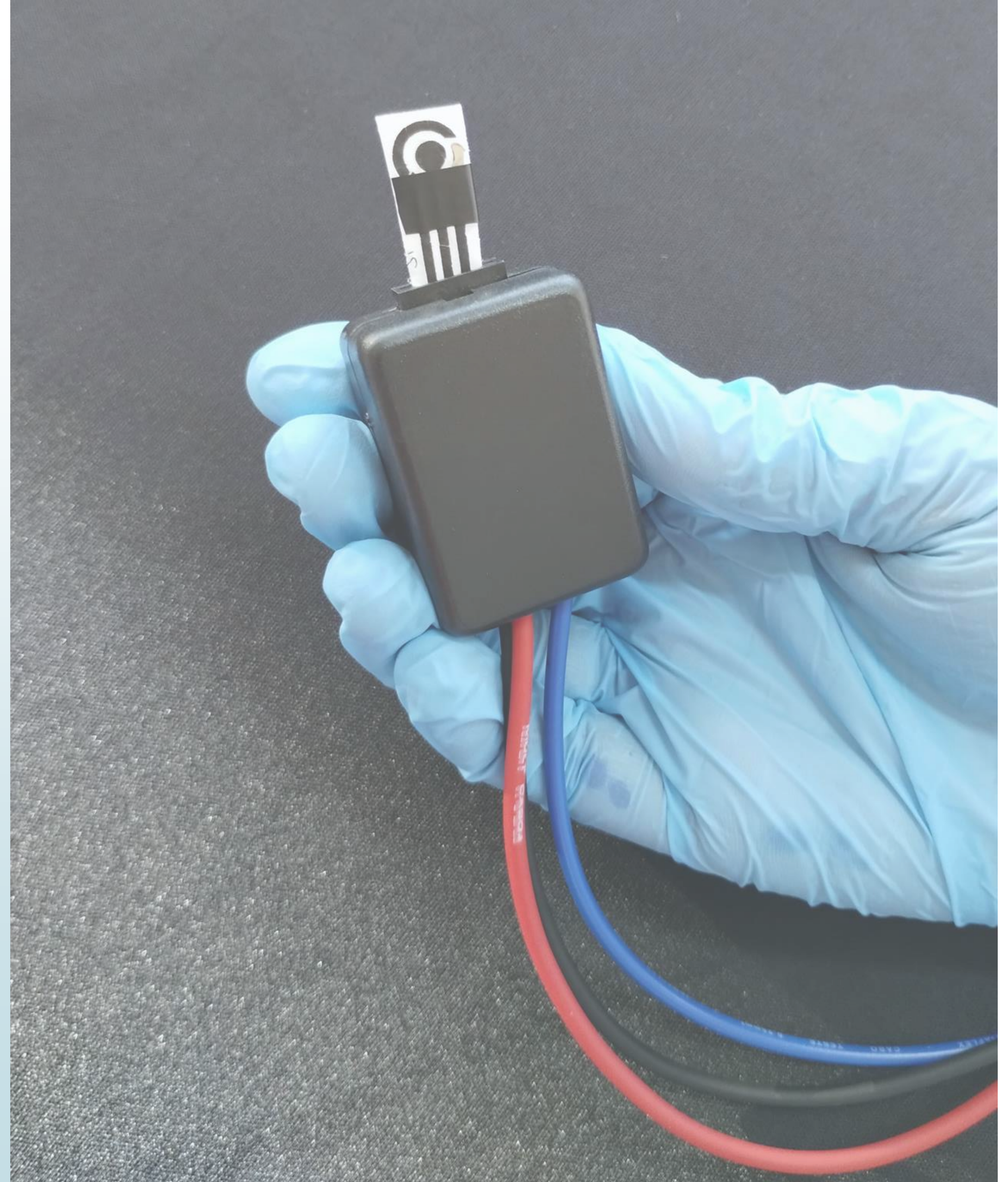
There is an urgent demand for alternative materials

eco-friendly, biodegradable, sustainable

Source: https://definicion.de/sustentable/

GOAL

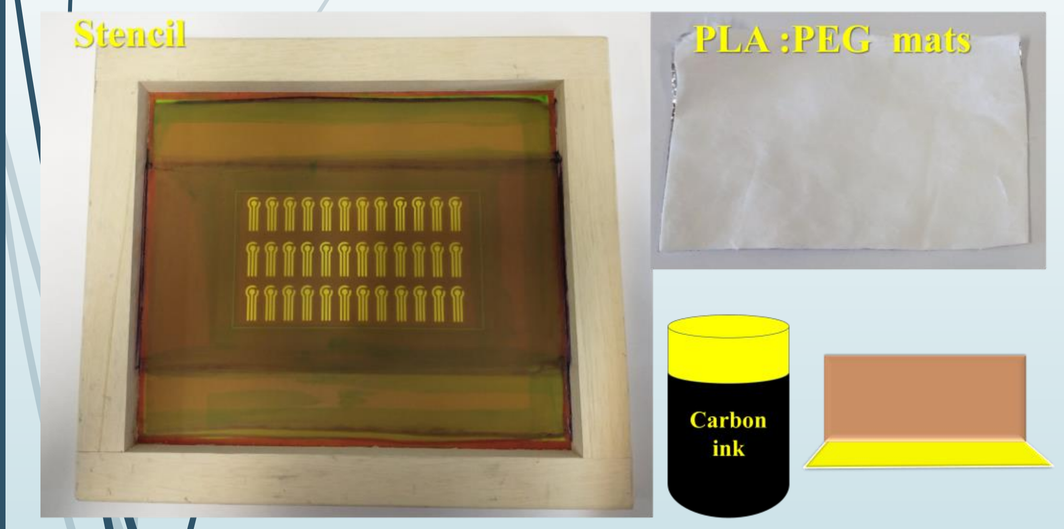
- We proposed a bifunctional support of polylactic acid (PLA) and polyethylene glycol (PEG) prepared with the solution-blow spinning technique to design an electrochemical biosensor
- The PLA/PEG nanofibers are degradable, free of waste, low-cost, and considered a sustainable material, making them promising for electrochemical biosensors projection



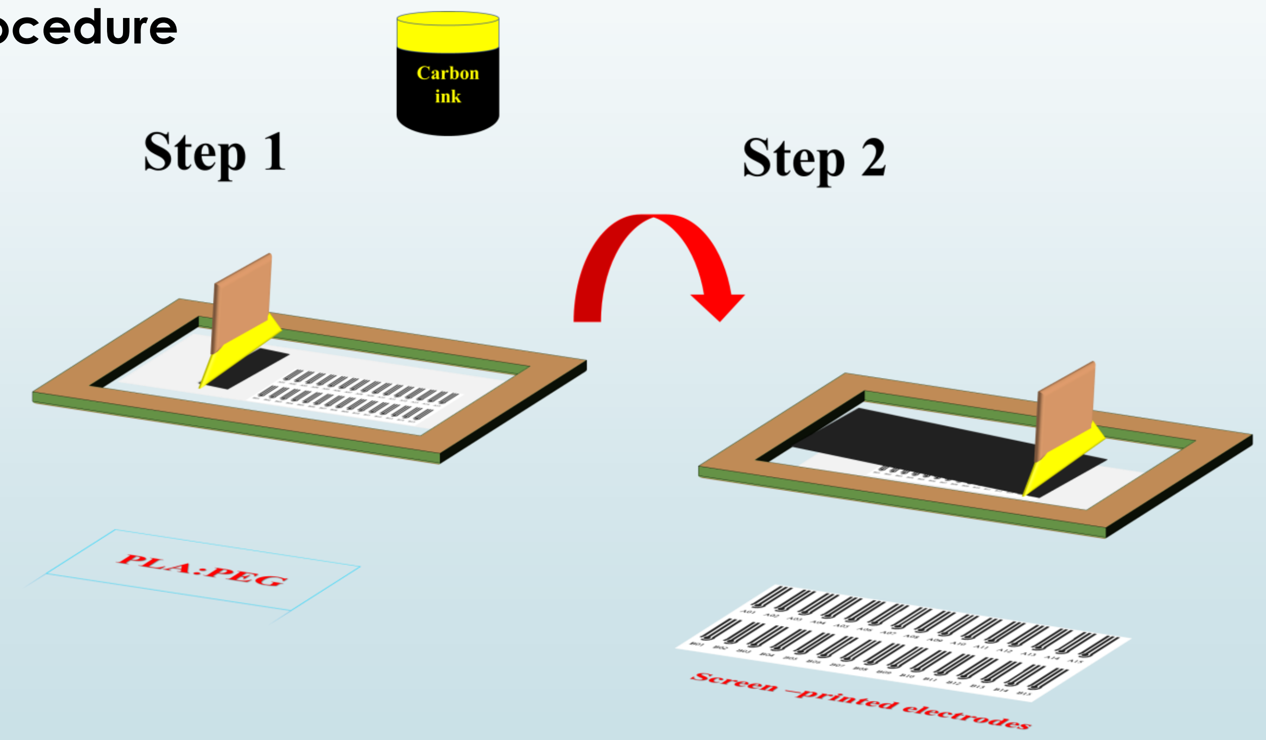
METHODS

Electrode fabrication

Materials



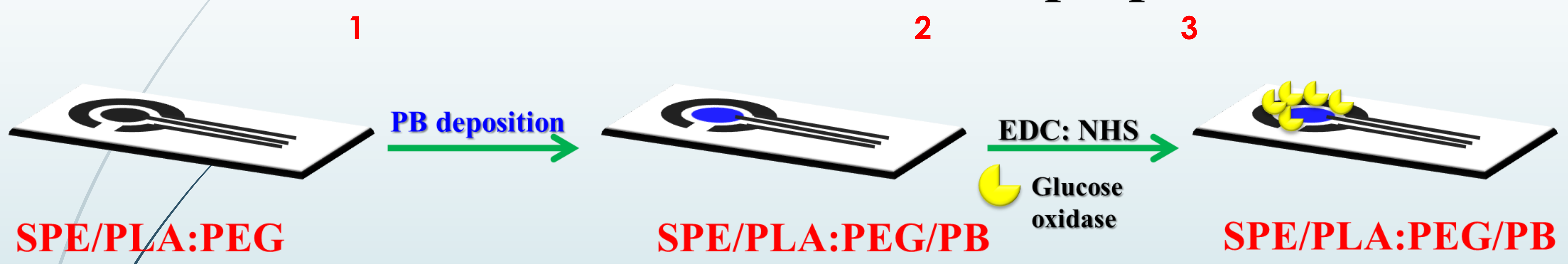
Procedure



METHODS

Glucose biosensor fabrication

Bifunctional surface based on PLA:PEG preparation



Note

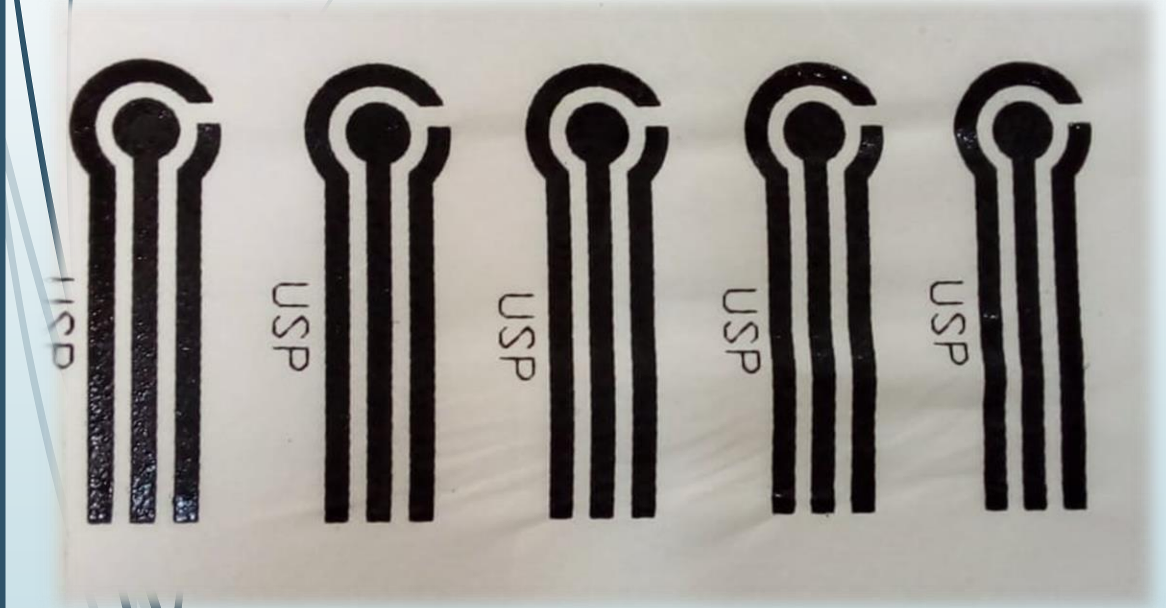
1:Electrochemical deposition of Prussian blue nanoparticles

2: The acid carboxylic group with EDC:NHS

3: Glucose oxidase immobilization onto PLA:PEG surface

RESULTS

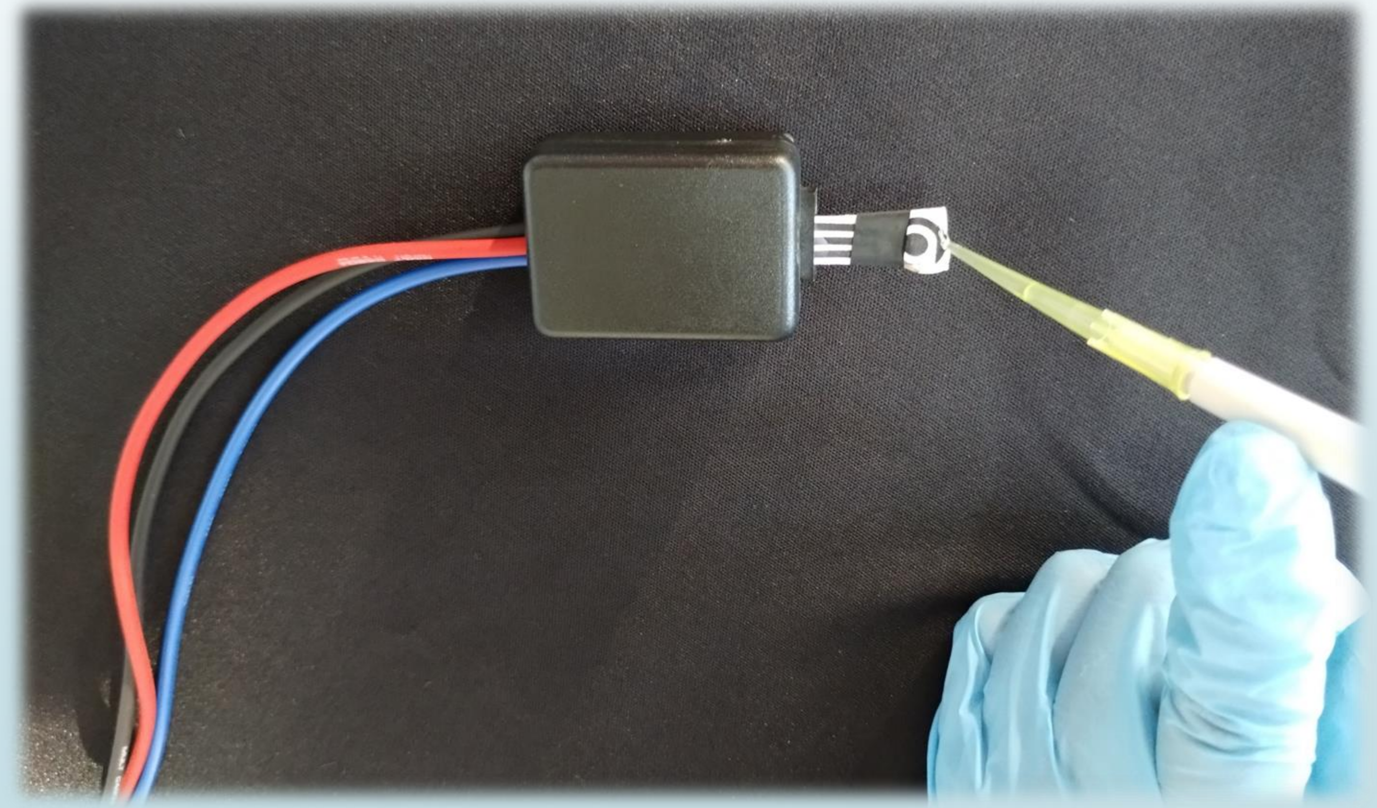
Photos of the PLA/PEG electrodes



Source: https://pubs.acs.org/doi/abs/10.1021/acssuschemeng.2c05438

RESULTS

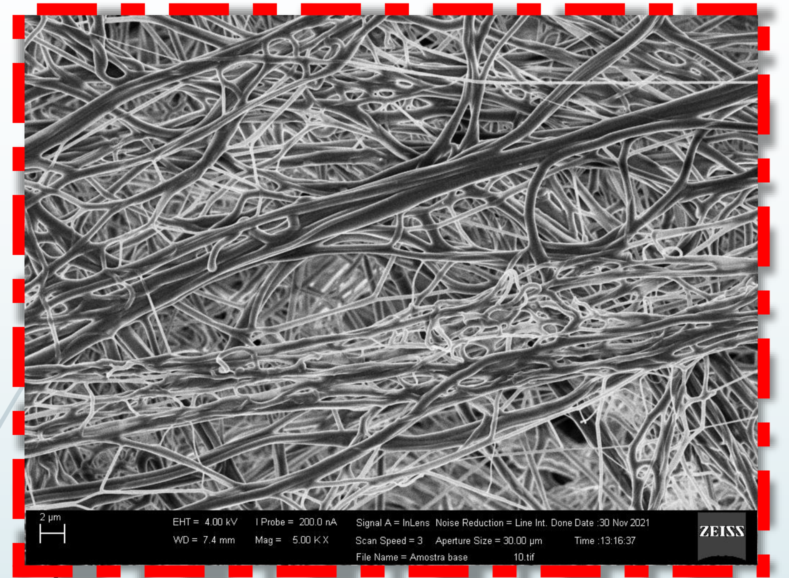
Photos of the PLA/PEG electrodes



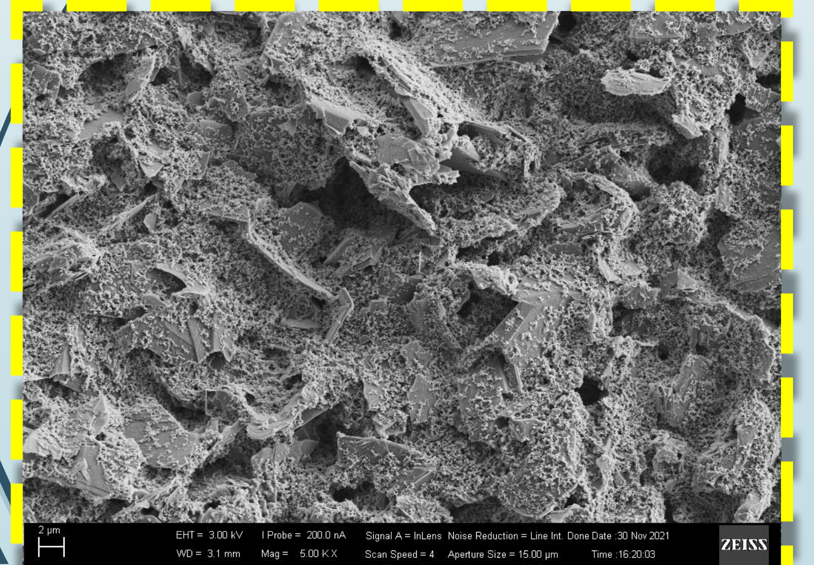
RESULTS

SEM images

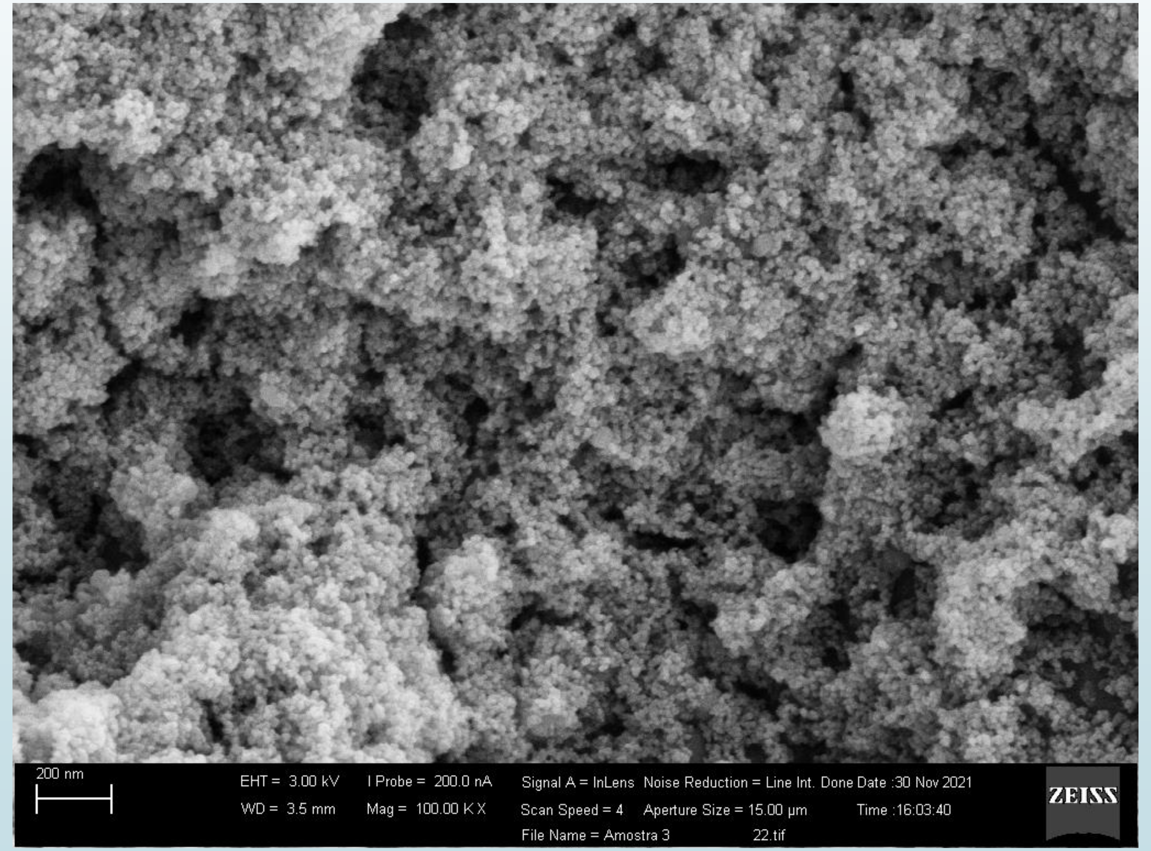
PLA:PEG



Working electrode (WE)

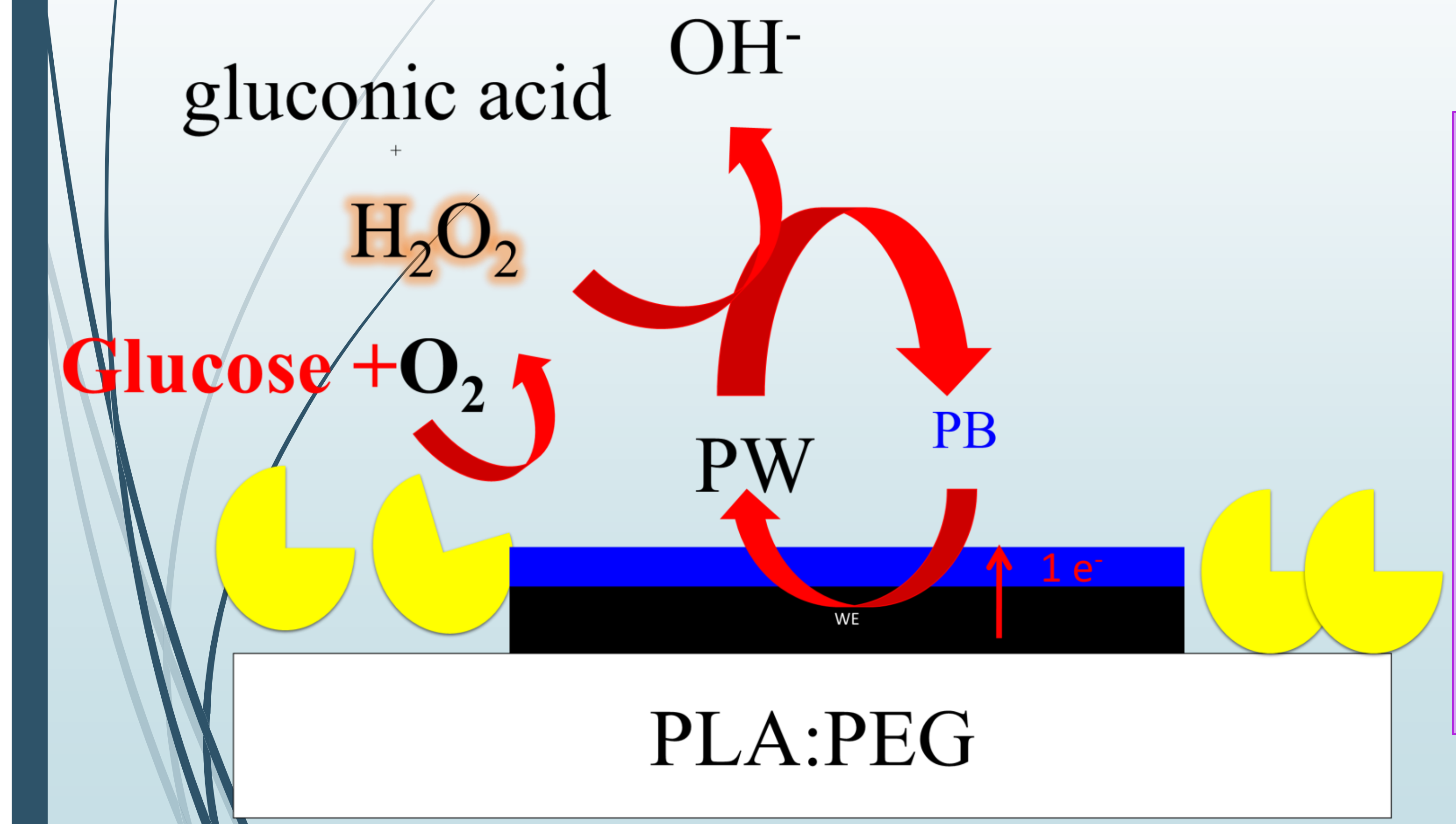


WE modified with prussian blue



RESULTS

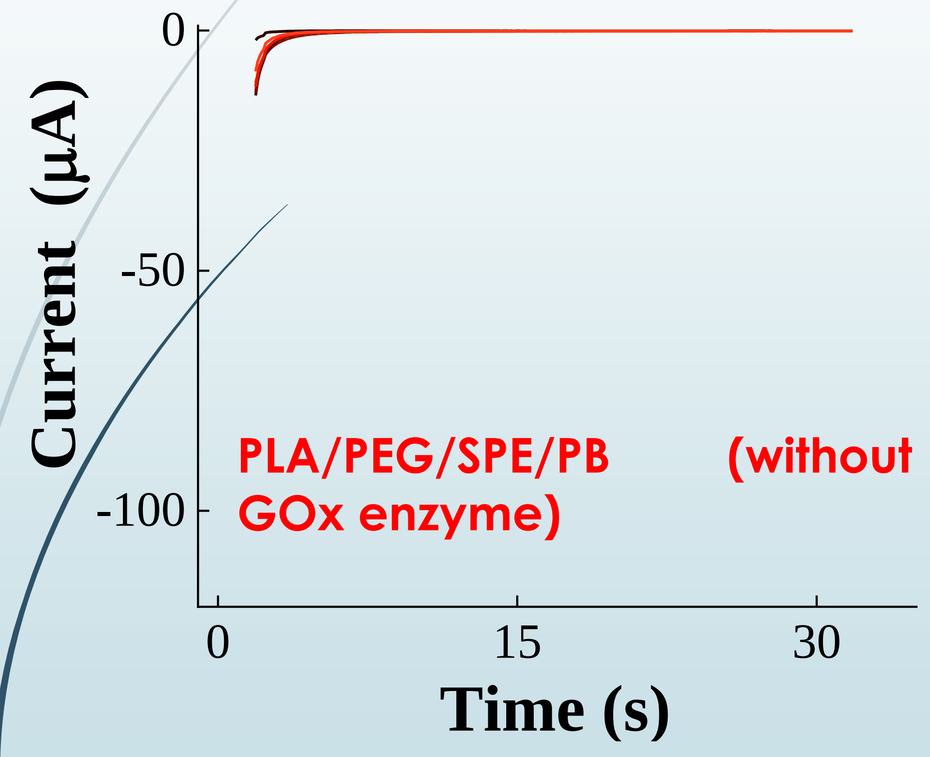
Operational principle of bifunctional surface based on PLA/PEG mat

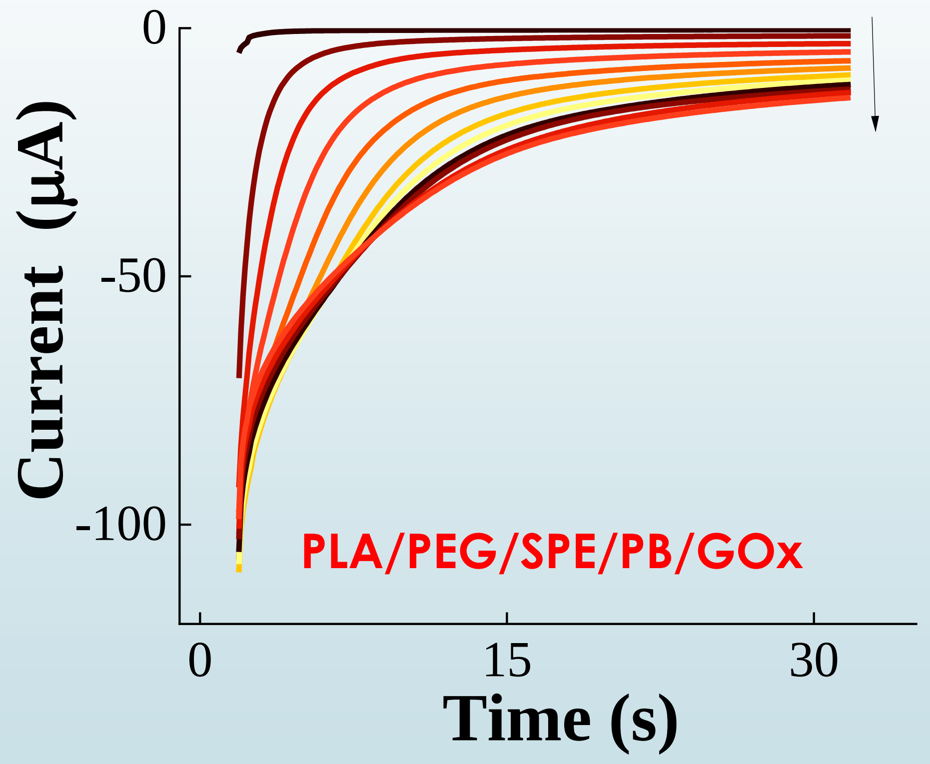


- Glucose oxidase enzyme catalytically converts glucose in presence of molecular oxygen into gluconic acid and hydrogen peroxide.
- PB electrodeposited on WE are reduced at 0.0 V to PW form
- The hydrogen peroxide produced by the enzymatic reaction is reduced by PW form

RESULTS

The chronoamperometric response obtained at 0 V for increasing concentrations of glucose in artificial urine



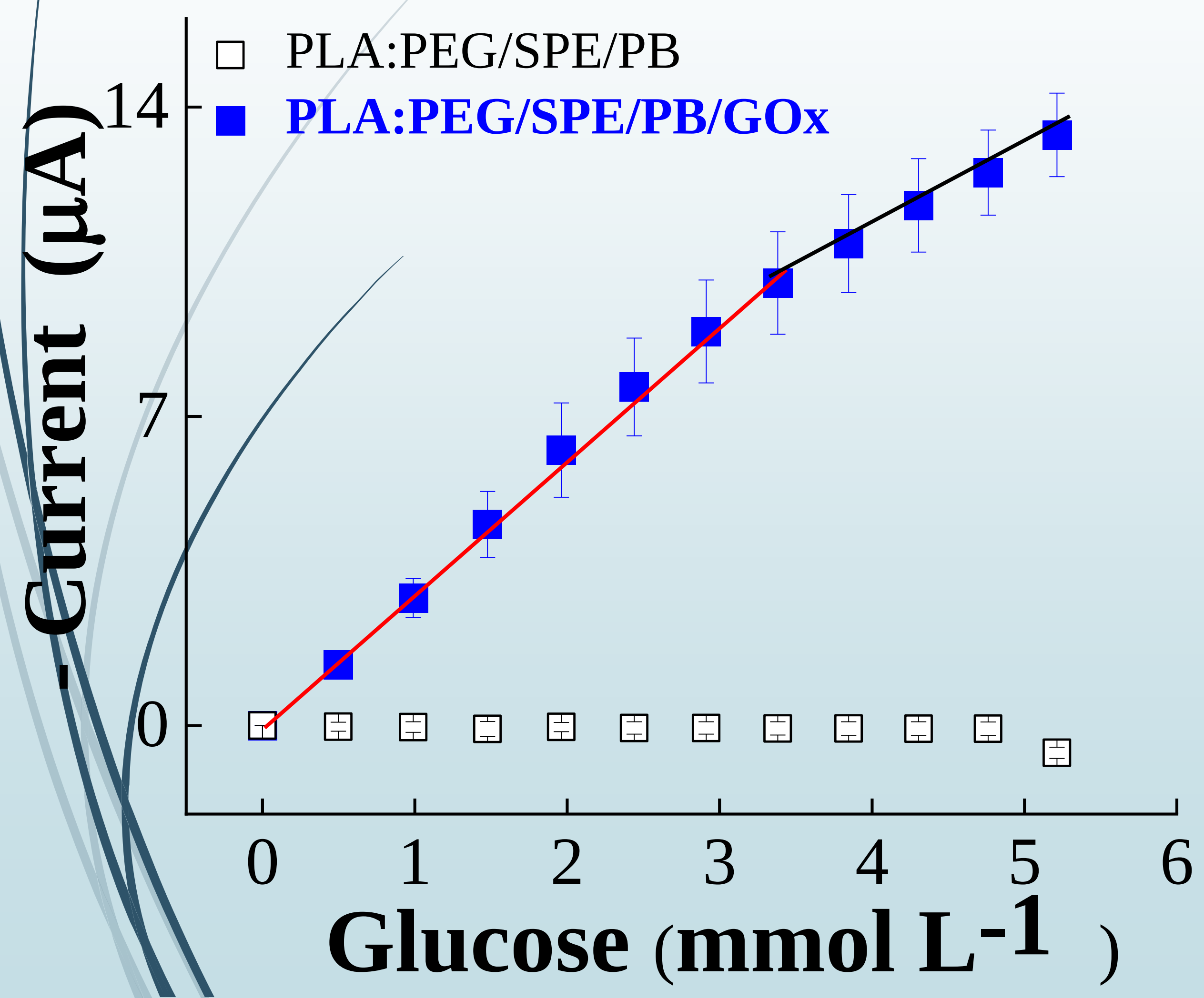


Conditions: All experiments were made in artificial urine (pH = 6.0, 0.1 M of KCl) with E_{appl} = 0 V (v.s Ag/AgCl) for 30 seconds.

Concentration range from 0.5 to 5.24 mM of glucose solution

RESULTS

Calibration curve



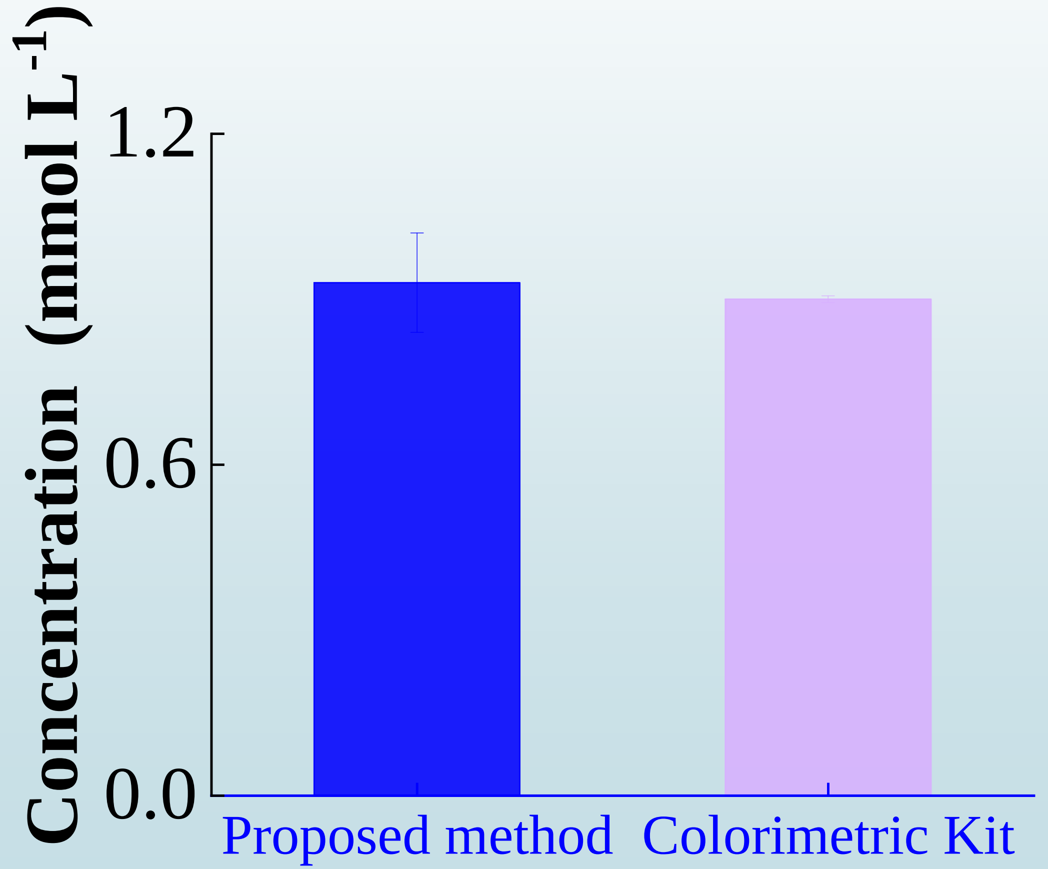
I (A) = -5.93 × 10^{-9} + 0.003 $C_{glucose}$ (M), R^2 = 0.998
and
I (A) = 3.91 × 10^{-6} + 0.0018 $C_{glucose}$ (M), R^2 = 0.999.

The detection limit was 0.197 mM

RESULTS

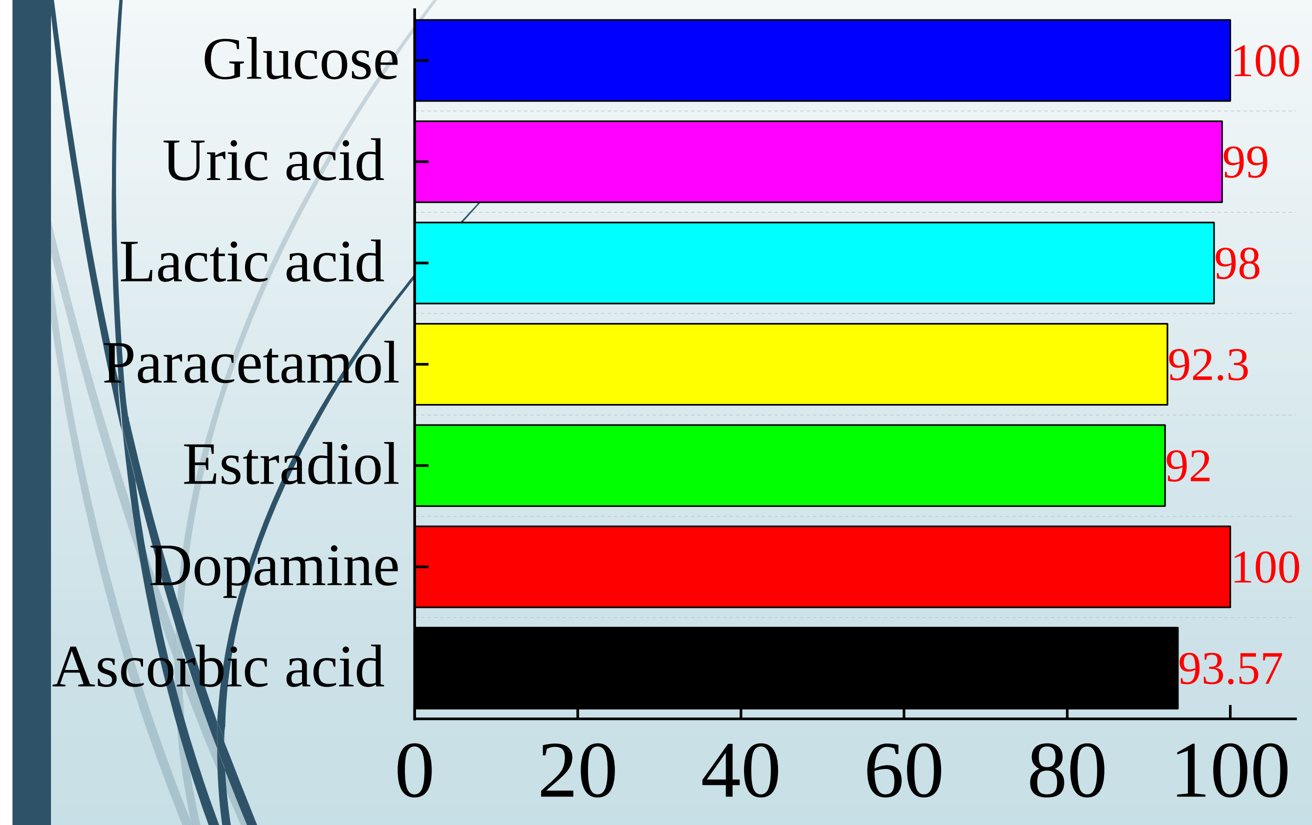
Glucose determination in urine samples and comparison with colorimetric kit

Both methods estimated concentrations of glucose close to 0.29 mM indicating good precision that there are no significant differences between the results from the biosensor and from the gold standard method



RESULTS

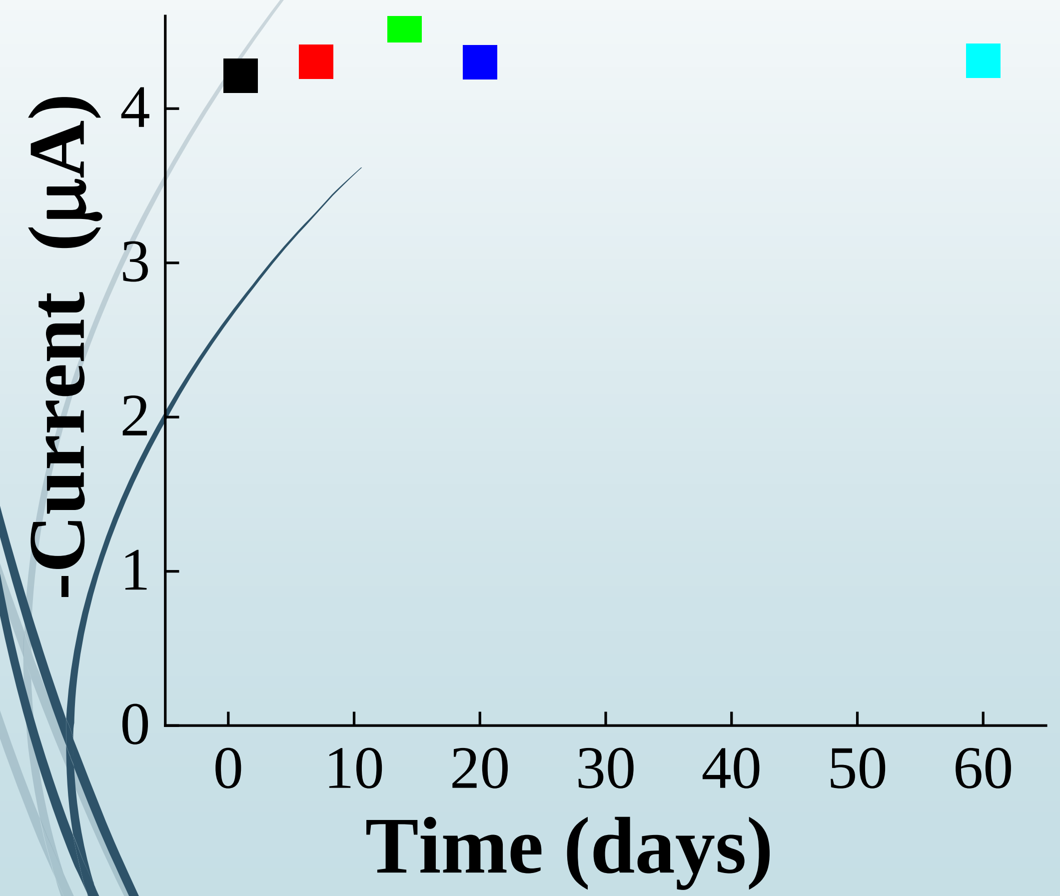
Selectivity test



The compounds exhibited a slight change in the current signal (< 8%)

RESULTS

Storage stability of the biosensor



The biosensor was stable over 60 days with relative standard deviation of 12% (n = 8) for the current values

CONCLUSION

- We offered a bifunctional surface based on PLA/PEG mats used as support for printing flexible sensors and as matrix for glucose oxidase immobilization
- The design allowed the modification of WE with PB nanoparticles to be free from biofouling effects and improve the efficiency of the biodevice for detecting hydrogen peroxide at low potential (0 V vs Ag/AgCl)
- PLA/PEG mats are promising support for designing eco-friendly, sustainable and biodegradable electronic devices being a green option to reduce the use of petroleum-based plastic materials

Thank you

Contact us for more information

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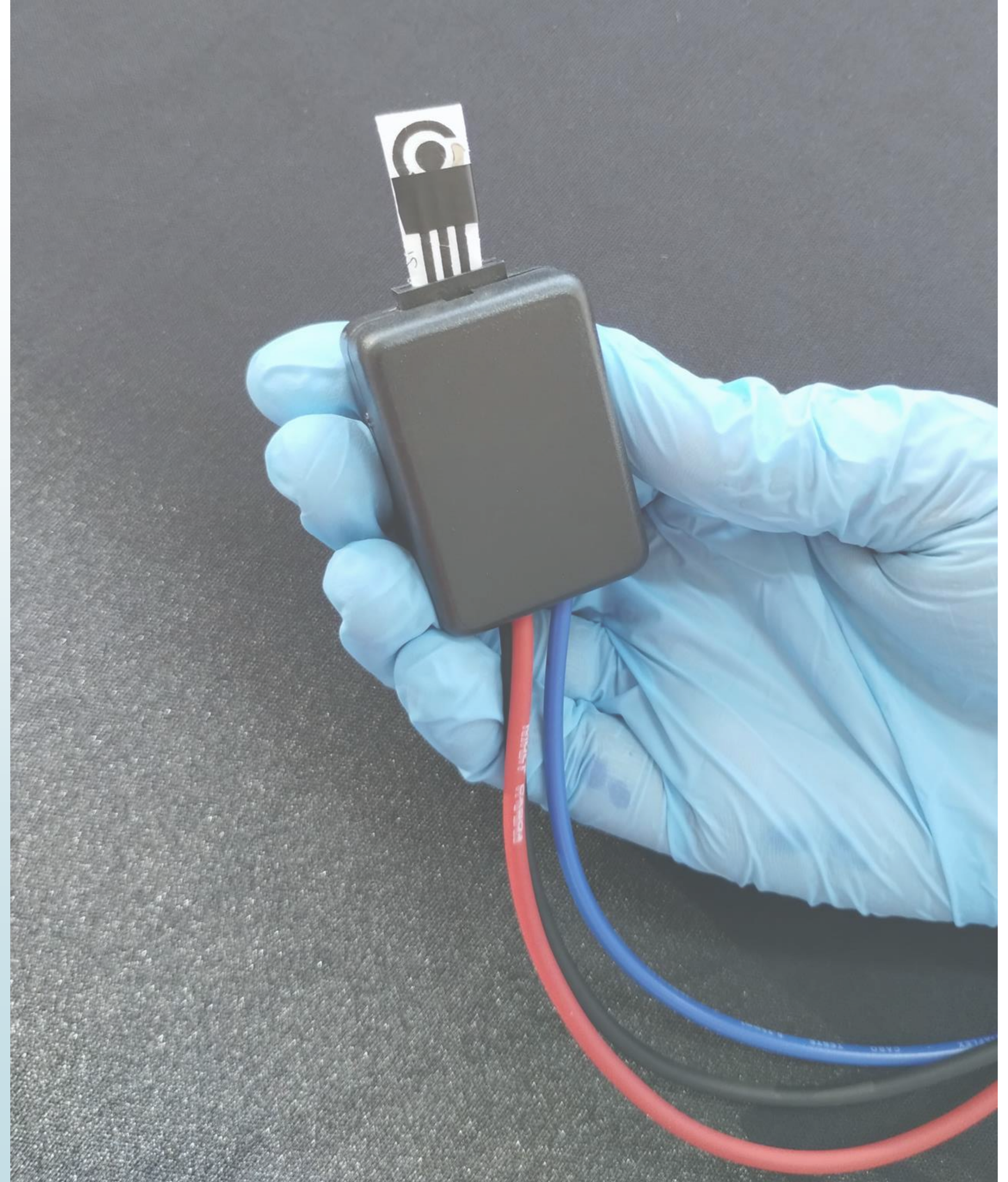

ACKNOWLEDGMENTS

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