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UNIVERSITÀ DEGLI STUDI DI ROMA

Biosensori in
"Priorità - Materiali avanzati e nanotecnologie"
Materiali avanzati e nanotecnologie: scenario internazionale

F. Arduini

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SENSE4MED via Renato Rascel 30, 00128, Rome, Italy

Fabiana Arduini, Professore Associato presso il Dipartimento di Scienze e Tecnologie Chimiche, Università di Roma “Tor Vergata”, CEO della start-up SENSE4MED, DG presso Laboratorio Certificato ISO9001 LabCap, Università di Roma “Tor Vergata”, Editore Associato di Microchemical Journal, Elsevier, Ediore Green Analytical Chemistry, Elsevier, Ediore Frontiers in Sensors, Micro/nanosensors e Coordinatore Gruppo Sensori, Società Chimica Italiana 2019-2021. L’ attività di ricerca riguarda lo sviluppo di dispositivi elettrochimici miniaturizzati utilizzando principalmente elettrodi serigrafati modificati con nanomateriali e sensori stampati su carta nei settori ambientale, biomedicale, agrifppd e della difesa , con oltre 120 articoli pubblicati su riviste peer-review, indice H 40, fonte Scopus, > 5 brevetti, coordinatore di diversi progetti nazionali/internazionali Il suo nome è presente in PLoS Biology https://doi.org/10.1371/journal. pbio.3000384 che ha elencato il 2% dei ricercatori più citati al mondo.

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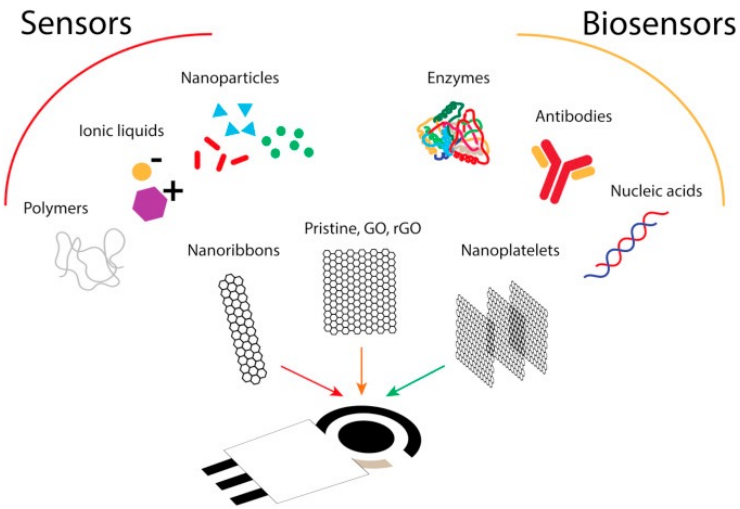
SENSORE

di Fabiana Arduini, Laura Micheli, Daniela Romanazzo, Roberto Steindler - Enciclopedia Italiana - IX Appendice (2015)

SENSORE. – Sensori di grandezze chimiche. Classificazione e proprietà. Biosensori elettrochimici. Bibliografia. Sensori di grandezze fisiche. Sensori a semiconduttore. Sensori a fibre ottiche. Sensori IR. Sensori per mappe. Sensori di prossimità. Sensori di velocità. Bibliografia

Sensori di grandezze chimiche di *Fabiana Arduini, Laura Micheli, Daniela Romanazzo.* – I s. chimici sono dispositivi integrati in grado di identificare e/o quantificare, in un sistema in analisi, una o più specie chimiche (analiti). Possiedono caratteristiche analitiche quali l'elevata sensibilità, l'accuratezza e la rapidità di misura, nonché requisiti operativi quali le limitate dimensioni, la maneggevolezza e la stabilità nel tempo. Tali caratteristiche ne consentono la trasferibilità sul campo, per un tempestivo intervento di controllo, e l'uso per operatori non specializzati, fornendo un'importante e valida alternativa ai metodi analitici tradizionali. I s. chimici sono classificati in base al tipo di trasduzione di segnale impiegata.

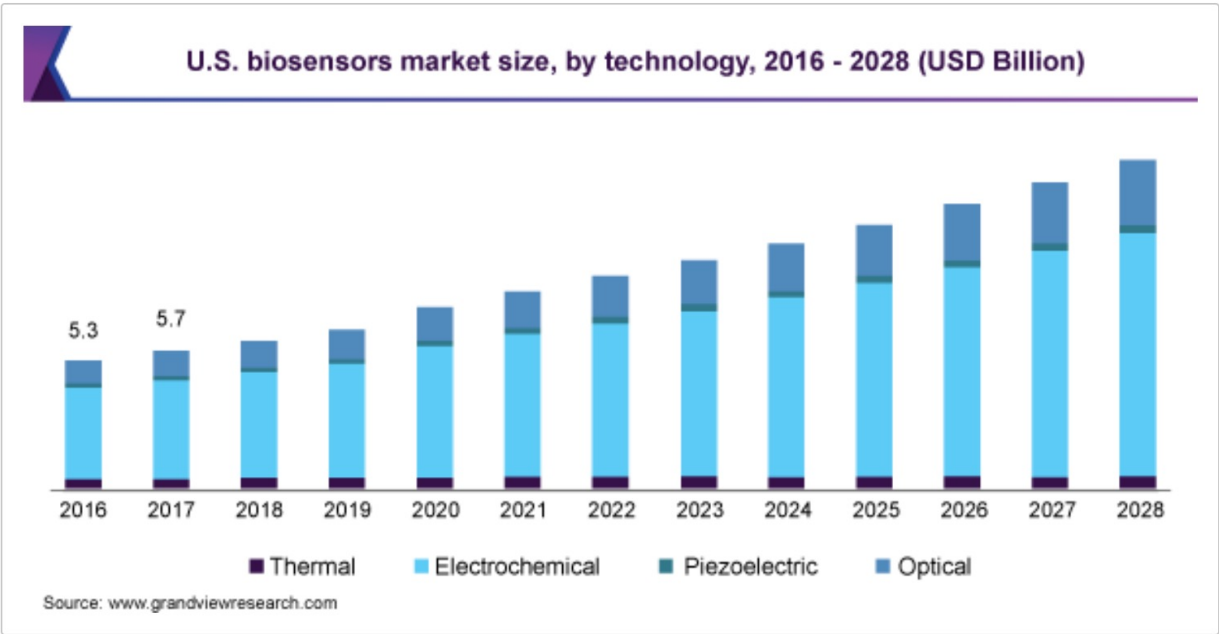


Biosensori elettrochimici. – Quando i s. chimici sono modificati con un biocomponente come un enzima, un anticorpo o una sequenza di DNA (*DeoxyriboNucleic Acid*), si definiscono *biosensori.* Un biosensore è un dispositivo analitico che incorpora un elemento di riconoscimento biologico (o di derivazione biologica) integrato o intimamente associato a un trasduttore di segnale chimico-fisico. Il segnale in uscita è conseguente alla reazione tra il biocomponente e l'analita e proporzionale alla concentrazione dell'analita stesso. I biocomponenti conferiscono ai s. chimici maggiori prestazioni in termini di specificità e sensibilità.

Quando il biocomponente è rappresentato da un enzima si parla di *biosensori enzimatici*, tra

Report Overview

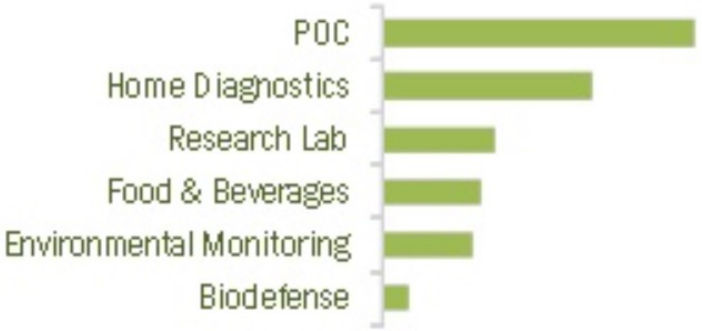
The global biosensors market size was valued at USD 22.4 billion in 2020 and is expected to expand at a compound annual growth rate (CAGR) of 7.9% from 2021 to 2028. Biosensors, owing to their ability to assess health status, and disease onset and progression, are being used extensively in-home healthcare by patients, and hence, are expected to boost market growth over the forecast period. Furthermore, technological advancements, as well as various non-medical-based applications are expected to enhance the applicability of the market for biosensors, thus promoting its growth.



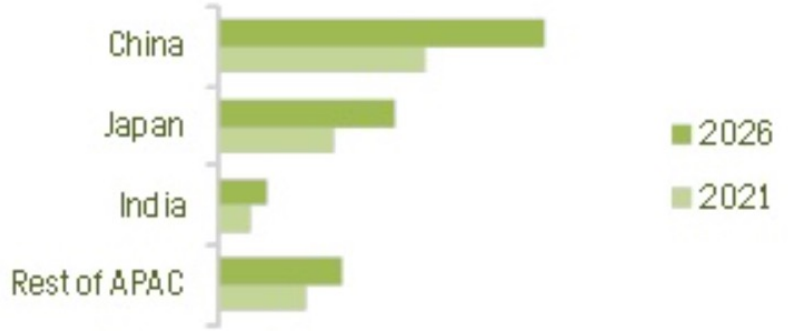
HIGHEST CAGR
(2021–2026)

China
Fastest-growing market
in APAC

BY APPLICATION, 2021 (USD BILLION)



BY COUNTRY, 2021 & 2026 (USD BILLION)



FACTORS DRIVING GROWTH OF MARKET IN APAC

Attractive opportunities in the Biosensors Market

The ongoing demand for remote monitoring and connected healthcare solutions will push the demand for wearable devices, which is expected to boost the sale of biosensors across POC and home diagnostic applications

25.5 USD BILLION 2021-e

36.7 USD BILLION 2026-p

CAGR of 7.5%

The biosensors market is valued at USD 25.5 billion in 2021 and is projected to reach USD 36.7 billion by 2026; it is expected to grow at a CAGR of 7.5% from 2021 to 2026.

The growing prevalence of infectious and lifestyle diseases, such as cardiac complications, diabetes, and the current COVID-19 pandemic is increasing the demand for POC diagnostics.

Governments across various countries are taking initiatives to provide diagnostics and drug services to ensure availability and access to diagnostic tests to reduce out-of-pocket expenditure incurred by patients on diagnostics.

Emerging markets, such as China, India, Brazil, and Mexico, offer significant growth opportunities for biosensors.

The emergence of wearable biosensors across medical and health services is expected to provide opportunities for the market

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1ST Workshop on NEXT GENERATION OF SENSORS

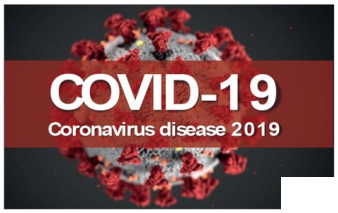
VIRTUAL CONFERENCE - 24 MARCH 2021

Young Generation in Sensors discussing Next-Generation of Sensors

NGS 2021

TOPIC

"Cutting-Edge (Bio)sensing Technologies for Fighting Infectious Diseases"



in collaboration with nano SPRINGER NATURE

The Scientific Committee

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Indian Institute of Technology (BHU)

Can Dincer
University of Freiburg, Germany

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California Institute of Technology, USA

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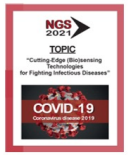


2021 2023 2025 2027 2029

Every two years with a selected hot topic on next generation sensors

For this reason, rapid tests have been strongly required for antigen detection to easily and quickly evaluate contagious people and thus delimitate the virus spread among the population. To this aim, the EC promptly launched on 30 January 2020 the Call for Projects entitled "SC1-PHECORONAVIRUS-2020: Advancing knowledge for the clinical and public health response to the [COVID-19] epidemic", founding 18 Projects with a budget of € 48.5 million, involving 151 research groups across Europe and beyond, for research activities devoted to counteracting COVID-19 emergency [7]. Four main pillars have been proposed, based on: i) infection monitoring systems, ii) point-of-care diagnostic tests, iii) new treatments, and iv) the development of new vaccines. Among them, the requirement for novel rapid diagnostics "will concentrate on enabling front-line health workers to make the diagnosis more quickly and more accurately, which will, in turn, reduce the risk of further spread of the virus", according to EC.

The following projects have been awarded for the development of novel diagnostics:

- CoNVat Combating 2019-nCoV: Advanced Nanobiosensing platforms for POC global diagnostics and surveillance, to develop a point-of-care device using optical biosensor technology for rapid diagnosis and monitoring the new coronavirus directly in the patient's sample (4 partners: ES(2), FR, IT) [8].

- CORONADX Three Rapid Diagnostic tests (Point-of-Care) for COVID-19 Coronavirus, improving epidemic preparedness, public health, and socioeconomic benefits, to deliver three complementary diagnostic tools, including one point-of-care diagnostic that can be used with minimal training (8 partners: AT, CN(2), DK(2), IT(2), SE) [9].

- HG nCoV19 test Development and validation of rapid molecular diagnostic test for nCoV19, to develop and validate a novel rapid molecular diagnostic test for coronavirus (4 partners: CN, IE, IT, UK) [10].

affaritaliani.it
Il primo quotidiano digitale, dal 1996

Conte Vaccino Draghi Coronavirus ATTIVA LE NOTIFICHE FONDATORE E DIRETTORE:

Home > Salute >Coronavirus, dall'Italia un test salivare rapido, economico e non invasivo

MEDICINA

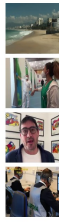
Mercoledì, 7 ottobre 2020 - 08:56:00

Coronavirus, dall'Italia un test salivare rapido, economico e non invasivo

Un team di ricercatori italiani mette a punto un biosensore elettrochimico miniaturizzato come possibile test di screening rapido, economico e non invasivo

L'enorme diffusione del **COVID-19** è causata dall'elevata infettività del virus SARS-CoV-2, dalla presenza di soggetti asintomatici e dall'assenza di vaccini e farmaci specifici che consentano una gestione accurata di questa esplosione pandemica.

Ti potrebbe i



Triennale SCIENZE DELL' E GASTRONO

Ministero dello Sviluppo Economico

Ricevuta di presentazione

per

Brevetto per invenzione industriale

Domanda numero: 102020000016948

Data di presentazione: 13/07/2020

Biosensors and Bioelectronics 171 (2021) 112686

Contents lists available at ScienceDirect

Biosensors and Bioelectronics

journal homepage: http://www.elsevier.com/locate/bios

Check for updates

Magnetic beads combined with carbon black-based screen-printed electrodes for COVID-19: A reliable and miniaturized electrochemical immunosensor for SARS-CoV-2 detection in saliva

Laura Fabiani [a], Marco Saroglia [b], Giuseppe Galatà [c], Riccardo De Santis [d], Silvia Fillo [d], Vincenzo Luca [d], Giovanni Faggioni [d], Nino D'Amore [d], Elisa Regalbuto [d], Piero Salvatori [e], Genciana Terova [b], Danila Moscone [a], Florigio Lista [d], Fabiana Arduini [a,f,*]

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[e] UOC, Army Medical Center, Rome, Italy
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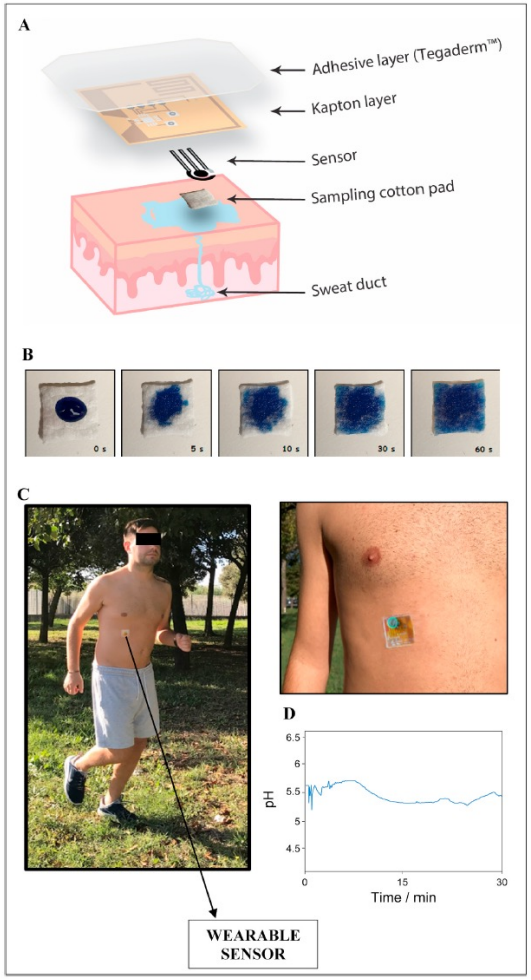
Magnetic beads combined with carbon black-based screen-printed electrodes for COVID-19: A reliable and miniaturized electrochemical immunosensor for SARS-CoV-2 detection in saliva

1 January 2021

Laura Fabiani | Marco Saroglia | Giuseppe Galatà | Riccardo De Santis | Silvia Fillo | Vincenzo Luca | Giovanni Faggioni | Nino D'Amore | Elisa Regalbuto | Piero Salvatori | Genciana Terova | Danila Moscone | Florigio Lista | Fabiana Arduini



Talanta 222 (2021) 121502

Contents lists available at ScienceDirect

Talanta

journal homepage: www.elsevier.com/locate/talanta

Medium-distance affordable, flexible and wireless epidermal sensor for pH monitoring in sweat

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[b] Department of Civil Engineering and Informatics, University of Rome Tor Vergata, Via del Politecnico,1, 00133, Rome, Italy
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Biosensors and Bioelectronics 172 (2021) 112750

Contents lists available at ScienceDirect

Biosensors and Bioelectronics

journal homepage: http://www.elsevier.com/locate/bios

Wearable electrochemical biosensors in North America

Jihong Min [a,1], Juliane R. Sempionatto [b,1], Hazhir Teymourian [b,1], Joseph Wang [b,*], Wei Gao [a,**]

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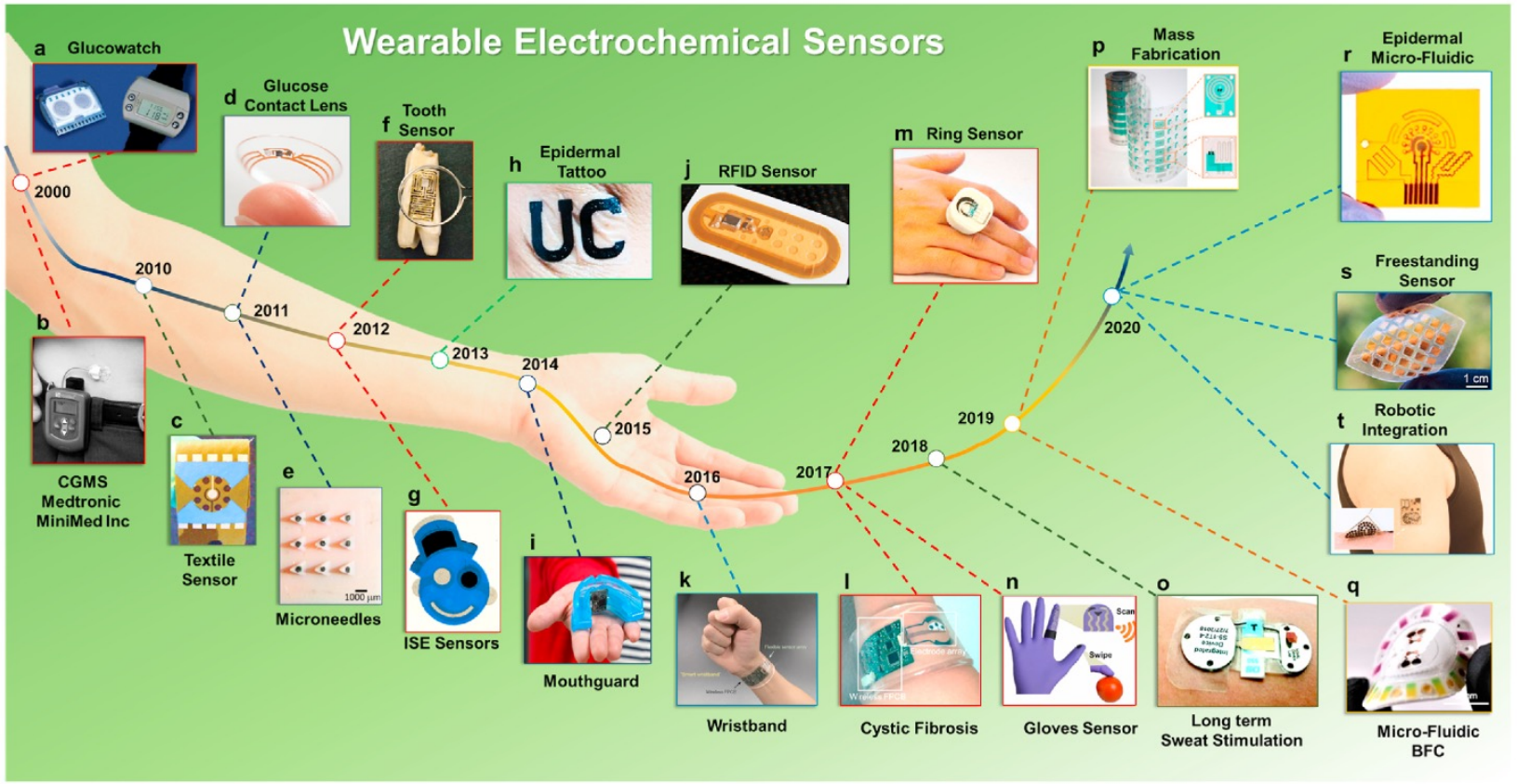
[b] Department of Nanoengineering, University of California San Diego, La Jolla, CA, 92093, USA

ARTICLE INFO

Keywords:
Wearable biosensors
Flexible electronics
Electrochemistry
Personalized medicine
COVID-19
Telemedicine

ABSTRACT

Tremendous research and commercialization efforts around the world are focused on developing novel wearable electrochemical biosensors that can noninvasively and continuously screen for biochemical markers in body fluids for the prognosis, diagnosis and management of diseases, as well as the monitoring of fitness. Researchers in North America are leading the development of innovative wearable platforms that can comfortably comply to the human body and efficiently sample fluids such as sweat, interstitial fluids, tear and saliva for the electrochemical detection of biomarkers through various sensing approaches such as potentiometric ion selective electrodes and amperometric enzymatic sensors. We start this review with a historical timeline overviewing the major milestones in the development of wearable electrochemical sensors by North American institutions. We then describe how such research efforts have led to pioneering developments and are driving the advancement and commercialization of wearable electrochemical sensors: from minimally invasive continuous glucose monitors for chronic disease management to non-invasive sweat electrolyte sensors for dehydration monitoring in fitness applications. While many countries across the globe have contributed significantly to this rapidly emerging field, their contributions are beyond the scope of this review. Furthermore, we share our perspective on the promising future of wearable electrochemical sensors in applications spanning from remote and personalized healthcare to wellness.


Wearable Electrochemical Sensors
a Glucowatch
b
CGMS
Medtronic
MiniMed Inc
c
Textile
Sensor
d Glucose
Contact Lens
e
Microneedles
f Tooth
Sensor
g
ISE Sensors
h Epidermal
Tattoo
i
Mouthguard
j RFID Sensor
k
Wristband
l
Cystic Fibrosis
m Ring Sensor
n
Gloves Sensor
o
Long term
Sweat Stimulation
p Mass
Fabrication
q
Micro-Fluidic
BFC
r Epidermal
Micro-Fluidic
s Freestanding
Sensor
t Robotic
Integration
2000
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020

Call

Tools and technologies for a healthy society (2021) (HORIZON-HLTH-2021-TOOL-06)

See budget overview

Type of action

HORIZON-IA HORIZON Innovation Actions

Type of MGA

HORIZON Action Grant Budget-Based [HORIZON-AG]

Open for submission

Deadline model

single-stage

Opening date

22 June 2021

Deadline date

21 September 2021 17:00:00 Brussels time

The Commission estimates that an EU contribution of around EUR 6.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts. Type of Action Innovation Actions Expected Outcome: This topic aims at supporting activities that are enabling or contributing to one or several expected impacts of destination 5 “Unlocking the full potential of new tools, technologies and digital solutions for a healthy society”. To that end, proposals under this topic should aim for delivering results that are directed, tailored towards and contributing toall of the following expected outcomes.

• Medical device developers provide sustainable and affordable smart active implants validated in the operational environment.• Medical professionals in resource-constrained clinical settings use sustainable and affordable surgical procedures for smart active implants.• Patients have access to sustainable and affordable smart medical devices suitable for minimally invasive surgical implantation through further clinical studies.
Scope: “Smart” technologies, i.e. micro-electronic sensor/actuator systems provide novel functionalities to surgically-implanted active medical devices. “Smart” active implants involve microelectronic components and are placed inside the body of the patient to achieve the desired physiological response. They open up therapeutic avenues for a wide range of medical handicaps, complex chronic conditions and lesions, thanks to their integrated diagnostic capabilities, and may help addressing hitherto unmet medical needs. Challenges involved in the development of these devices include but are not limited to miniaturization, sensor robustness, wireless power supply, etc. Such devices require specific surgical implantation procedures, dependant on the type of device and on the intended use, with the successful surgical implantation and activation of such smart medical implants, being crucial steps for their functioning.

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HORIZON-CL6-2022-ZEROPOLLUTION-01-04: Securing drinking water quality by protecting water sources against pollution, providing innovative monitoring and treatment solutions and ensuring safe distribution

Horizon Europe - Work Programme 2021-2022
Food, Bioeconomy Natural Resources, Agriculture and Environment

Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 2.00 and 4.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 15.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 5 by the end of the project – see General Annex B.

Expected Outcome: In line with the European Green Deal's zero pollution ambition, successful proposals will contribute to halt and prevent pollution of freshwater and soils, and consequently also protecting biodiversity, as addressed by several impacts under Destination 4, in particular "Advanced understanding of diffuse and point sources of water pollution in a global and climate changing context, enabling novel solutions to protect water bodies, aquatic ecosystems and soil functionality, and further enhancing water quality and its management for safe human and ecological use, while fostering the European position and role in the global water scene."

Project results are expected to contribute to some of the following expected outcomes:

- A wider use of a better understanding and an enhanced knowledge base required to assess pollution sources, pathways and combined effects on drinking water systems, including forward looking approaches aimed to anticipate and prepare for future or emerging challenges.
- Implement advanced preventive and mitigating strategies and measures to protect drinking water sources, treatment and supply against harmful effects of global and climate change.
- Apply effective risk assessment and risk management strategies enabling early warning systems and delivering ready-made outputs for decision-making and governance.
- Exploit advanced, integrated and cost-effective water quality sensors and analytical methods.
- Deploy innovative and robust monitoring systems and real-time information on drinking water quality, from sources to supply.
- Disseminate and use a robust knowledge on the occurrence, persistence and degradability of disinfection by-products (DBPs) in drinking water with due consideration to operational parameters, chemicals, materials and biofilms interactions, including the pathways related to human exposure.

- Spread the use of advanced and cost-effective drinking water treatment and disinfection processes and technologies, including transformative approaches.
- Broad uptake of advanced knowledge, breakthrough solutions and innovative technologies to enhance competitiveness of the EU water sector and fostering the EU's position and role in the global water scene.
- Increasing the EU scientific and technological base and guidance on measures to manage drinking water quality and evidence for policy-making, safety planning and implementation.
- Science and evidence-based implementation of the European Green Deal and the Sustainable Development Goals, notably the SDG 6 "Ensure availability and sustainable management of water and sanitation for all".

Scope: The European Union policy framework has secured public safety and health objectives by the Drinking Water, Bathing Water and Floods Directives (EU, 1998, 2006, 2007), and the ongoing development and implementation of minimum requirements for water reuse. Despite the valuable output of implemented measures, some persistent problems are still a major, and sometimes unknown, risk factor for human and ecosystem health. Past contaminated sites and industrial activities managing hazardous chemicals, such as highly persistent compounds, together with agriculture and food production (pesticides, herbicides, antibiotics etc.), and household activities release a number of substances that individually or combined represent a concern for the safety of drinking water supplies. Detrimental effects of natural/human-made disasters and increasing water temperatures due to climate change could deteriorate the quality of drinking water sources by favouring the conditions for enhanced eutrophication leading to algal and cyanobacterial outbreaks as well as pathogen development or the spread of invasive species. Emerging concerns are also rising at the level of drinking water treatment and distribution, notably in relation to disinfection operations, materials and products, aging infrastructure, biofilm growth and possible harmful effects of unintentionally formed by-products and metabolites.

Actions in this field should aim to expand the knowledge base required to identify, assess and prevent pollution threats (micro-pollutants, pathogens, toxins, algal blooms, etc.) and the combined effects of multiple stressors on water sources, including risk assessment and management, to protect drinking water preparation and distribution. Particular attention to extreme weather events and possible synergistic effects affecting hydraulic flows, temperatures and pollutants' loads should be considered, whenever appropriate.

Advanced water quality assessment will need further development of sensors sensitivity, automated routine monitoring and fast analytical responses that fully integrate IT advances. Proposals in this topic should aim to extend the current analytical capacity to enable among other issues the detection of suspect and non-targeted pollutants, resulting in robust and reliable monitoring systems for consideration in future legislation. They should also consider the requirements of the revised Drinking Water Directive as regards catchment management.

Horizon Europe - Work Programme 2021-2022
Food, Bioeconomy Natural Resources, Agriculture and Environment

Unintended disinfection by-products (DBP) and interactions with chemical reagents used for drinking water treatment (DWT), engineering and contact materials as well as the combined effects of biofilms formation are emerging as hazardous chemical risks that could affect human health. Proposals in this field should further extend the knowledge base of mechanisms and reactions leading to DBP formation by analysing raw water quality and precursors, as well assessing DWT operational parameters, including disinfection needs, methods and doses. Advanced DWT solutions should explore integrated systems coupling different treatment technologies and strategies enabling the optimization of the operational DWT effectiveness while removing DBP risks.

In general, the participation of academia, research organisations, utilities, industry and regulators is strongly advised, as well as civil society engagement whenever necessary, also aiming to broaden the dissemination and exploitation routes and to better assess the innovation potential of developed solutions and strategies.

If appropriate, applicants are advised to seek complementarities and synergies, while avoiding duplication and overlap, with relevant actions funded under previous Horizon 2020 calls[336], as well as targeted topics supported in the last Horizon 2020 and Horizon Europe calls, addressing micro/nano-plastics, persistent and mobile pollutants, such as per- and polyfluoroalkyl substances (PFAS), pharmaceuticals and contaminants of emerging concerns (CECs), pathogens and antimicrobial resistance. Whenever possible, proposals should consider already developed digital solutions for real-time water monitoring systems. Activities related to water reclamation and reuse, indirect potable use or alternative water sources are beyond the scope of this topic.

In order to better address some or all of the expected outcomes, international cooperation is encouraged.

Annex II

Significant research projects selected within the frame of the Executive Programme of Scientific and Technological Cooperation between Italy and Sweden for the years 2018 - 2020

AREA	TITLE	ITALIAN CO-ORDINATOR	ITALIAN INSTITUTION	SWEDISH CO-ORDINATOR	SWEDISH INSTITUTION
CH	Innovative tools for conservation and monitoring of artworks in concrete by exploiting electrochemical paper-based sensors, functionalized nanomaterials, and modelling INNOCONCRETE	ARDUINI Fabiana	Tor Vergata University - Rome	KERSTI Hermansson	Uppsala University
ENV	Natural hazards in future forests: how to inform	TOGNETTI			Swedish University

Fig. 1 Sustainable Development Goals (SDGs) established by United Nation. A picture of a paper-based device has been added as marker where this device can help to achieve the selected SDG.

ChemElectroChem
Chemistry Europe
European Chemical Societies Publishing

Article

A Paper-Based Potentiometric Sensor for Solid Samples: Corrosion Evaluation of Reinforcements Embedded in Concrete Structures as a Case Study

Dr. Noemi Colozza, Dr. Alessandro Sassolini, Dr. Lorenzo Agosta, Alfredo Bonfanti, Prof. Kersti Hermansson, Prof. Fabiana Arduini

First published: 03 May 2020 | https://doi.org/10.1002/celc.202000330 | Citations: 1

Analytica Chimica Acta 960 (2017) 123–130

Contents lists available at ScienceDirect

Analytica Chimica Acta

journal homepage: www.elsevier.com/locate/aca

A paper-based nanomodified electrochemical biosensor for ethanol detection in beers

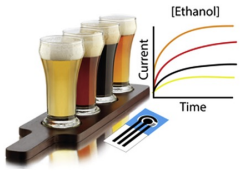
Stefano Cinti*, Mattia Basso, Danila Moscone, Fabiana Arduini**

Department of Chemical Science and Technology, University of Rome "Tor Vergata", Via della Ricerca Scientifica, 00133 Rome, Italy

HIGHLIGHTS

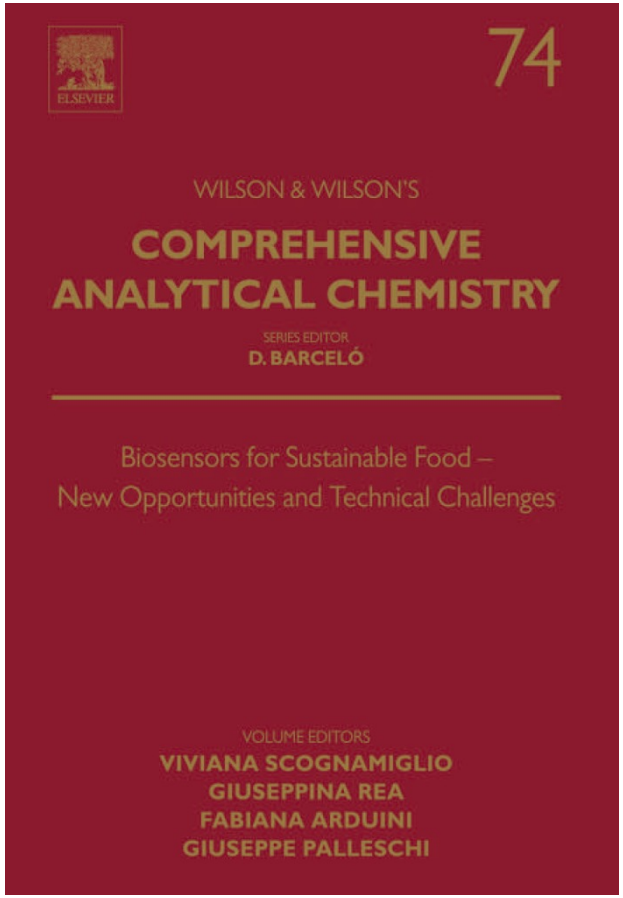
- Novel ethanol biosensor fabricated onto office paper.
- Enhanced hydrogen peroxide detection using Carbon black/Prussian blue nanoparticles.
- Only 100 μL required to perform measurements.
- Paper-based electrochemical device coupled with a portable potentiostat.
- Rapid quantification of ethanol in beer samples.

GRAPHICAL ABSTRACT



ARTICLE INFO

ABSTRACT



Commercially Available (Bio)sensors in the Agrifood Sector

A. Antonacci,[1] F. Arduini,[2] D. Moscone,[2] G. Palleschi[2] and V. Scognamiglio[1,*]

[1]*IC-CNR Istituto di Cristallografia, Rome, Italy;* [2]*Università di Roma Tor Vergata, Rome, Italy*

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Chapter Outline

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Sense4Med

Thank you

for the kind attention!