INNOVATIVE FULLERENOL - HYDROGELS BASED NANOMATERIALS FOR HEALTH DIAGNOSTIC AND CARE APPLICATIONS

Acronym: FULSENS-GEL

Web site: https://www.fulsens-gel.ro/en/

Coordinator: National Institute for R&D in Chemistry & Petrochemistry – ICECHIM, Bucharest, Romania

ICECHIM

Project director: Dr. ANA-MARIA GURBAN

Duration: June 2022 – December 2024 (30 months)

Total Requested Budget: 452.400 EURO

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NATIONAL INSTITUTE FOR RESEARCH AND DEVELOPMENT IN CHEMISTRY & PETROCHEMISTRY

- Is one of the major research entities in Romania, being involved in all fields of chemistry.
- Established in 1950 by the Decision of the Council of Ministers no. **604/1950** being oriented mainly on applied research for new products and technologies.

Applied research for the development of new products and technologies in:

- ✓ Capitalization of bioresources;
- ✓ Nanoscience and nanomaterials;
- ✓ Environmental protection and sustainable management of resources;
- ✓ Increasing the competitiveness of industrial products;
- ✓ Refurbishment and revitalization of the Romanian chemical and petrochemical industry;
- ✓ Recovery, recycling and recovery of by-products.

DIRECTIONS

- ❖ ***BIOTECHNOLOGIES, BIORESOURCES AND BIOPRODUCTS FOR BIOECONOMY***
- ❖ ***SMART POLYMERIC MATERIALS AND NANOMATERIALS***
- ❖ ***NEW AND EMERGING TECHNOLOGIES***

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CONSORTIUM

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The **FULSENS-GEL** project consisted in the development of an ***innovative nanomaterial,*** based on combination of the elastic, flexible and resistant ***crosslinked hydrated polymer network*** with functional polyhydroxylated derivatives of fullerene, ***Fullerenols (FL), resulting a new conductive hydrogel with tunable network structures, active surface and improved electrochemical, mechanical and optical properties for sensing applications.***

FULSENS-GEL project **addresses** the needs for ***safety in healthcare, food industry, nutrition, agriculture and the environment,*** through developing miniaturized bioanalytical tools based on innovative functional nanomaterials for the rapid and accurate determination of (bio)markers, toxins, drugs residues, pollutants, etc.

PROJECT OBJECTIVES

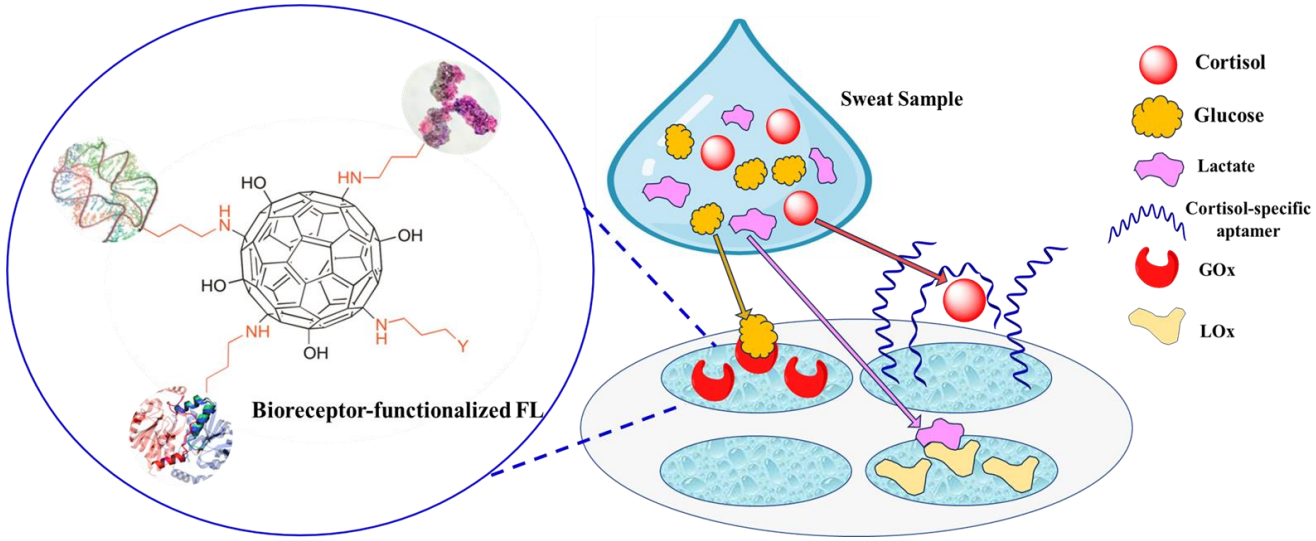
- To develop new Fullerenol - Hydrogel nanomaterials with better functionality, mechanical, electrochemical and optical performances;
- To design and optimize (bio)sensitive FL-Hydrogels with higher stability, selectivity and sensitivity;
- To design and develop a highly sensitive, selective and flexible wearable multiplex patch, based on the novel material, for rapid and efficient screening of biological and physiological parameters (e.g. glucose, lactate, cortisol, chloride ions and pH);
- To evaluate and demonstrate the multiplex sensor patch performances for biophysiochemical analytes determination.

FROM WHERE FULSENS-GEL STARTED

STARTED WITH A SIMPLE IDEA

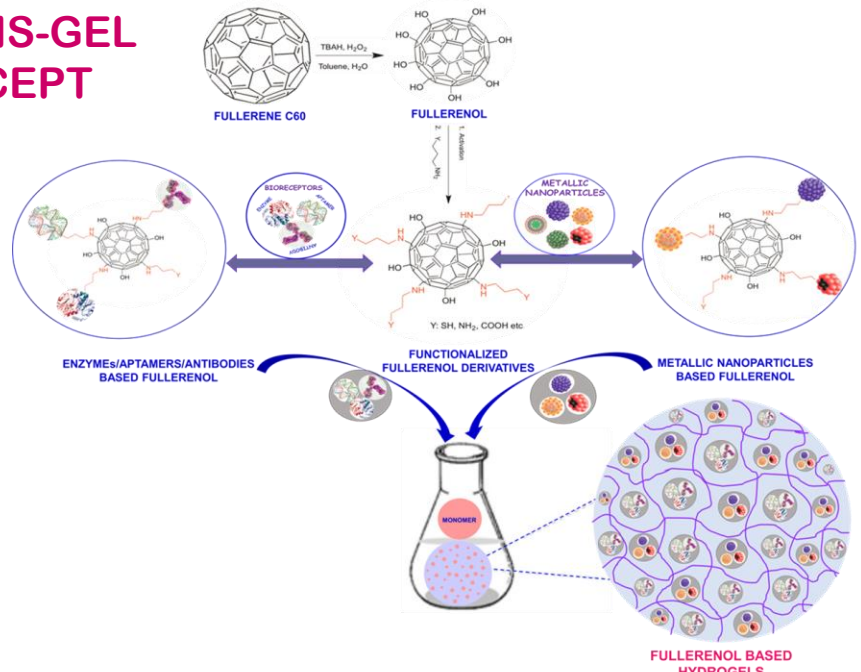
- How can be quickly and accurately detect certain essential markers, without the need for bulky equipment and complicated laboratories?

NANOTECHNOLOGY

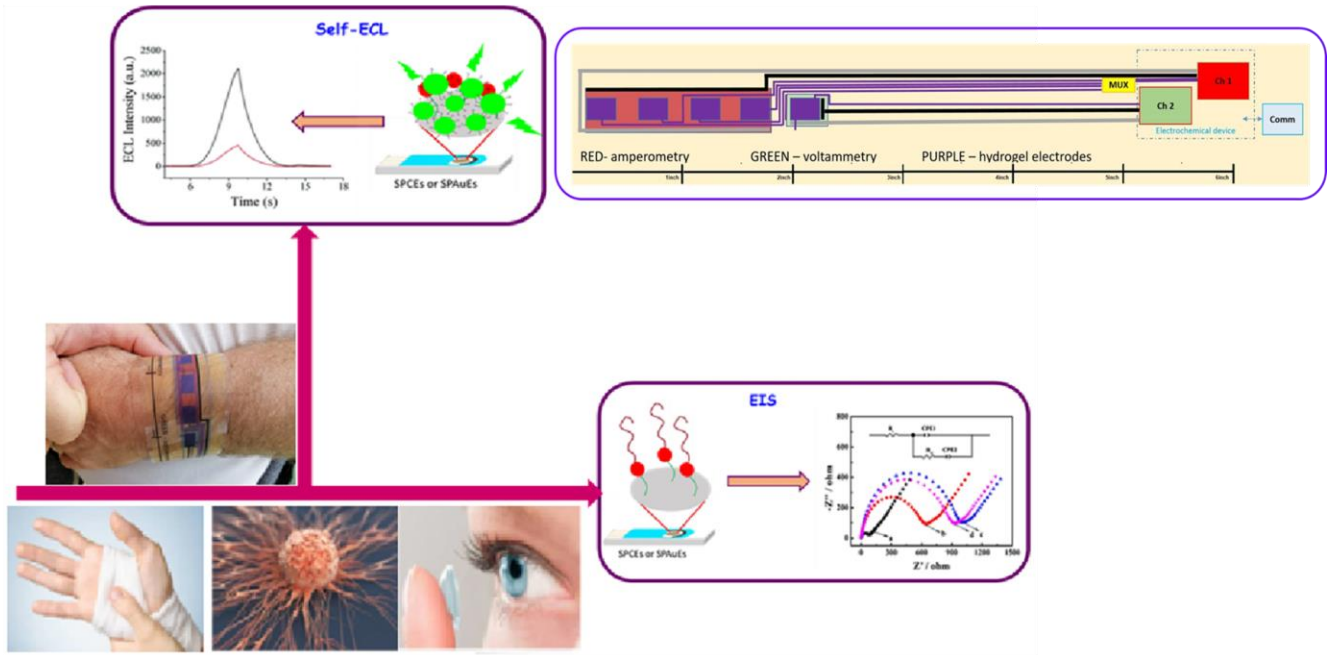


FULSENS-GEL CONCEPT

FROM LABORATORY



TO REAL LIFE APPLICATIONS IN FIELD/ ON SITE



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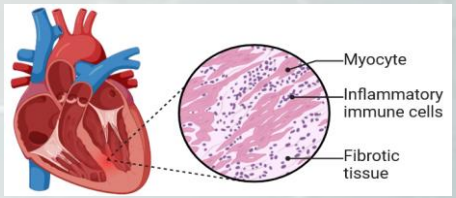
CLINICAL BIOMARKERS FROM SWEAT

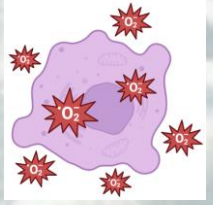
RELATED HUMAN CONDITION MONITORING

Relative Content in Sweat

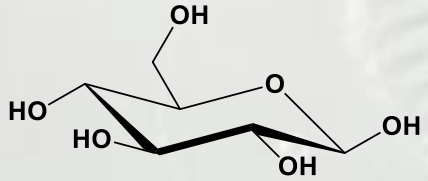
H_2O_2
HYDROGEN PEROXIDE

Inflammation of tissue





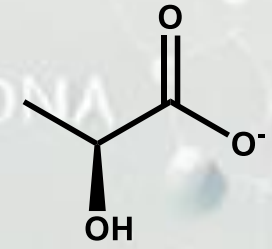
<100 µM



GLUCOSE

Diabetes

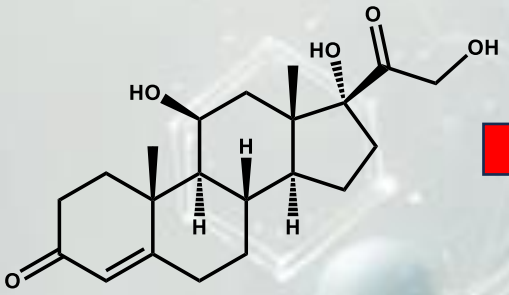
10-200 µM



L-LACTATE

Cystic Fibrosis,
Stress Ischemia,
Lactic Acidosis

5-20 mM



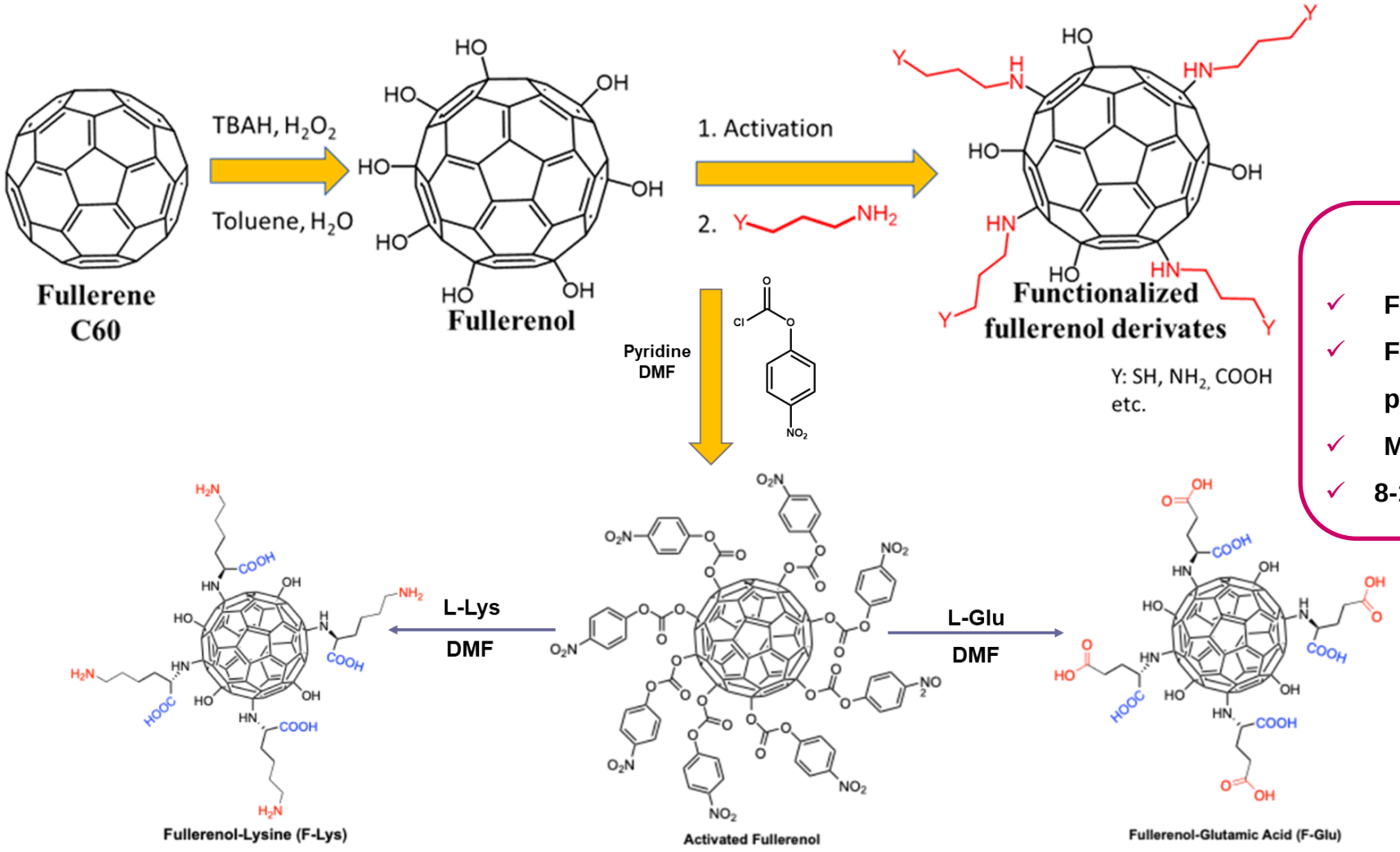
CORTISOL

Muscle weakness, Fatigue,
Osteoporosis, Hyperglycemia,
Obesity, Bilateral Adrenal Hyperplasia

8-140 ng/mL

SYNTHESIS OF NANOMATERIAL- FULLERENOL

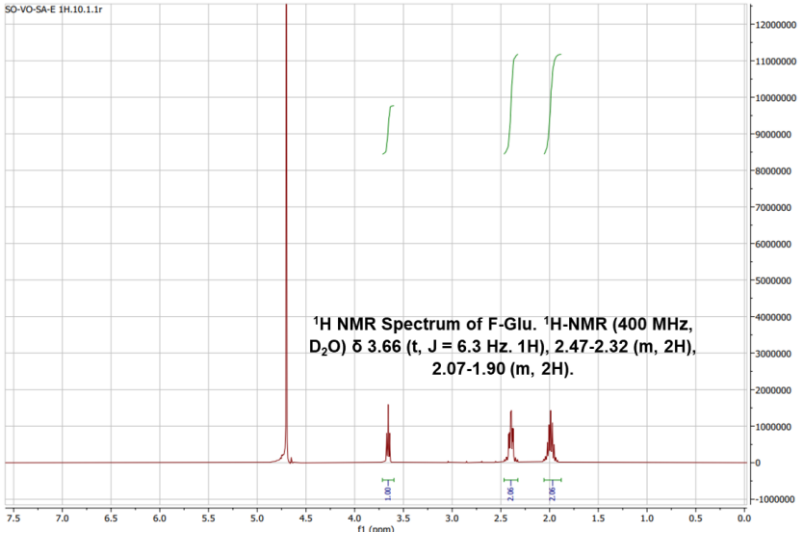
Hydroxylation of fullerenes in a mixture of NaOH, H_2O_2 and tetrabutyl ammonium hydroxide in toluene ► ACTIVATED FULLERENOL



FORMATION OF ACTIVATED FL

- ✓ FL formation increases solubility in polar solvents
- ✓ FL activation confirmed by the presence of broad peak around 3500 cm^{-1} corresponding to the –OH
- ✓ Modular and easy synthesis in three steps.
- ✓ 8-12 AA/fullerenol

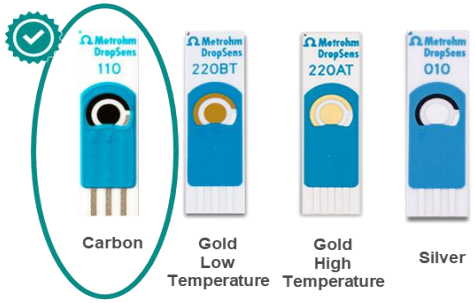
STRUCTURAL CHARACTERISATION OF FULLERENOL (FL)



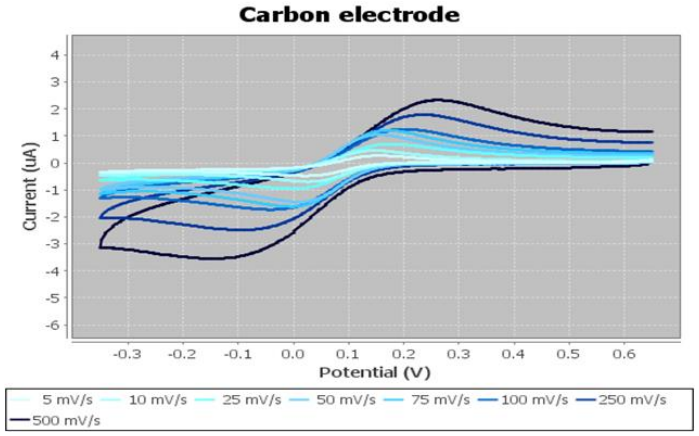
- Synthesis of fullerenol starting from commercial fullerene C-60;
- Characterization of FL using ^{1}H, ^{13}C NMR and FTIR spectroscopy;
- Activation of FL confirmed by the presence of aromatic doublets at 6.9 and 8.1 ppm in ^{1}H NMR spectroscopy;
- Degree of functionalization determined by elemental analysis;
- Synthesis of Lysine and Glutamic acid functionalized - FL derivatives (FL-Lys and FL-Glu);
- Overall yield synthesis of FL-Glu was 52% and for FL-Lys about 45%, respectively;
- The degree of substitutions was 8 for FL-Glu and 9 for FL-Lys (calculated based on the integration value of internal standard -DMF in ^{1}H NMR spectra).

SELECTION OF THE ELECTRODE MATERIAL

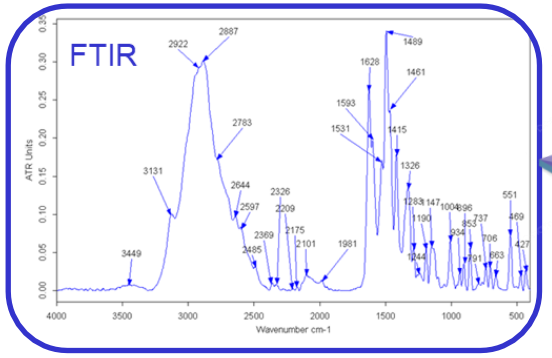
Surface material selection

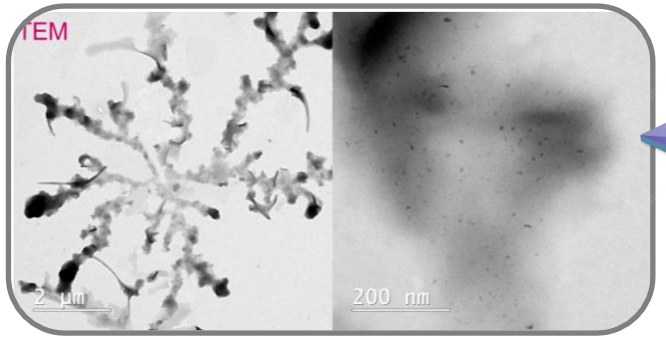


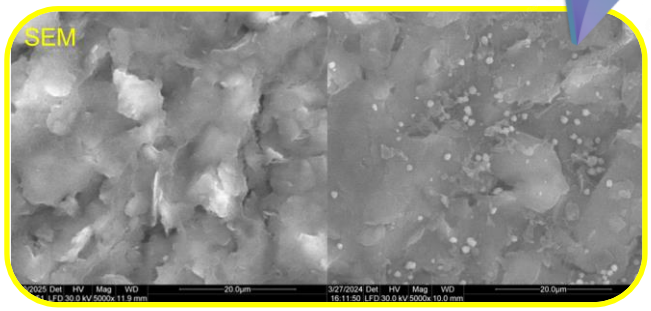
Electrode	Electroactive area
Carbon	0.9868cm^2
Gold High temperature	0.0067 cm^2
Gold Low temperature	0.0300 cm^2
Silver	----



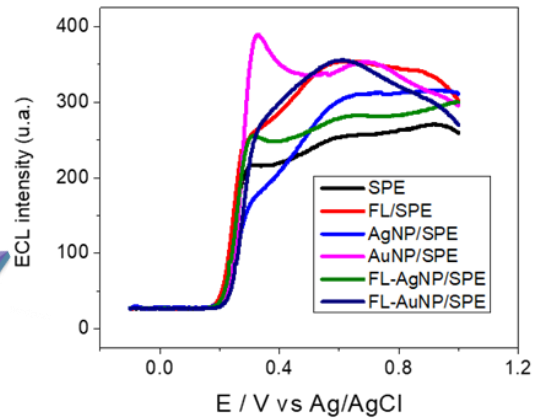
OPTO-ELECTROCHEMICAL CHARACTERISATION OF FULLERENOL BASED SPEs



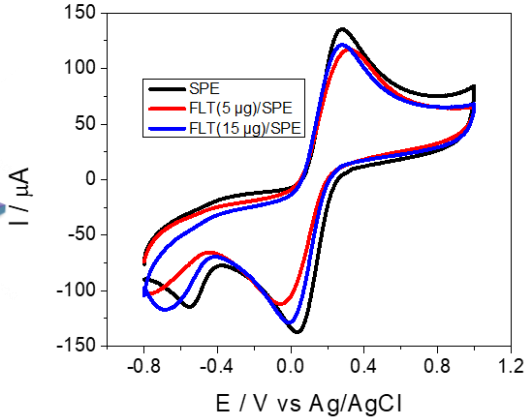




ECL characterization of FL



Cyclic Voltammetry

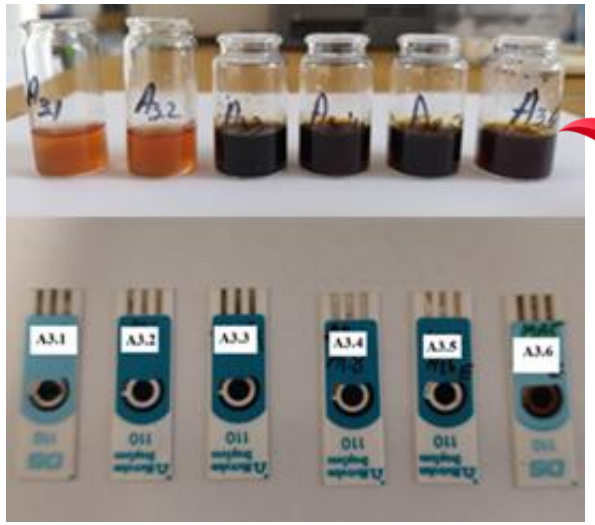


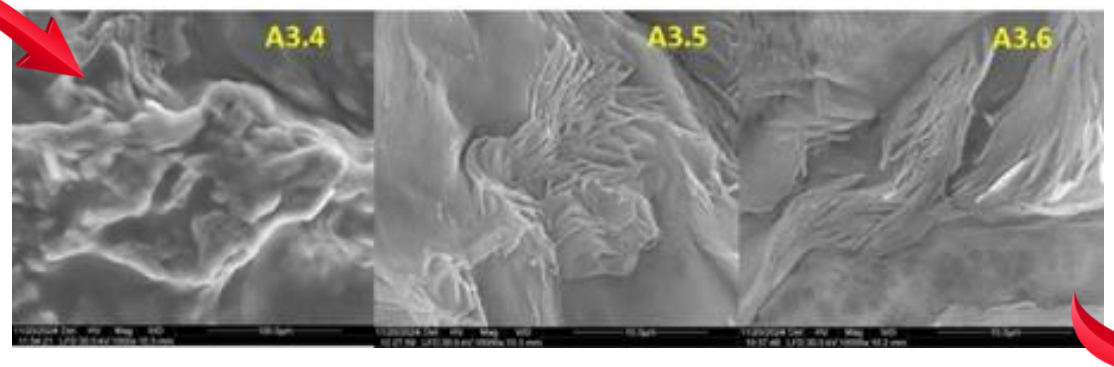
FULLERENOL – POLYHYDROXYLATED FULLERENE

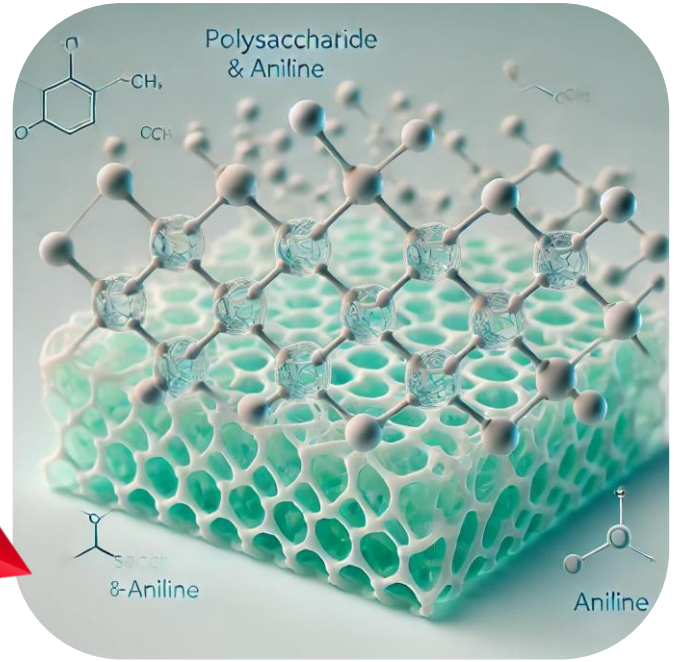
- High solubility in water and polar solvents;
- Facilitates the electron transfer between the analyte and the sensor surface
- Large active surface area of FL increases the sensitivity for analyte detection
- Electron acceptor ► suitable for sensing applications.

SYNTHESIS AND CHARACTERIZATION OF HYDROGEL BASED BIOPOLYMER

In-situ **polymerization of aniline in the microporous biopolymer support ► *BIOPOLYMER-POLYANILINE COMPOSITE FILMS***



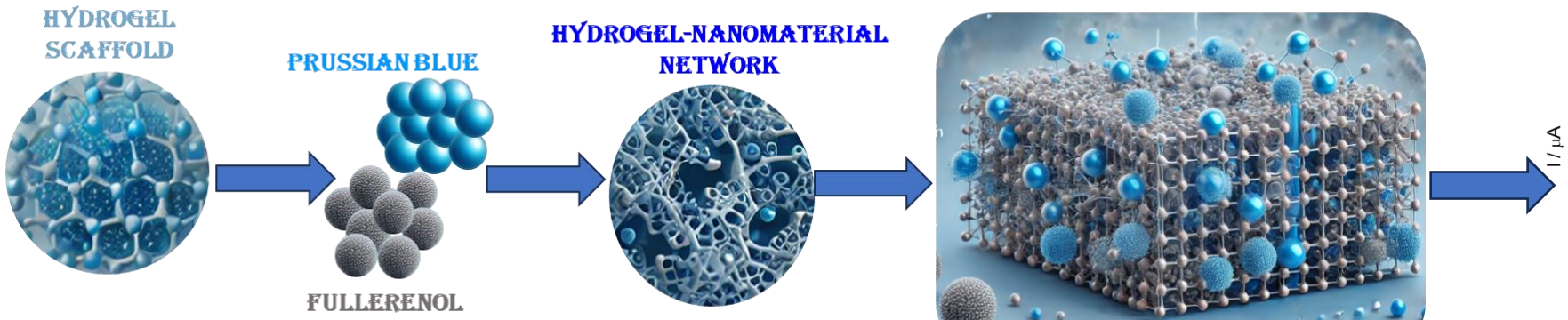




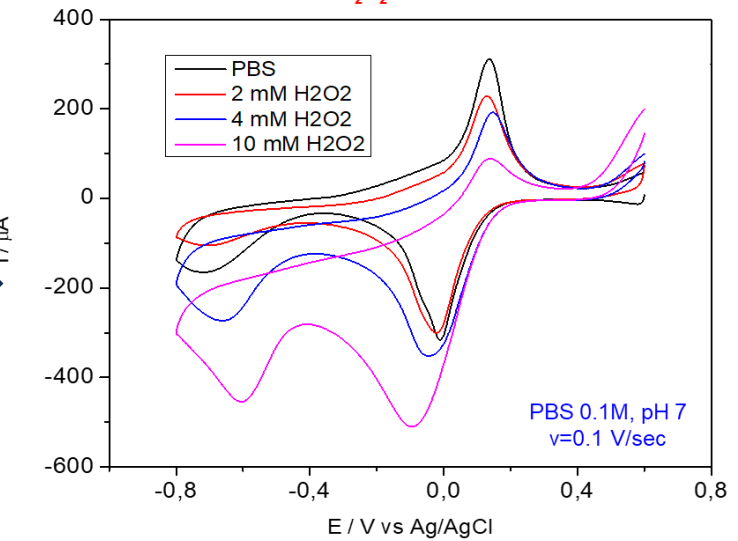
HYDROGELS - crosslinked hydrophilic polymer

- **Higher water content provides biocatalysis conditions close to homogenous catalysis;**
- **Provides selective permeability.**
- **Allows encapsulation of nanomaterials, bioreceptors, drugs, etc.**
- **Polysaccharide-polyaniline biopolymer based composites represent stable film-forming materials.**

DEVELOPMENT OF INNOVATIVE FULLERENOL-HYDROGEL BASED SENSORS



ELECTROCATALYTIC ACTIVITY OF FL-PRUSSIAN BLUE-HYDROGEL TOWARDS H_2O_2 REDUCTION



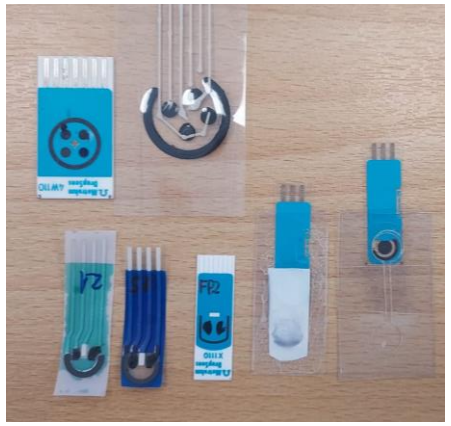
AMPEROMETRIC DETECTION OF H_2O_2 USING NANOCOMPOSITE BASED SENSORS

SPE	Linear range (µM)	Specific sensitivity ($mA \cdot M^{-1} \cdot cm^{-2}$)	Detection limit (µM)
SWCNT-PtNP	71-1890	137.58	2.5
FL-PB	8-243	57.14	6.3
FL-PB-HG	**8-833**	**177.86**	**2**

ADVANTAGES OF *FL-PB-HYDROGEL NANOCOMPOSITE*

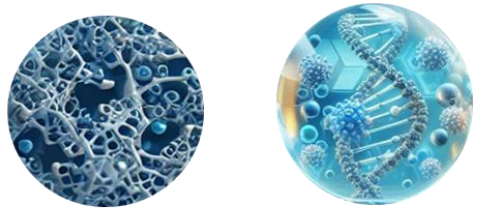
- ✓ **Improved electrocatalytic properties for H_2O_2 detection;**
- ✓ **Synergistic effect of Fullerenol, Prussian Blue and Agarose-based Hydrogel;**
- ✓ **Direct reduction of H_2O_2 at low potential values (0.04 V vs. Ag/AgCl);**
- ✓ **High sensitivity by facilitating the electron transfer between the analyte and SPE surface;**
- ✓ **High surface-to-volume ratio and high electric conductivity of the novel nanomaterials led to good analytical performances.**

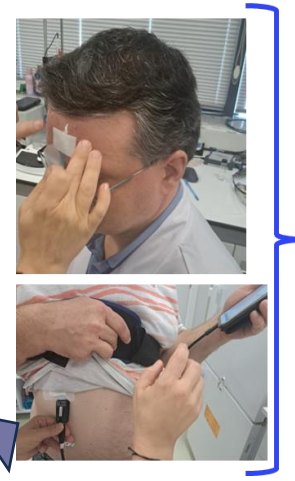
DEVELOPMENT OF MULTISENSING ELECTROCHEMICAL PLATFORM FOR CLINICAL BIOMARKERS DETECTION

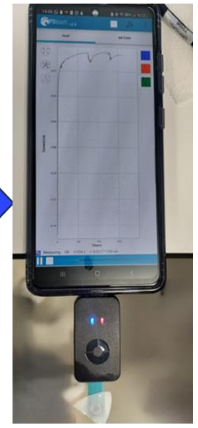


FL-PB-HYDROGEL NANOCOMPOSITE

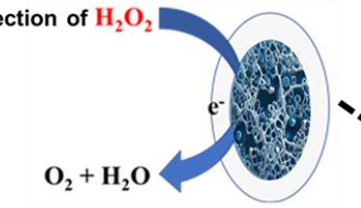
BIORECEPTORS

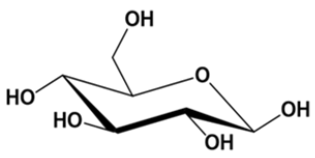






Electrochemical detection of H_2O_2

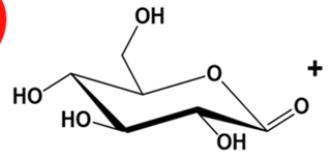




$+ O_2 + H_2O$

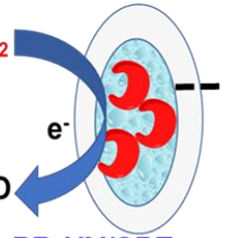
Glucose oxidase

Glucose

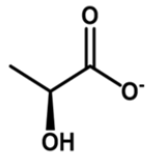


D-Glucono -1,5 – Lactone

$+ H_2O_2$



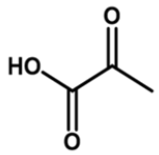
GOx/FL-PB-HY/SPE



L-Lactate

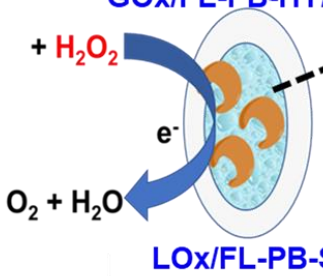
$+ O_2 + H_2O$

L-Lactate oxidase

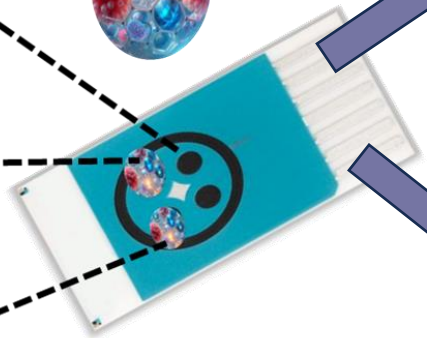


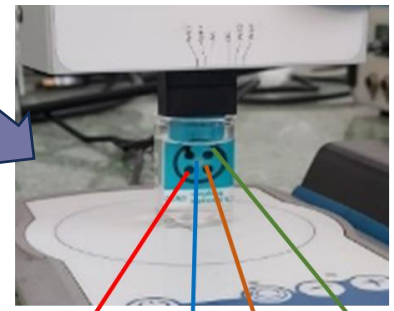
Piruvate

$+ H_2O_2$



LOx/FL-PB-SG/SPE





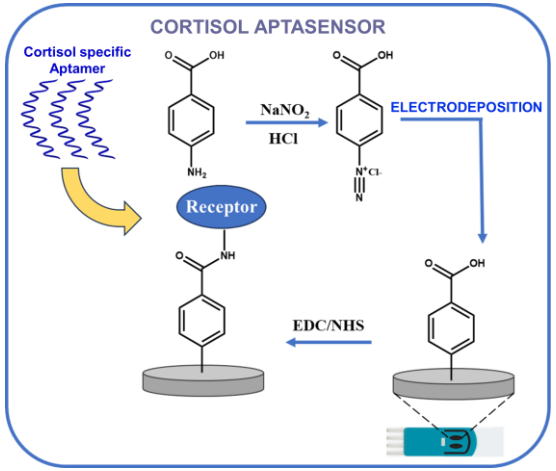
1.FL-PB/SPE

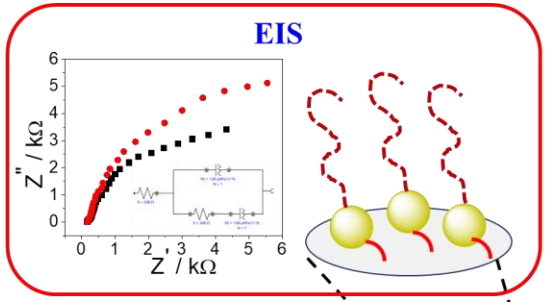
2. Apt-FL-PB/SPE

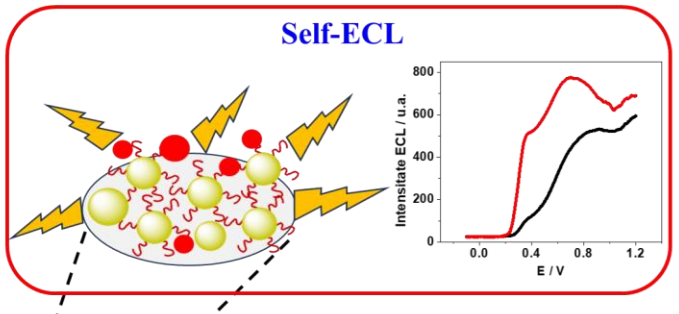
3. GOx-FL-PB /SPE

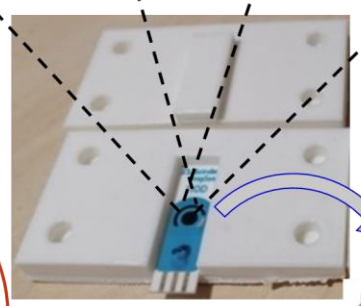
4. LOx-FL-PB/SPE

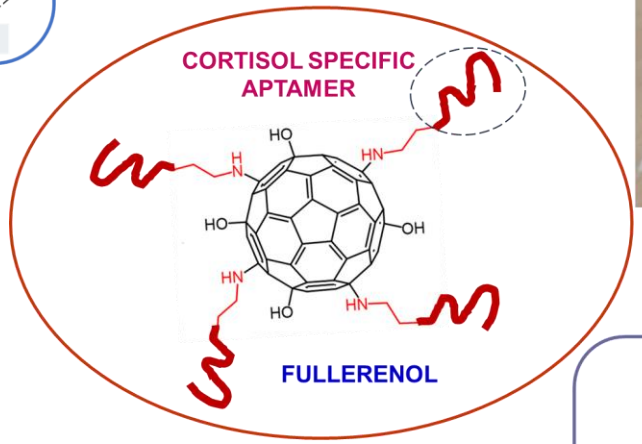
DEVELOPMENT OF OPTO-ELECTROCHEMICAL APTASENSOR BASED ON FULLERENOL FOR CORTISOL DETECTION

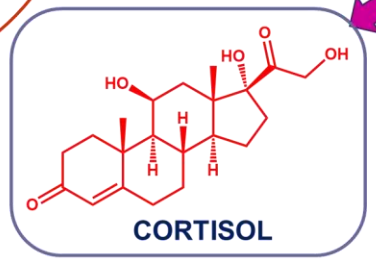


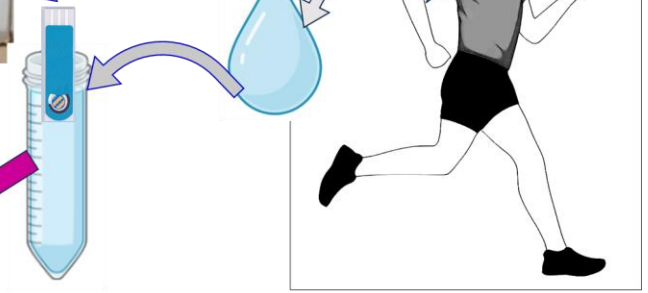


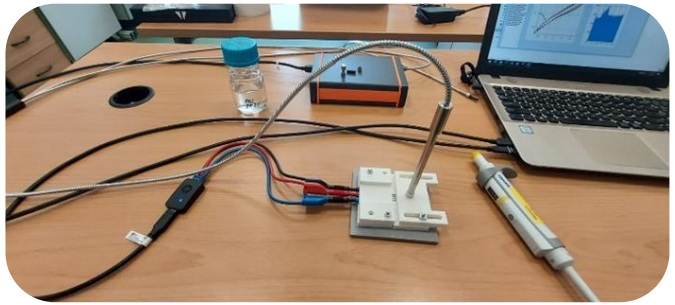










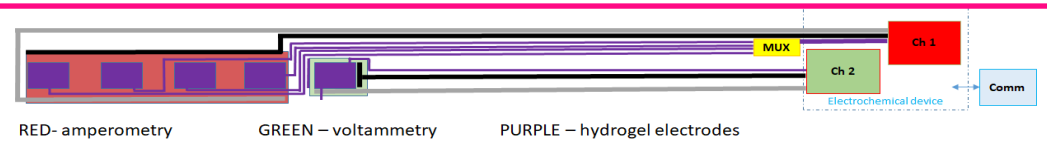


EIS: 1 mM $Fe(CN)_6^{4-}/Fe(CN)_6^{3-}$ in KCl 0.1 M

ECL: 0.1 mM luminol + 10 mM H_2O_2, in PBS pH 7.4

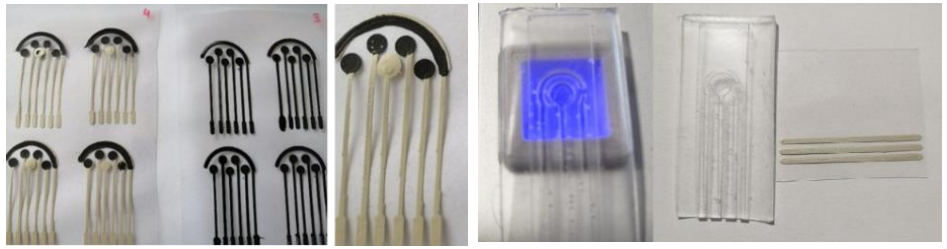
- Cortisol Incubation- 30 min

DESIGN AND DEVELOPMENT OF THE FLEXIBLE, WEARABLE FL-HYDROGELS MULTIPLEX PATCHES FOR RAPID AND EFFICIENT HEALTH STATUS SCREENING



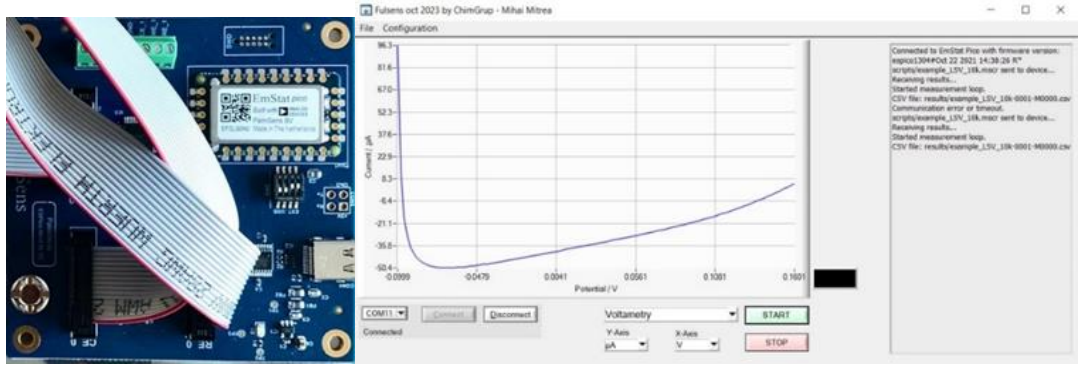
INITIAL CONCEPT OF WEARABLE SENSOR DESIGNED BY CHIMGRUP

MULTI-WORKING SPEs SETUP



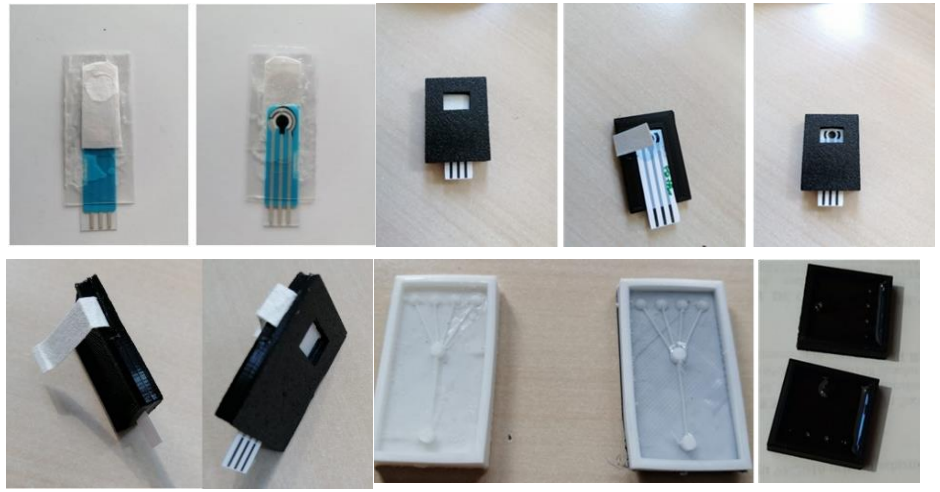
- Prototype sensor with 4 working electrodes (2D-print on PVC/paper)
- Prototyping elastomer mold for one WE
- Mold of microfluidic devices from PDMS (elastomer) – 3D-PRINT
- Absorbent layer (textile, filter paper - diffusion of 25-50 µL PBS

16-CHANNEL MULTIPLEXER CONFIGURATION AND MEASUREMENT PANEL IN THE SOFTWARE APPLICATION



INTEGRATION OF MICROFLUIDIC DEVICE CONTAINING SPE INTO A MINIATURIZED CONFIGURATION

INITIAL DESIGN OF MICROFLUIDIC ELEMENTS



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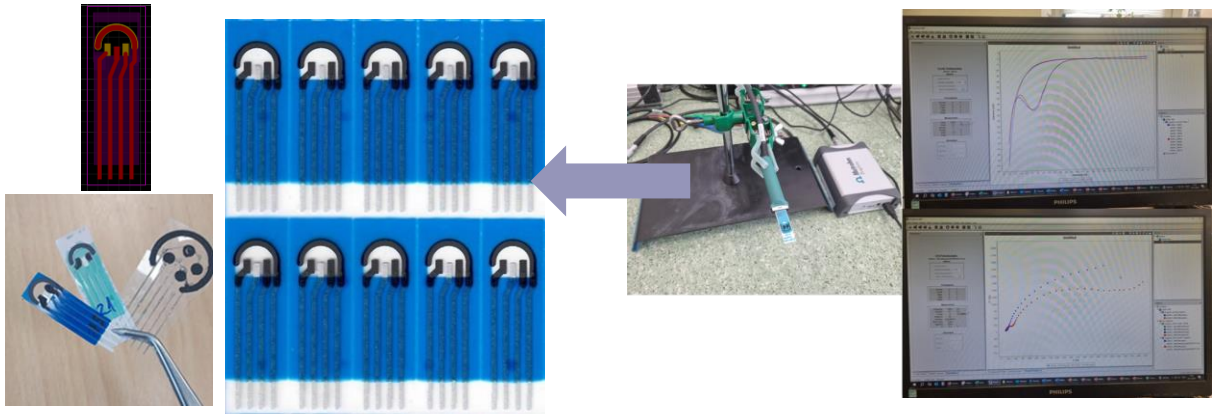
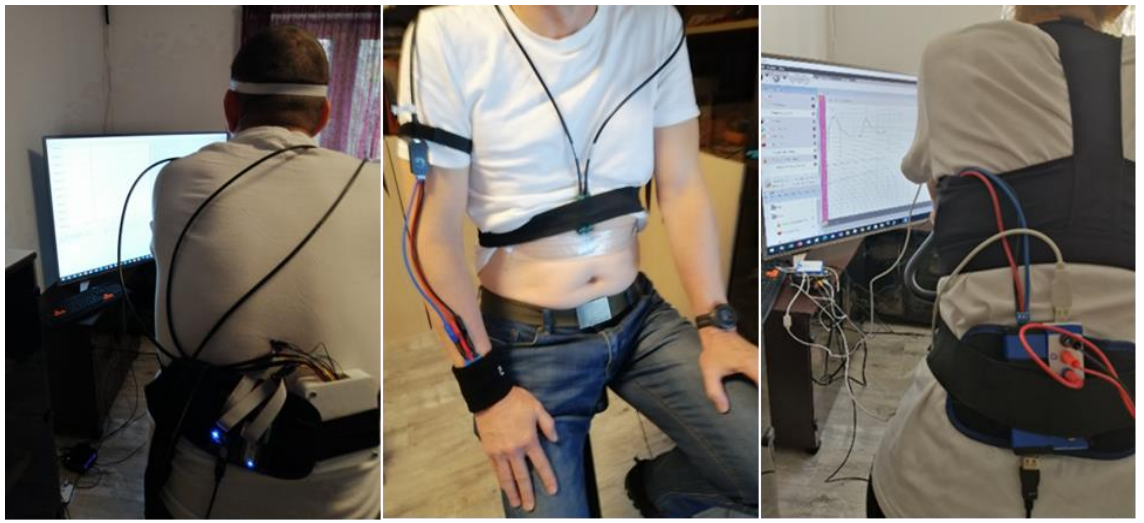
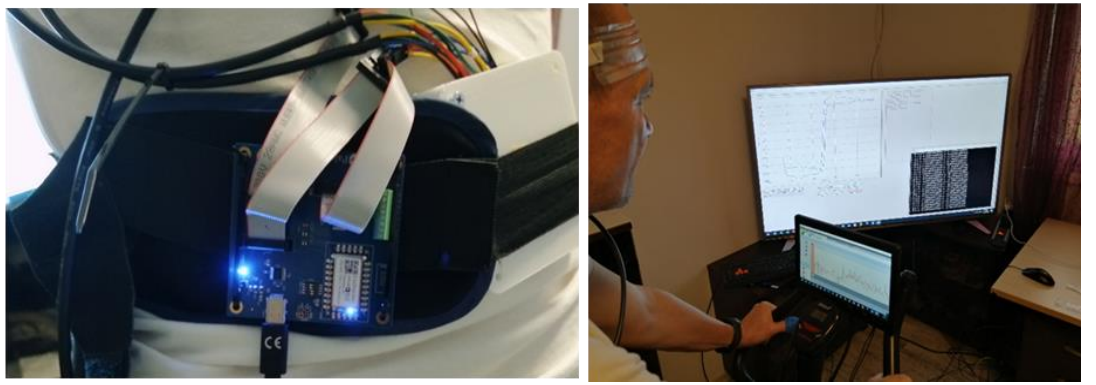
DESIGN AND DEVELOPMENT OF THE FLEXIBLE, WEARABLE FL-HYDROGELS MULTIPLEX PATCHES FOR RAPID AND EFFICIENT HEALTH STATUS SCREENING

FINAL OPTIMIZED CONFIGURATION OF MULTI-SENSING SPEs



INITIAL MEASUREMENTS ON 4 CHANNELS - SPORT CONFIGURATION CARRIED OUT WITH WEARABLE MULTISENSORS





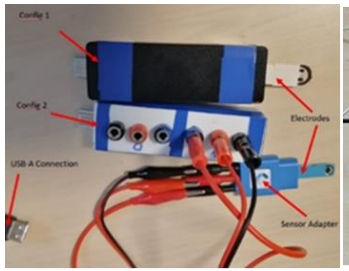
WEARABLE PATCH CONFIGURATIONS FOR MEASURING WITH COMBINED 2WEs SETUP

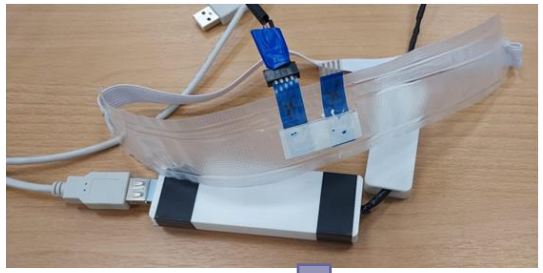
ICECHIM

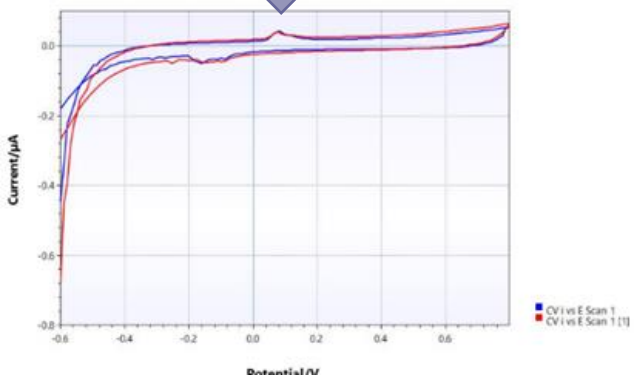
EEG ECO ENGINEERING GROUP

DESIGN AND DEVELOPMENT OF FUNCTIONAL HARDWARE MODULES TO BE IMPLEMENTED INTO A MULTICHANNEL WEARABLE CONFIGURATION

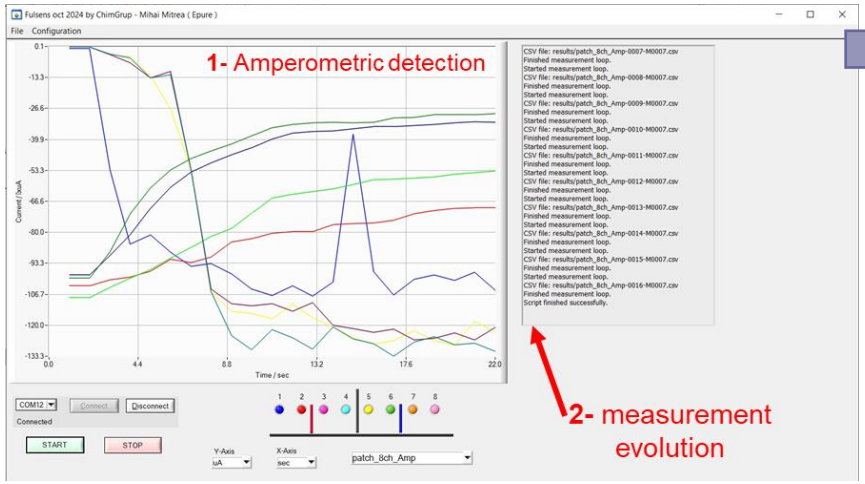
Bi-POTENTIOSTAT WITH FIRMWARE EMSTAT PICO ELECTROCHEMICAL DETECTORS WITH 2 CHANNELS

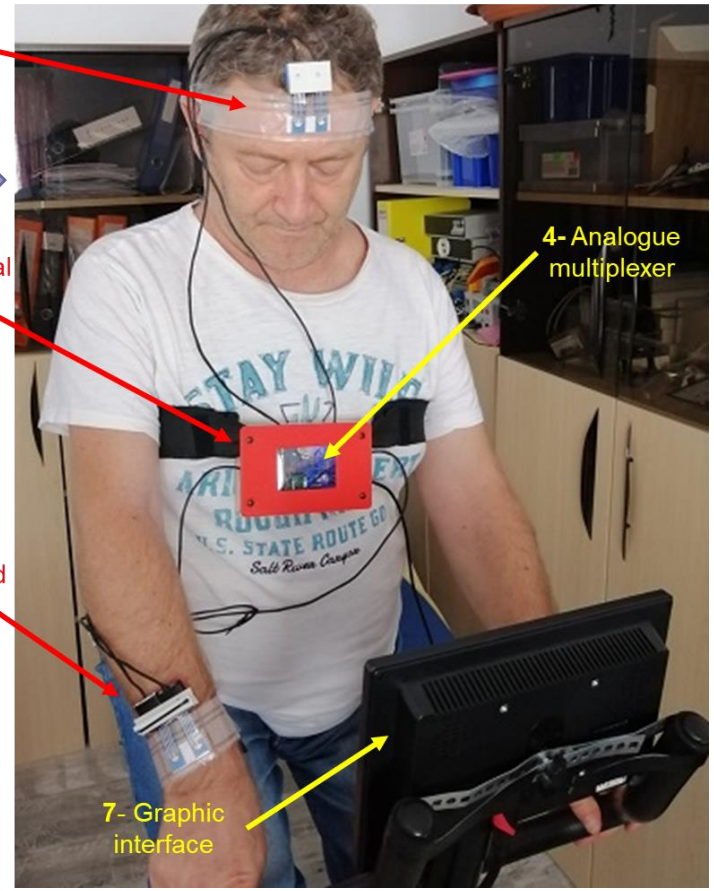






SIGNALS ACQUIRED WITH BI-POTENTIOSTAT

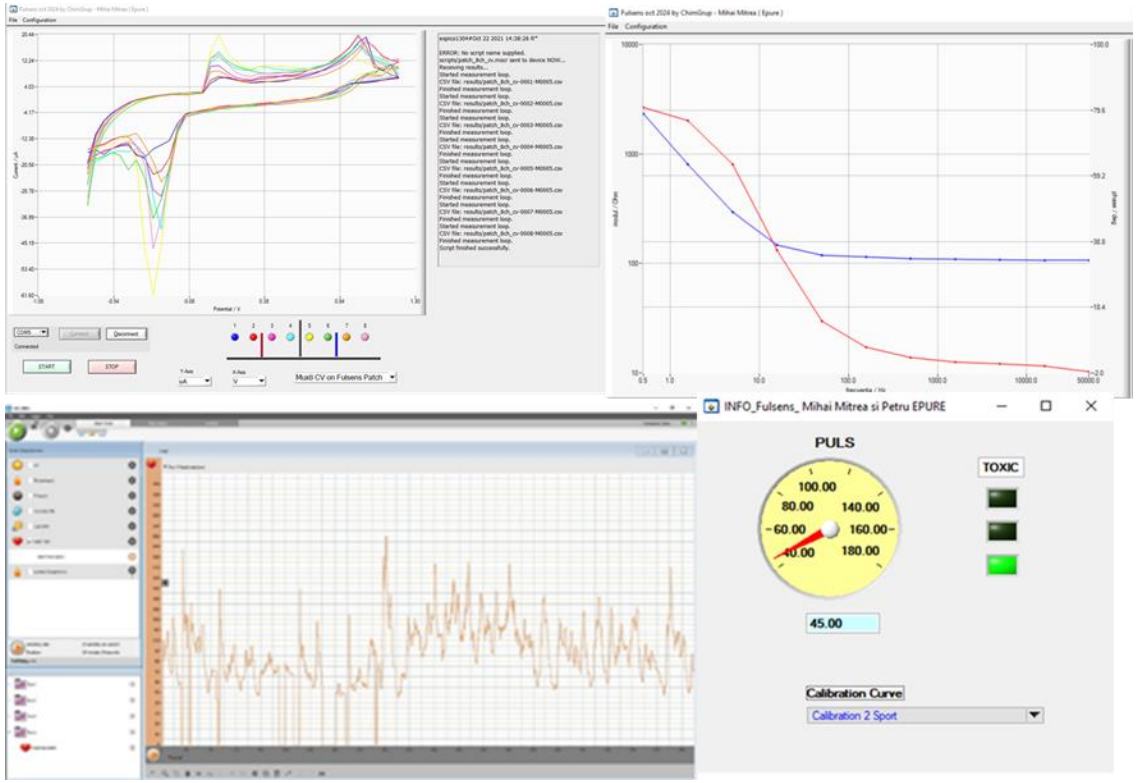




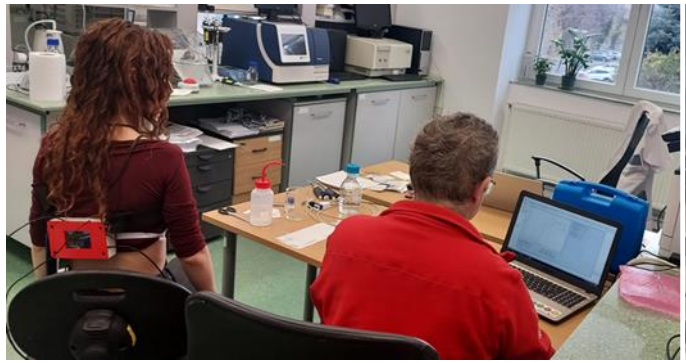
SOFTWARE PACKAGE

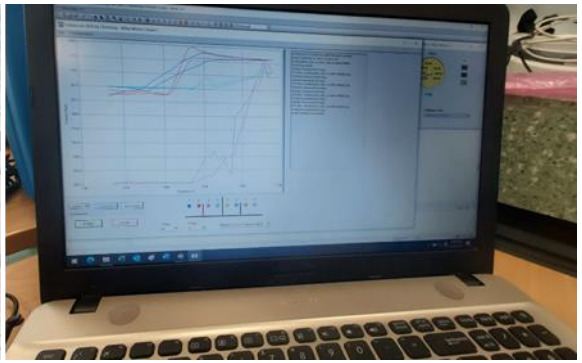
- ✓ C (embedded) for microcontrollers;
- ✓ LabWindows/CVI to provide the GUI and analog and digital measurements from the sensors.
- ✓ Measuring device integrates ARM CORTEX-m3 microcontrollers (Cypress-PSOC 5, ADuCM355-PICO, STM32F103) functionalized with embedded programs in Keil C allowing signal monitoring using platforms with low-cost.

SOFTWARE DEVELOPMENT FOR MULTIPLE CONFIGURATIONS



- Cyclic Voltammetry technique on combined setup device
- Impedance technique on combined setup device
- Chronoamperometry on combined setup device
- Capable of sequentially measuring on up to 16 channels
- Ready to implement calibration curves





ADVANTAGES

- FLEXIBILITY
- OPEN TO DEVELOPMENT
- CONCEIVED FOR PERFORMANCE
- RELIABLE

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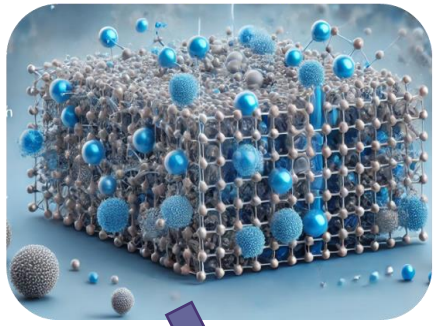
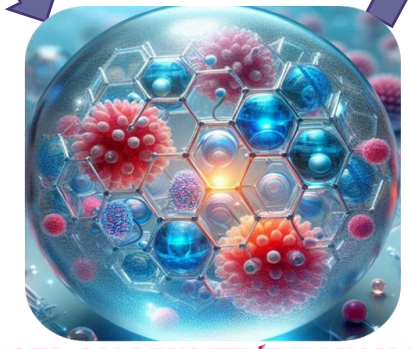
TO WHERE FULSENS-GEL ENDED

FULSENS-GEL explored, tested and optimized functional nanomaterials, managing to transform this concept into a real solution.

A MULTISENSORY WEARABLE PATCH, CAPABLE OF MONITORING CERTAIN ESSENTIAL PARAMETERS IN REAL TIME

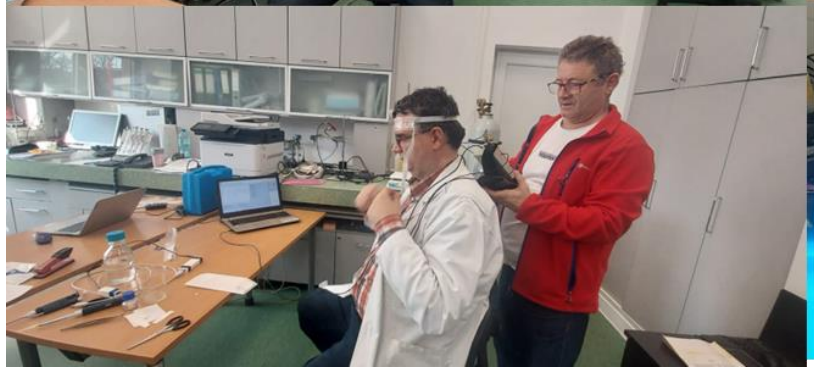
FL-PB-BASED NANOMATERIAL





FL-BASED BIOSENSITIVE NANOMATERIAL

WHAT WE HAVE ACHIEVED SO FAR IS JUST THE BEGINNING!



NOW IS A REALITY WITHIN REACH

A flexible, portable and efficient device that paves the way for a new era of advanced multi-sensing detection.

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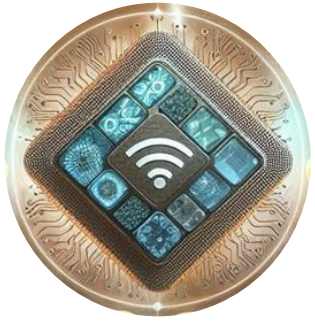
FULSENS-GEL INNOVATION

Design and development of a multiplex, flexible, wearable and portable patch, based on the new electroconductive Fullerenol-Hydrogel material functionalized with specific bioreceptors, enzymes/aptamers for the simultaneous, sensitive and selective detection of clinically important analytes (glucose, lactate, cortisol, hydrogen peroxide, chloride ions and pH) from non-invasive biological fluids (sweat).

- Development of a new nanocomposite materials with tunable network structure, active surface and improved electrochemical, mechanical and optical properties, by combination of elastic, resistant and flexible Hydrogels with functionalized Fullerenol (FL)-based nanomaterials;
- Development of innovative bio-sensitive nanomaterials by incorporation of specific bioreceptors into FL-conductive nanostructures;
- Development of highly sensitive, selective and reproducible electrochemical sensors based on FL-Hydrogel nanomaterials;
- Development of a multi-sensing electrochemical platform with unique characteristics and diverse functionalities for simultaneous detection of specific biomarkers (glucose, lactate, H_2O_2, etc);
- The multisensing platform was characterized and optimized for electrochemical detection of clinically relevant analytes, as well as for optical detection by electrochemiluminescence of cortisol using specific aptasensor.



THESE FLEXIBLE AND PORTABLE MULTISENSORY BIOANALYTICAL PLATFORMS CAN BE USED FOR DETECTION OF A NUMBER OF OTHER IMPORTANT COMPOUNDS IN FOOD, ENVIRONMENT OR OF CLINICAL IMPORTANCE, SUCH AS DRUG RESIDUES, HORMONES, PESTICIDES, etc., ENABLING THE CONTROL AND MONITORING OF QUALITY OF LIFE

IMPACT AND RELEVANCE

FULSENS-GEL PROJECT SIGNIFICANTLY CONTRIBUTES TO IMPROVING THE QUALITY OF LIFE AND ADVANCING FUNCTIONAL MATERIALS FOR DETECTION APPLICATIONS, OFFERING INNOVATIVE SOLUTIONS TO CURRENT SCIENTIFIC AND SOCIO-ECONOMIC CHALLENGES.

The major impact of the **FULSENS-GEL** project is the development of an innovative nanocomposite material based on the combination of elastic, resistant and flexible hydrogels with functionalized **Fullerenol (FL)** nanomaterial, obtaining new conductive network structures, with active surface and improved electrocatalytic, optical and mechanical properties.

SCIENTIFIC COMMUNITY

By incorporating **biomolecules/bioreceptors** into such conductive nanostructures, unique characteristics and diverse functionalities were obtained, which can be exploited for different very promising application areas, such as:

- ❑ wearable and flexible sensors;
- ❑ point-of-care sensors for clinical diagnosis;
- ❑ food quality control
- ❑ environmental monitoring;
- ❑ human-machine interfaces and smart sensors,
- ❑ nanomaterials with self-regeneration/adhesive properties

THE EU'S RESEARCH POTENTIAL

Stimulating international collaboration, knowledge exchange, training, etc.

INDUSTRY

By producing and exploiting new flexible and portable bioelectronics.

SOCIETY

Developing bioelectronic devices containing such new nanomaterials offers the possibility of rapid, real-time monitoring of health conditions, food quality and detection of contaminants/pathogens, thus increasing the quality of life.

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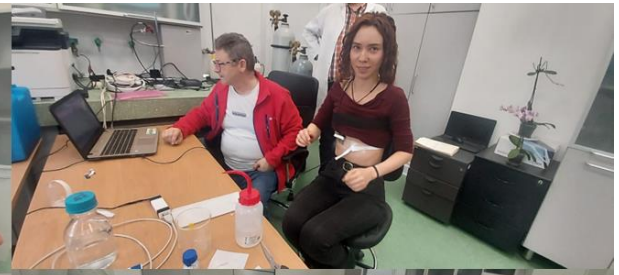
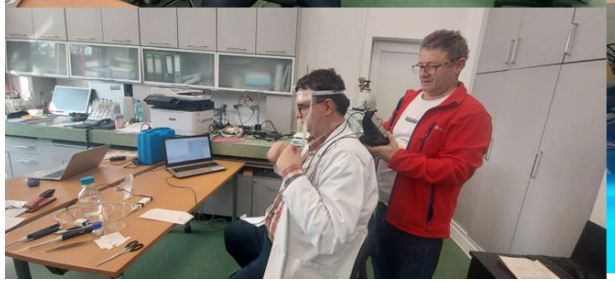
WORKING VISITS





INTELLECTUAL PROPERTY and DISSEMINATION

PATENT APPLICATIONS

- **A/00687-12.11.2024** – *Procedure for realization of a multisensitive platform based on innovative nanomaterials for monitoring of clinically relevant biomarkers* – **ICECHIM**
- **A/00732–22.11.2024** – *Portable measuring tool for simultaneous electrochemical detection of lactate and glucose from sweat* – **CHIMGRUP**

WORKSHOPS

- *Portable Miniaturized Opto-Electrochemical Systems for In-Field Measurements*, Ana-Maria Gurban, October 11th, 2023, Bucharest Romania – Organized by Coordinator ICECHIM.
- *New challenges in the pharmaceutical field*, Mariana Constantin, Titu Maiorescu University, November 22th, 2024, Bucharest, Romania.

ROUND TABLE

- *Portable miniaturized bioanalytical tools for (bio)sensing applications – Ana-Maria Gurban* – **Invited speaker at 4th Local Government Congress of the Three Seas Regions,** June 12-13th, 2024, Lublin, Poland

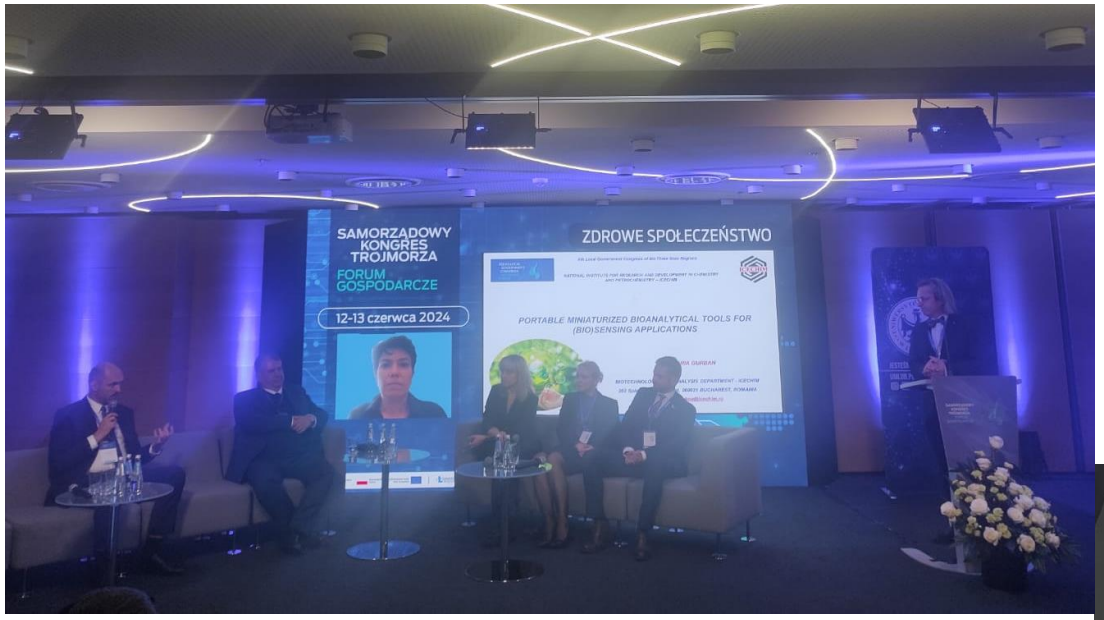
SEMINAR

- *Biotechnological and biosensing approaches for the development of innovative solutions with applications in agriculture, food and environmental fields,* Ana-Maria Gurban, Necmettin Erbakan University, BITAM Center, November 06-07th, 2023, Konya, Turkey.

INTERNATIONAL SCIENTIFIC EVENTS – 20 participations (7 oral communications)

WORKSHOPS – SEMINARS – ROUND TABLES

XIX EDITION OF PRIOCHEM - "PRIORITIES OF CHEMISTRY FOR A SUSTAINABLE DEVELOPMENT" INTERNATIONAL SYMPOSIUM



PUBLICATIONS

- Kurbanoglu S., Can Cevher Ş., **Gurban A-M**, Doni M., **Soylemez S**. *Conjugated Polymers in Enzyme-based Electrochemical Biosensors, Advances in Materials Science Research*, 2022, Vol 58, Chapter 1, p 1-48, Nova Science Publisher ISBN: 979-8-88697-488-1; ISSN: 2159-1997; https://doi.org/10.52305/SREW6529
- †**Ianchis R**.; Alexa R.L.; Gifu I.C.; et. al., *Novel green crosslinked salecan hydrogels and preliminary investigation of their use in 3D printing,* Pharmaceutics 2023, 15, 373. https://doi.org/10.3390/pharmaceutics15020373;
- Marin M.M.; et. al, †**Ianchis R**. *Novel nanocomposite hydrogels based on crosslinked microbial polysaccharide as potential bioactive wound dressings*. Materials 2023, 16, 982. https://doi.org/10.3390/ma16030982
- **Zamfir L-G**, Răut I., Constantin M., Corneli N.O., Firincă C., Jecu ML, **Epure P**, Nistor CL, Doni M, **Gurban AM*** - *Assessment of biogenic amines produced by microorganisms as food spoilage indicators by sensitive detection using portable opto-electrochemical tools based on biosensors*, Food Control 2025, 172, 111161, https://doi.org/10.1016/j.foodcont.2025.111161
- **Soylemez, S**., Kurbanoglu, S., Kuralay, F*., Nanoscale Physics of Electrochemistry*, Elsevier, Biophysics at the Nanoscale, 2024, 43-71, https://doi.org/10.1016/B978-0-443-15359-4.00006-1
- **Epure P*., Mitrea M., Gurban AM.** (2023). *Lactate Optical Detection Setup Used for Preventive Care*. In: Auer, M.E., Langmann, R., Tsiatsos, T. (eds) Open Science in Engineering. REV 2023. Lecture Notes in Networks and Systems, vol 763. Springer, Cham. https://doi.org/10.1007/978-3-031-42467-0_68
- **Zamfir L.-G., Epure P., Mitrea M.**, Gîfu I.C., Răut I., Constantin M., Firincă C., Jecu L., Trică B., Doni M., **Gurban A.-M.,** *Wearable multisensing patch based on nano-composites for clinical biomarkers monitoring from sweat*, Polymers (in prep)
- **Gîfu I C**, Nistor C. L., Petcu C., Alexandrescu E., Doni M., Zamfir L.-G., **Gurban A.-M.,** *Natural polysaccharides- based hydrogels - a versatile tool for biomedical engineering development* , Polysaccharides (in prep).

INTERNATIONAL INVENTION EXPOSITIONS AND CONFERENCES	TITLE OF PRESENTATION AWARDED	MEDAL/ AWARD
KIDE2024 - Kaohsiung International Invention and Design EXPO (KIDE) 2024, Kaohsiung Exhibition Center (KEC), December 5-7, 2024, Qianzhen District, Kaohsiung, **TAIWAN**	Procedure for realization of a miniaturized electrochemical multisensing platform based on nanocomposites and enzymatic bioreceptors for the monitoring of clinically relevant biomarkers	**GOLD**
ITE2024 - International Invention and Trade Expo London, Kingston University, September 24-25, London, **GREAT BRITAIN**	Procedure for manufacturing of a miniaturized nanocomposite based multisensing platform for the monitoring of clinically relevant biomarkers	**GOLD**
EURO-POLITEHNICUS2024 - International Salon of Innovation and Inventions, November 22-24Th, 2024, Bucharest, Romania	Procedure for manufacturing of a miniaturized nanocomposite based multisensing platform for the monitoring of clinically relevant biomarkers	**GOLD**
iCAN 2023 - The 8th International Invention Innovation Competition in Canada, August 26th, 2023, Toronto, **CANADA**	Innovative fullerenol - hydrogels based nanomaterials for health diagnostic and care applications - FULSENS-GEL	**GOLD**
INOVA2024 - 48th International Invention Show –October 16-19th, 2024, Zagreb, **CROATIA**	Procedure for manufacturing of a miniaturized nanocomposite based multisensing platform for the monitoring of clinically relevant biomarkers	**SILVER**
INOVA2024 - 48th International Invention Show, October 16-19th, 2024, Zagreb, **CROATIA**	Innovative fullerenol-hydrogels based nanomaterials for health diagnostic and care applications - FULSENS-GEL	**SILVER**
EURO-POLITEHNICUS2024 - International Salon of Innovation and Inventions, November 22-24, 2024, Bucharest, **ROMANIA**	Procedure for manufacturing of a miniaturized nanocomposite based multisensing platform for the monitoring of clinically relevant biomarkers	**Diploma of Excellence awarded by University of Polytechnic, Timisoara, Romania**
EURO-POLITEHNICUS2024 - International Salon of Innovation and Inventions, November 22-24, 2024, Bucharest, Romania	Procedure for manufacturing of a miniaturized nanocomposite based multisensing platform for the monitoring of clinically relevant biomarkers	**Diploma of Excellence awarded by the Justin Capra Association, Romania**
BIOSENSORS 2024, 6th International Congress on Biosensors, September 05-07, 2024, Konya, **TURKEY**	Multisensing Portable Tool Based On Novel Fullerenol Derivatives For Health Status Monitoring	**The 2nd Best Poster Presentation Award**
PRIOCHEM XX - The International Symposium "PRIORITIES OF CHEMISTRY FOR A SUSTAINABLE DEVELOPMENT", October 16-18th, 2024, Bucharest, **ROMANIA**	Wearable multi-sensing patch based on SWCNT-PtNPs nanocomposite for clinical biomarkers monitoring from sweat	**The award for recognizing the outstanding presentation given at the symposium**
PRIOCHEM XIX - The International Symposium "PRIORITIES OF CHEMISTRY FOR A SUSTAINABLE DEVELOPMENT", October 16-18th, 2024, Bucharest, **ROMANIA**	Design and development of MIP based electrochemical sensor for cortisol detection	**PRIOCHEM2023 AWARD**
ICan 2024 - The 9th of the International Invention Innovation Competition in Canada,. 24 august 2024, Toronto, **CANADA**	Procedure for realization of electrochemical biosensors based on nanomaterials for biogenic amines determination	**GOLD**
innoCenta 2024 - The International Exhibition of Innovation and Technological Transfer, November 7th, 20024, Timisoara, **ROMANIA**	Procedure for realization of electrochemical biosensors based on nanomaterials for biogenic amines determination	**GOLD**
EUROINVENT2024 - The 16th Edition of the European Exhibition of Creativity and Innovation, June 6-8th, 2024, Iași, **ROMANIA**	Procedure for realization of electrochemical biosensors based on nanomaterials for biogenic amines determination	**GOLD**
KIDE2024 - Kaohsiung International Invention and Design EXPO (KIDE) 2024, Kaohsiung Exhibition Center (KEC), December 5-7, 2024, Qianzhen District, Kaohsiung, **TAIWAN**	Procedure for realization of electrochemical biosensors based on nanomaterials for biogenic amines determination	**GOLD**

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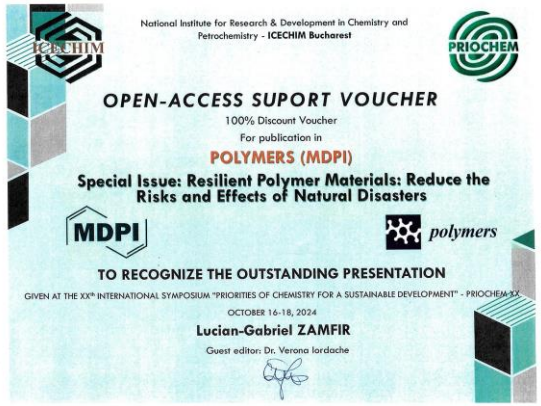
AWARDS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Special Issue: Resilient Polymer Materials: Reduce the Risks and Effects of Natural Disasters

MDPI polymers

TO RECOGNIZE THE OUTSTANDING PRESENTATION

GIVEN AT THE XX[th] INTERNATIONAL SYMPOSIUM "PRIORITIES OF CHEMISTRY FOR A SUSTAINABLE DEVELOPMENT" - PRIOCHEM XX

OCTOBER 16-18, 2024

Lucian-Gabriel ZAMFIR

Guest editor: Dr. Verona Iordache


BIOSENSORS 2024

5-7 September 2024

The 2nd-Best Poster Presentation Award

Biosensors 2024, 6th International Congress on Biosensors

Konya, Türkiye, 5-7 September 2024

Presented to:

Lucian-Gabriel Zamfir

For the poster presentation:

Multisensing Portable Tool Based on Novel Fullerenol Derivatives for Health Status Monitoring

Assoc. Prof. Dr. Erhan Zor

Congress Chair


National Institute for Research & Development in Chemistry and Petrochemistry - ICECHIM Bucharest

The scientific committee of the XIX[th] International Symposium "Priorities of Chemistry for a Sustainable Development" PRIOCHEM XIX, October 11-13, 2023

is pleased to award

PRIOCHEM 2023 AWARD

to

Maria-Lorena JINGA

for the work entitled:

DESIGN AND DEVELOPMENT OF MIP BASED ELECTROCHEMICAL SENSOR FOR CORTISOL DETECTION

Authors: Maria-Lorena JINGA, Lucian-Gabriel ZAMFIR, Petru EPURE, Daniel PREDA, Mariana CONSTANTIN, Iuliana RĂUT, Maria-Luiza JECU, Mihaela DONI, Iulia Gabriela DAVID, Ana-Maria GURBAN

President of the Scientific Committee
Dr. Habil. Radu Claudiu FIERASCU

General Manager
Dr. Biochem. Mihaela DONI


48. HRVATSKI SALON INOVACIJA S MEĐUNARODNIM SUDJELOVANJEM - INOVA 2024.

20. IZLOŽBA INOVACIJA, PROTOTIPOVA I POSLOVNIH PLANOVA - BUDI UZOR 2024.

48[th] INTERNATIONAL INVENTION SHOW - INOVA 2024

20[th] INVENTION AND PROTOTYPE SHOW AND BUSINESS PLAN COMPETITION - BE THE ROLE MODEL 2024

SREBRO
SILVER

ANA-MARIA GURBAN, LUCIAN-GABRIEL ZAMFIR, MIHAELA DONI, MIHAI MITREA, PETRU EPURE, MARIA LUIZA JECU, CRISTINA FIRINCĂ, MARIANA CONSTANTIN, IULIANA RĂUT

National Institute for Research & Development in Chemistry and Petrochemistry – ICECHIM Bucharest

Innovative fullerenol - hydrogels based nanomaterials for health diagnostic and care applications

2024 BUDI UZOR BE THE ROLE MODEL


Certificate of Participation

THIS CERTIFICATE IS PROUDLY PRESENTED TO:

National Institute for Research & Development in Chemistry and Petrochemistry – ICECHIM Bucharest

Ana-Maria Gurban, Lucian-Gabriel Zamfir, Mihaela Doni, Iuliana Răut, Mariana Constantin, Cristina Firincă, Maria Luiza Jecu

has been successfully participated in the 2024 Kaohsiung International Invention & Design EXPO which featured 448 entries from 32 different countries. The event took place from 5 to 7 December, 2024 in Kaohsiung, Taiwan

Certificate of Award

This is to certify that

has been awarded the

GOLD MEDAL

for the invention

on the occasion of 2024 Kaohsiung International Invention & Design EXPO

5 - 7 December, 2024

Kaohsiung, Taiwan

World Invention Intellectual Property Associations

COLLABORATIONS – NEW CONSORTIA

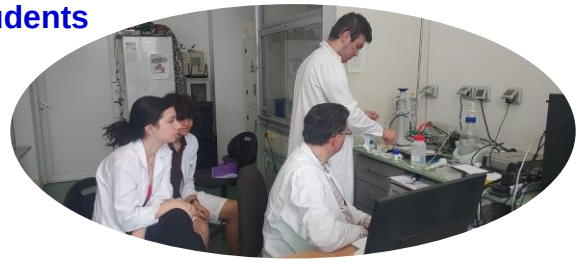
- **ERANET-COFUND2024 - project12519** - Innovative spiro conjugated polymers-mxenes nanostructures for monitoring and control of human-microbial-related pollutants in eu aquatic ecosystem – Proposed for funding (failed due to poor partner financing) (**Turkey-Romania-Poland-Spain**);
- **ERANET-COFUND2023 - project11275** - Engineered upconversion nanoparticles-conjugated polymers for precision medicine (**Turkey-Romania-Spain**)
- **ERA4HEALTHNANO-252-2024** - Customized MXene nanoStructures for Cutting-Edge Research and Optimization in Colorectal Cancer Diagnostic - NanoSCORP (**Poland-Romania-Portugal-Romanian SME**)
- **ERA4HEALTHNANO-265-2024 -** Innovative electrochemical point-of-care device for smart intraoperative evaluation of surgical margins in sarcome and bone metastasis – PoCMARGINS (**Italy-Spain-Romania-Spain Hospital – Italy Hospital**)
- **OC-2022-1-25999-2022 -** Wearable nanobiosensors for continuous monitoring: From laboratory to real-life applications – WEARSENSE – COST (**18 countries** – 40 participants)
- **24UA19001-2024-NEÜ**, International Research Project – Continuous Development and Application of Sensors for Wearable Technologies for Simultaneous Detection of Some Important Biomarkers (**Turkey – Romania**)
- **PN-IV-P2-2.1-TE-2023-1281**- Innovative MXene-peptides for electrochemical miniaturized platforms dedicated to tumor biomarker detection -MXEPEPMIN – **Romania young research team** (Founded)

YOUNGS INVOLVED

EMPLOYED – 1 Master student

YOUNGS INVOLVED – 1 Master, 4 PhD, 3 Post-docs

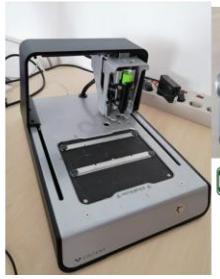
MENTORING – 6 students and 4 high-school students



PURCHASED EQUIPMENT IN THE CONSORTIUM

SPECTRAMAX ID3 MULTI-MODE MICROPLATE DETECTION PLATFORM

VOLTERA V-ONE PCB PROTOTYPING PRINTER



AMPEROMETRIC DETECTOR

POTENTIOSTATE/ GALVANOSTATE

OVERCOMING CHALLENGES

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- ❑ PROJECT DURATION - SHORTENING THE RUNNING PERIOD from 36 MONTH to 30
- ❑ THE GAP IN FUNDING AND STARTING THE ACTIVITIES BETWEEN PARTNERS

TECHNICAL

- ➢ FULLERENOL-synthesis - nanomaterial agglomeration inducing sensitivity limitations
- ➢ HYDROGEL synthesis - Crosslinking degree and polymerization conditions of hydrogel
- ➢ Bioreceptors-FL based biosensors – different immobilization strategies for the same platform
- ➢ Manufacturing flexible screen-printed multi-sensing electrodes - made in 2 steps (layers unstable, detaching);
- ➢ WEARABLE and PORTABLE set-up – working simultaneously with multiple channels and implementing three different detection techniques (voltammetry, amperometry, EIS) on a multi-channel structure and wearable hardware is really challenging.
- ➢ Dimensional correlation of the multi-sensory platform and the wearable patch with connectors and adapters
- ➢ Design and development of microfluidic layer – correlation between the hydrophobic substrate of the SPEs and hydrophilic layer for sweat collection.
- ➢ Reproducibility and long-term stability of the developed biosensors.

†RALUCA IANCHIȘ

- ❖ MAJOR CHALLENGE - the loss of the key person within the project affected the team dynamics and tested the resources to maintain the continuity of the project.

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PERSPECTIVES FOR THE FUTURE DEVELOPMENT OF OPTO-ELECTROCHEMICAL SYSTEMS

- New nanomaterials with enhanced opto-electrochemical properties are still emerging for innovative applications, such as catalysts, electronics, solar panels, batteries and biomedical applications, including diagnostic devices and tumor therapies;
- Miniaturized opto-electrochemical bioanalytical tools using advanced nanomaterials offer diverse functionalities: wearable sensors for diagnostics, environmental monitoring, flexible energy storage, human-machine interfaces, and more.

- **Complementary technologies -** Integration with other technologies, such as the **Internet of Things (IoT), artificial intelligence (AI), and cloud technology**, will enhance the functionality and connectivity of opto-electrochemical systems.
- ***Durability and robustness -*** need to be developed to be durable and resistant to harsh environmental conditions or wear and tear over time.
- ***Cost reduction -*** the production and implementation costs of these systems will need to decrease to make them more affordable and to expand their use in a wider range of applications and in different regions of the world.
- ***Medical applicability -*** the development of portable opto-electrochemical technologies for medical diagnosis and health monitoring is an important direction for the future. These devices can contribute to personalized healthcare and more effective management of chronic diseases.

❖ **Future development of portable opto-electrochemical systems focuses on increasing the performance, portability and versatility of these technologies, enabling them to address a wide range of challenges and applications in areas such as health, security, environment and industry.**

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Thank you for your attention