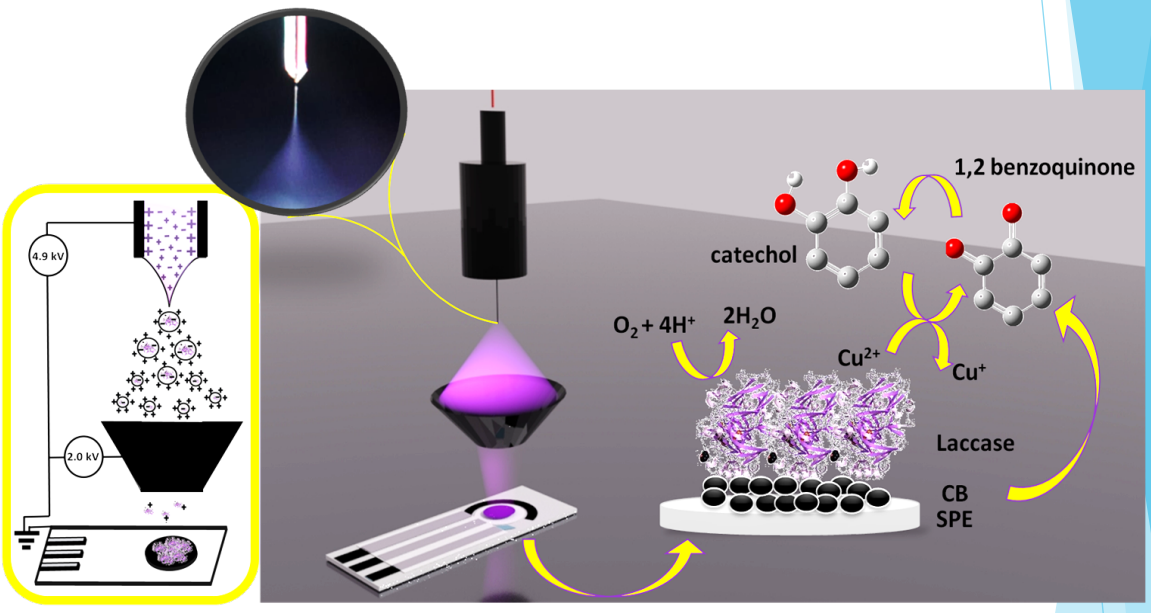
“Nuove tecnologie per sensori e biosensori @ CNR- Area della Ricerca di Roma 1”
25 Febbraio 2021- Virtual Event

Evento nell’ambito del Progetto
«Deposizioni per ElectroSpray Ionization e biosensoRi-DESIR»
Bando «progetti di Grupppi di Ricerca» 2017-Legge13/2008-art4 Lazio Innova



Credit: Biosensors and Bioelectronics 2020, 163, 112299

Partecipa all’evento da computer-tablet-smartphone:
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DESIR
DEPOSIZIONI PER ELECTROSPRAY IONIZATION E BIOSENSORI

Partner del progetto

Collaboratori del progetto

Nell'ambito del progetto DESIR (Deposizioni per ElectroSpray Ionization e biosensoRi), progetto finanziato ai sensi della L.R.13/08 BANDO "GRUPPI DI RICERCA" da Lazio Innova, è stato organizzato per il giorno 25 febbraio 2021 il workshop online "Nuove tecnologie per sensori e biosensori @ Area della Ricerca di Roma 1".

Lo scopo del progetto DESIR è quello di realizzare un prototipo per la deposizione di enzimi per biosensori per ambienti di vita, alimenti e diagnosi precoci. Il raggiungimento di questo obiettivo ha visto l'applicazione sinergica di varie competenze dalla progettazione e realizzazione di dispositivi alla preparazione e trattamento di soluzioni e di biosistemi, dalla simulazione teorica con metodi di dinamica molecolare ai software per il controllo in real-time di strumentazione e di analisi dati. Molte di queste competenze hanno visto coinvolti colleghi di Istituti dell'Area della Ricerca Roma 1 e PMI che collaborano con questi Istituti.

Da questa esperienza è nata l'idea di utilizzare l'evento per dare evidenza delle competenze multidisciplinari presenti sull'Area nel settore delle tecnologie per sensori e biosensori e delle collaborazioni con PMI del territorio che hanno trovato applicazione in tutta una serie di progetti europei o nazionali in settori quali salute, ambiente, agroalimentare e beni culturali.

L'evento fornirà anche l'occasione per confrontarsi sulle tecnologie sviluppate, e valutare le possibili applicazioni/collaborazioni e opportunità di mercato insieme a PMI innovative presenti sul territorio e dare un piccolo contributo alla costruzione di un pianeta più sostenibile.

Agenda	Speaker		Time
Welcome	L. Avaldi Project Coordinator		9:00-9:05
Opening	*On. M. Smeriglio,* Dr. G. Mancini, Prof. A. Di Carlo		9:05-9:30
DESIR Project: Principal results	Speakers L.Avaldi, P. Bolognesi, A.R. Casavola, A. Cartoni, M Castrovilli		9:30-10:30
Topic1: Diagnostica medicale	PMI Microsis	R. Antoniucci	10:30-11.15
	Progetto Sensocard	M. Parracino	
	PMI Sens4Med	F. Arduini	
Time for discussion: Meet the speakers 10:45– 11.15			
Topic2: Diagnostica ambientale	Progetto AD-SWIM	V.Scognamiglio	11:15-12:00
	PMI Biosensor	G. Varani	
	Progetto INAIL-(BRIC16ID12/BRIC19ID07)	A. Macagnano	
Time for discussion: Meet the speakers 12:00-12:15			
Topic2: Diagnostica ambientale	Progetto NMP-APACHE	D. Trucchi	12:15-13:00
	Progetto AQUALITY	C. Bombelli	
	Progetto Life-RESPIRE	G. Ciotoli	
Time for discussion: Meet the speakers 13:00-13:15			
Conclusive remarks 13:15-13:30			

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DESIR Project WP1 Responsible: A. Cartoni (Università di Roma Sapienza)

REALIZATION AND OPTIMIZATION OF AN ELECTROSPRAY IONIZATION SYSTEM FOR THE DEPOSITION (ESD) OF ENZYMES AT AMBIENT PRESSURE

A. Cartoni; M.C. Castrovilli

[1] Sapienza Università di Roma; [2] CNR-ISM, Area della ricerca di Roma 1

The main goal of this working group inside the DESIR project was the development and application of ElectroSpray Ionization (ESI) technique to deposit enzymes (ESD) on different surfaces at ambient pressure and temperature with the aim of developing high reproducibility and reliability biosensors. The laccase enzyme has been chosen for its well documented and huge use in different fields of life science. An automatized ambient pressure and temperature deposition system was projected and developed with significant reduction of the costs and the times of the whole process in comparison with other vacuum deposition techniques. The multidisciplinary team composed of Chemists, Physics, Biologists and motivated technicians together with the PMI Biosensor srl after about one year and half achieved a new laccase amperometric biosensor for catechol detection with excellent storage stability and reuse[1,2] (Figure 1). A standardized and reliable immobilization protocol that preserves activity of the laccase enzyme, improving its working/storage stability has been developed and new protocols have been expanded for new enzymes depositions. The Wp1 has also formed a precarious researcher Dr. Castrovilli (now permanent researcher CNR-ISM) to these new technologies promoting the dissemination of knowledge to the new generations with also the preparation of theses on this topic. Dr. Castrovilli, nowadays the responsible of the ESD apparatus in Montelibretti, will give a brief overview of the work carried out. The future perspectives are: 1) to create new biosensors, 2) to understand the molecular basis of this new effective and promising strategy.

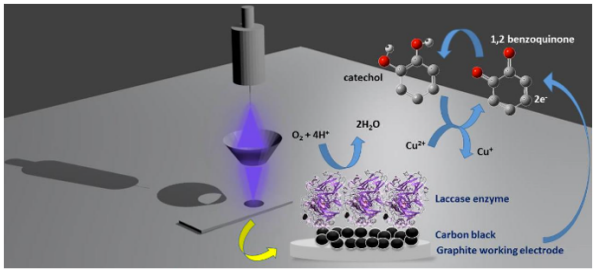

Figure 1: Schematic of ESI apparatus for deposition at ambient pressure and laccase catalysed red –ox reaction of catechol pollutant.

[1] MC Castrovilli et al., Trends in Analytical Chemistry.2019;119: 115615. DOI: 10.1016/j.trac.2019.07.026 ;
[2] MC Castrovilli et al., Biosensors and Bioelectronics.2020; 163: 112299. DOI: 10.1016/j.bios.2020.112299

COMPUTATIONAL STUDY OF THE ENZYME-SOLVENT AND ENZYME-SUPPORT INTERACTION

A. Cartoni[1], S. Borocci[2], A.R. Casavola*[3]
[1] Sapienza Università di Roma, [2]Università della Tuscia, [3]CNR-ISM, Area della ricerca di Roma1

Electrospray ionization (ESI) mass spectrometry (MS) is a widely used analytical technique that covers a various range of applications [1−3]. The ESI process starts with analyte solution that is passed through a conductive capillary to which high voltage has been applied. Redox processes lead to the buildup of positive or negative charge (depending on the polarity used) in the solution as it passes through the capillary [4]. This charge accumulation induces the formation of a Taylor cone at the capillary outlet from which a plume of highly charged droplets is emitted [5].
The study of evaporation of water from biological macromolecules is important for the understanding of electrospray mass spectrometry experiments. In electrospray ionization (ESI), electrically charged nanoscale droplets are formed from solutions of, for example, proteins. Then evaporation of the solvent leads to dry protein ions that can be analyzed in the mass spectrometer.
At the initial stage of the study, Cytochrome has been used in the definition of the computational methodology. The choice of this enzyme was due both to its size, which facilitate the choice of the optimal parameters for conducting Molecular Dynamics (MD) simulations, and for its use in the field of biosensors. In particular, the most suitable force field has been identified for the discussion of the interaction between the various atoms of the system both in solution and in the absence of solvent. The methodology has been validated through a comparison with the data and literature related to CytC. Successively, the laccase enzyme was studied, and MD simulations allowed to evaluate the effect of hydration on the dynamics and on the functionality of the enzyme. Indeed, simulations of both the laccase in solution and the evaporation process carried out under conditions similar to the experimental ones allowed to evaluate any structural changes of the protein following the loss of solvent molecules and the possible presence of amino acids on the surface of the protein or inside cavities which, following the interaction with water molecules, remain hydrated during evaporation at atmospheric pressure, as shown in fig.1.

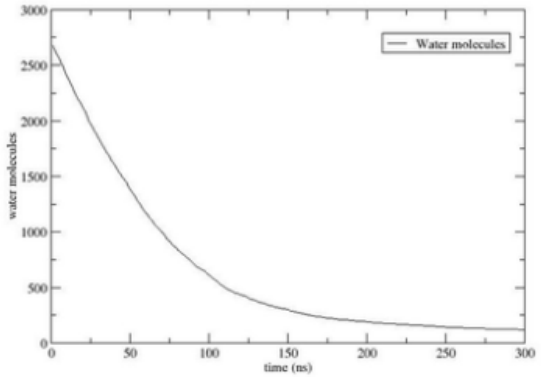

Figure 1A *Number of water molecule as a function of time.*

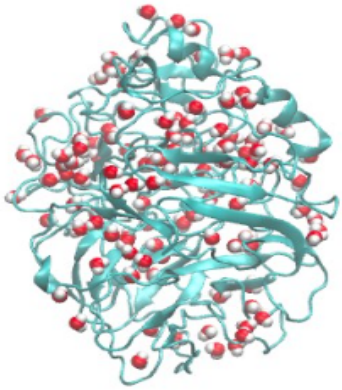

Figure 1B Laccase structure after 300 ns

REFERENCES
(1) Fenn, J. B. Electrospray wings for molecular elephants (nobel lecture). Angew. Chem., Int. Ed. 2003, 42, 3871−3894.
(2) Kaltashov, I. A.; Bobst, C. E.; Abzalimov, R. R. Mass spectrometry-based methods to study protein architecture and dynamics. Protein Sci. 2013, 22, 530−544.
(3) Nilsson, T.; Mann, M.; Aebersold, R.; Yates, J. R.; Bairoch, A.; Bergeron, J. J. M. Mass spectrometry in high throughput proteomics: Ready for the big time. Nat. Methods 2010, 7, 681−685.
(4) Van Berkel, G. J.; Kertesz, V. Using the electrochemistry of the electrospray ion source. Anal. Chem. 2007, 79,5511−5520.
(5) Kebarle, P.; Verkerk, U. H. Electrospray: From ions in solutions to ions in the gas phase, what we know now. Mass Spectrom. Rev. 2009, 28, 898−917

A PROTOTYPE ELECTROSPRAY IONISATION APPARATUS FOR HIGH VACUUM DEPOSITION OF MASS/CHARGE SELECTED SPECIES

P. Bolognesi[1], J. Chiarinelli[1], L. Carlini[1], P. Calandra[2], A. Cartoni[3], L. Avaldi[1]

[1] CNR-ISM, Area della ricerca di Roma 1; [2] CNR-ISMN, Area della ricerca di Roma 1; [3] Sapienza Università di Roma

The ElectroSpray Deposition (ESD) is a valuable approach for growing controllable layers of large and fragile biomolecular species that, being nebulized from a solution of low concentration of analyte into a fine mist, reach the target substrate with substantially preserved structure and biological activity, and allow the fabrication of biosensors [1].
The target substrate can be placed either facing the emitting source of the spray, in atmospheric pressure, or under vacuum, to achieve a clearer and better desolved deposit, with conformational control of the biomolecular species via mass-over-charge selection and 'soft-landing' technique.
The purpose of the Work Package 3 of the DESIR project was to design, construct and characterize a set-up in which an electrospray ionization source is coupled to a series of vacuum chambers that progressively guides the molecular beam into high vacuum environment, selecting specific mass/charge ratios for deposition in ultra-high vacuum.
The entire apparatus has been developed on an original, home-made, design for the molecular beam [2] (Figure 1) and deposition chamber (Figure 2).

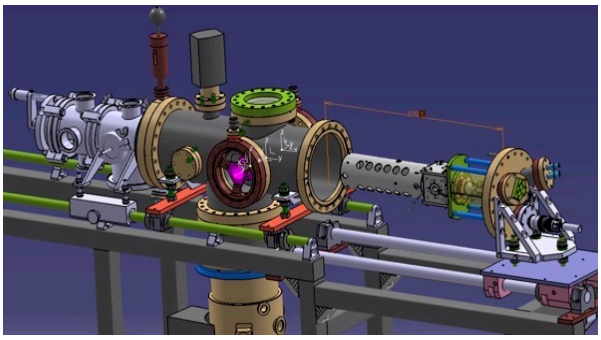

Figure 1. *The electrospray ionization (ESI) source, in-vacuum transfer and mass/charge selection.*

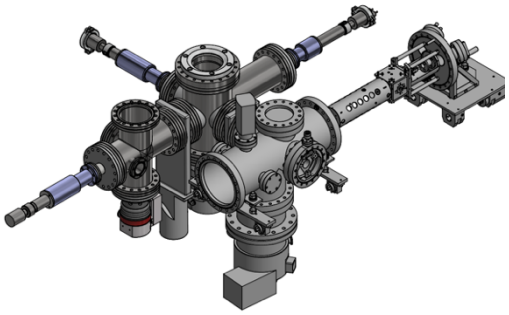

Figure 2*. The deposition chamber (Ionvac Process srl) connected to the ESI source.*

Acknowledgement.
We are very grateful to Aarhus University (Denmark) and CNRS-CIMAP, GANIL (France) for the technical support in the design and construction of the electrospray source apparatus.

References.
[1] M.C. Castrovilli, P. Bolognesi, J. Chiarinelli, L. Avaldi, A. Cartoni, P. Calandra, E. Tempesta, M. T. Giardi, A. Antonacci, F. Arduini, V. Scognamiglio, *Electrospray deposition as a smart technique for laccase immobilisation on carbon black-nanomodified screen-printed electrodes*, Biosensors and Bioelectronics 163, 112299 (2020).
[2] J. Chiarinelli , P. Bolognesi , and L. Avaldi, *Ion optics simulation of an ion beam setup coupled to an electrospray ionization source, strengths, and limitations* Rev. Sci. Instrum. 91, 073203 (2020).

Topic1: Diagnostica medicale

Sensors and EKG signal integration for a wider cardiovascular emergencies analyzing experience

Roberto Antoniucci

Microsis Via degli Olmetti,8A 00060 Formello (RM)

Microsis is a system integrator that boasts over ten years of experience in the study and implementation of complex systems dedicated to the world of medicine and scientific research. It has also carried out several projects that involved the implementation of special biosensors for the detection of antibiotic substances in liquids and has a vast know-how in electronic design and in the harmonization and integration of electronic and medical systems.
In recent years we have been involved in creating all the drivers necessary for communication with the sensors, the software for sampling and analyzing the data collected according to the algorithms defined in collaboration with the Cardiology department of the " Sapienza" University of Rome and several other institutes of the “CNR”.

The main purpose of our intervention is to provide non-invasive, low-cost and easy-to-find analysis tools on the market alongside innovative analysis tools in particular on saliva, for the study and specifically prevention of heart failure and sudden death risk.

Sensocard Project Responsible: L. Avaldi (ISM-CNR)

AU-NANOSTRUCTURED ELECTRODE SURFACE ENGINEERING VIA ELECTROSPRAY DEPOSITION FOR STABLE AND RELIABLE TROPONIN-APTASENSOR DEVELOPMENT

M.A. Parracino[1]
[1] *CNR-ISM, Area della ricerca di Roma 1*

In recent years several efforts have been done to develop and extensively utilize In-Vitro-Diagnostics (IVDs) based on the evaluation of cardiac biomarkers. However, both clinicians and laboratory-professionals still claim the need of improving the analytical quality of the diagnostic tools to monitor the myocardial injury (MI). The Troponin, a regulatory protein related to
Myocardial-contractility, has been associated to MI and identified as specific biomarker for monitoring the offset of pathology. The use of selective bioreceptors, such as the aptamers (single-stranded nucleic acid) able to target in a specific way the Troponin, would improve a sensitive detection of the biomarkers, providing reliable results to clinicians.
In this framework *Sensocard* has merged different expertise for the development of a POC for the early diagnosis of cardiac disorders, and in particular of MI.
We are exploiting the electrospray deposition (EDS) technique[1] at ambient pressure and temperature for the biomodification of the electrode surface allowing the creation of the biomolecules layer of identified aptamers onto a sensing surface capable to specifically target the Troponin[2-3]. The combination of highly stable and selective thiol-modified aptamers with EDS for reliable functionalization of the gold nanostructured electrode surface to maximizes the recognition. Moreover, the production of a highly dense packaged aptamers onto the electrode surface helps to avoid the non-specific interaction of target with surfaces[4], conferring to the aptasensor working and storage stability.

Figure: *Apatamers immobilization via improved ESI-thiol-linker and development of reliable aptasensor for troponine*

References.
[1] MC Castrovilli et al., Biosensors and Bioelectronics, 2020
[2] Anal. Chem. 2015, 87, 9869−9875
[3] Biosensors and Bioelectronics 134 (2019) 49–56
[4] ACS Omega 2020, 5, 25899−25905

PAPER-BASED BIOSENSORS: WHEN PAPER BECOMES A HUGE RESOURCE IN ELECTROCHEMISTRY

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[1]Department of Chemical Science and Technologies, Tor Vergata University, [2]SENSE4MED, via Renato Rascel 30, 00128, Rome, Italy

The paper-based colorimetric assays have been widely reported in literature being cost-effective, not requiring additional components (i.e. pump) for microfluidic handling of the solution, and avoiding the sample treatment thanks to the filtering property of the paper. In the last decade, the electroanalysis has discovered the utility of using paper as electrode-active support, converging the reported advantages of paper with the features of electroanalysis such the high sensitivity, selectivity, and the capability to work in complex matrices (e.g. coloured samples).
I will present the research activity carried out in the last 5 years at Nanobiosensing Lab and SENSE4MED at the Department of Chemical Science and Technologies of Tor Vergata University aimed to develop sustainable and cost-effective (bio)sensors for application in environmental, agrifood, security, and biomedical fields.

Fabiana Arduini is Associated Professor at Department of Chemical Science and Technologies, University of Rome “Tor Vergata”, CEO of start-up SENSE4MED, DG at ISO9001 Certified Laboratory LabCap, University of Rome "Tor Vergata”, Associated Editor of Microchemical Journal, Elsevier, and Coordinator of Italian Sensor Group, Italian Chemical Society 2019-2021. Her research activity deals with the development of miniaturised electrochemical devices mainly using screen-printed electrodes modified with nanomaterials and paper-based analytical tools applied in environmental, biomedical, and defense sectors, with over 120 articles published in peer-review journals, H index 40, scopus source, and more than 10 submitted patents. She has recently listed as World’s Top 2% Scientists.

AdSWIM Project

INNOVATIVE (BIO)SENSORS IN THE FRAME OF INTERREG ITALY-CROATIA ADSWIM PROJECT "MANAGED USE OF TREATED URBAN WASTEWATER FOR THE QUALITY OF THE ADRIATIC SEA"

Sabina Susmel[1], Federico Figueredo[1], Fabiana Arduini[2], Amina Antonacci[3], Viviana Scognamiglio[3]*

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AdSWiM connects research institutions, municipalities and managers of wastewater (WW) treatment plants to maintain and improve the quality of marine water (Water Framework Directive 2000/60/EC). The project investigates new treatments, new analytical devices and new chemical and microbiological parameters to maintain and improve the environmental quality conditions of sea and costal area and of the BW quality through the control of the WW.
AdSWiM improves sea and coastal water quality by using innovative technologies in the monitoring, treatment and management of the UWW depuration process. Among the different activities, the development of innovative biosensing solutions has been achieved for the detection of pesticides, pathogens, and orthophosphates.
In details, an optical biosensor has been realized exploiting artificial peptides bioinspired to the D1 protein from the Photosystem II of the green photosynthetic alga Chlamydomonas reinhardtii. Such biomimetics have been designed by computational modeling, produced by automated synthesis, and immobilized on quantum dots for the detection of pesticides [1]. In particular, two peptides, namely QDs/D1Pep-70-H and QDs/D1Pep-70-S268C, showed a limits of detection of 0.04 and 0.017 µg/L towards atrazine, respectively, within a linear range of 0.05 to 2.5 µg/L. Any matrix effect was observed in water samples for QDs/D1Pep-70-S268C, with a ratio between slopes of the calibration curves obtained in standard solutions and real samples equal to 1, and recovery values of 99±5 % and 98±3 % were obtained for 1 µg/L of atrazine. This detection capability is able to meet the requirements of European legislations which set the MRL for pesticides in surface water at 0.6 - 2 µg/l (2013/39/EU) [2].
Then, an electrochemical biosensor has been realized immobilizing whole cells of C. reinhardtii on carbon black nanomodified screen-printed electrodes for pathogen detection. In particular, the presence of Escherichia coli has shown the capability to enhance algae oxygen production and thus the current response of algae under light illumination, as also highlighted in literature for bacteria/algae co-cultivation. Indeed, the possibility of algal growth stimulation by bacterial attenuation of photosynthetic oxygen tension was described simulating the effect of bacteria through a physical removal of oxygen [3]. Preliminary results have demonstrated a 25 % of current increase at an applied potential of -0.6 V in the presence of 2000 CFU/mL of E. coli, concentration mainly found in wastewater.
Finally, a sensor for orthophosphates has been obtained modifying a graphite-composite electrode (PE) with a molybdate-derivative purposely synthesized to obtain non-aqueous soluble species. The electrode, easily prepared by casting-evaporation also varying the amount of molybdate, was characterized by XRD, SEM and, as proof of concept,

it was tested in an acidic solution of water of high ionic strength to detect orthophosphate. A range of concentration from 1 to 75 nM (Ip = 0.026 [H2PO4-] + 1.83, R2= 0.99) was investigated and a limit of detection (LOD) of 6.1 nM was calculated (3σ) which is in good agreement with the measurement of this nutrient in an oligotrophic environment. A comparison was finally carried out between the results of the analysis of seawater from Lignano offshore (FVG region) performed with Mo-PE electrode and the colorimetric approach (EPA #365.1). The concentration of H2PO4- was 12.30 ± 1.92 nM, when measured with Mo-PE, in accordance with the value obtained with the spectroscopic method (9.15 ± 3.84 nM).

References.

[1] Antonacci, A., Celso, F. L., Barone, G., Calandra, P., Grunenberg, J., Moccia, M., Gatto, E., Giardi, M.T., Scognamiglio, V. (2020). Novel atrazine-binding biomimetics inspired to the D1 protein from the photosystem II of Chlamydomonas reinhardtii. International Journal of Biological Macromolecules, 163, 817-823.

[2] Giardi, M. T., Zappi, D., Turemis, M., Varani, G., Celso, F. L., Barone, G., Calandra, P., Antonacci, A., Scognamiglio, V. (2021). Quantum dots functionalised artificial peptides bioinspired to the D1 protein from the Photosystem II of Chlamydomonas reinhardtii for endocrine disruptor optosensing. Talanta, 224, 121854.

[3] Mouget, J. L., Dakhama, A., Lavoie, M. C., de la Noüe, J. (1995). Algal growth enhancement by bacteria: is consumption of photosynthetic oxygen involved?. FEMS Microbiology Ecology, 18(1), 35-43.

Development and production of multitask sensor solutions

Gabriele Varani

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Biosensor SRL is a company that operates in the environmental and monitoring sector with consolidated experience in producing sensors and electronic instruments for agri-food and human safety applications. Biosensor is currently involved in three European and one national research projects. Respectively EUCALIVA ("EUCAlyptus LIgnin VAlorisation for Advanced Materials and Carbon Fibres", BBI-JTI 2016Horizon2020 ,Grant Agreement ID: 745789), NEMOSINE (European Union's Horizon 2020 Program: NMBP-35-2017—Innovative solutions for the conservation of 20th-century cultural heritage , Grant agreement ID: 760801), CANBIOSE (MSCA-RISE-2017 — Research and Innovation Staff Exchange H2020-EU.1.3.3 , Grant agreement ID: 778157) and TRUST-ME (funding by Progetti Stradegici AdS scienze della vita, Grant ID: 20192).

As a partner of the EUCALIVA research project, the company has projected innovative and completely eco-friendly electrodes obtained from the Eucalyptus processing chain's waste. Stretchable electronics were obtained by assembling the renewable conductive ink and the elastic Bio-polyurethane substrate. The electrodes, made using Screen Printing and Spray Coating techniques, can be employed to detect analytes of interest in various application fields such as agri-food and human health monitoring through amperometric analyzes or as capacitance-resistive tools for engineering applications. Also, the company is active in the development of wearable sensors for sweat analysis. Sweat can provide valuable information on the patient's state of health and the intensity of an athlete's effort during a training session.

Among the different tasks, Biosensor works in the gas detection field, environmental safety monitoring, and cultural heritage preservation. As a partner of the European project NEMOSINE, the company has developed several sensor arrays based on nanostructured materials to detect harmful gases. This innovative technological solution was used to monitor the acetic acid released by the degradation of cultural heritage films made of cellulose acetate. The proposed system can quantify and discriminate selectively and accurately the gases generated by the reels up to concentrations down to ppb levels.

Biosensor is currently involved in the TRUST-ME research project of "Lazio Innova" to develop instrumentation for rapid tests on urine, blood, or saliva with biosensors to diagnose infectious diseases. The goal is to create a new technology capable of detecting antigens through electric current/photometer flow variations in a special pre-conjugated chip. The chip can be functionalized with monoclonal antibodies that can detect and quantify in biological fluids the specific antibodies for a particular pathogen's biomarker. Biosensor has already developed a prototype to realize economic tests that do not require specialized personnel for applications in the "point of care" field. This prototype integrates an array with two cells for fluorescence measurements and a miniaturized instrumentation for electrochemical measurements on screen-printed electrodes.

Biosensor is also involved in the CANBIOSE European project, which arises from the multidisciplinary collaboration of international partners. In this context, researchers share new ideas, knowledge transfer from research to market, and vice-versa in the field of nanostructured metal oxide optical biosensors for cancer cell detection. Interdisciplinary project research and innovation goals are targeted to develop a new portable tool for early-stage cancer detection, which can solve one of the critical health challenges in EU society.

https://www.canbiose.lu.lv/en/

https://nemosineproject.eu/index.php

https://nemosineproject.eu/index.php

INAIL-BRIC16ID12/

BRIC19ID07

COMPOSITE POLYMER-BASED NANOFIBERS IN CONDUCTIVE CHEMICAL SENSORS FOR VOLATILE AND GASEOUS COMPOUNDS IN WORKPLACES: INAIL BRIC16-ID12

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Quantifying gas and volatile organic compounds (VOCs) to which personnel can be exposed, are becoming ever more a critical process due to rigorous environmental regulations and increasing health concerns. An inaccurate monitoring procedure introduces errors in health estimations, with consequent repercussion onto epidemiological research worldwide. Stuffy air can be responsible of tiredness and headaches, affecting people's comfort and wellbeing as well as productivity. On the other hand, more serious consequences can occur such as eye, nose, and throat irritation, nausea, dizziness and in some cases acute and chronic respiratory illnesses including asthma, pneumonia, chronic obstructive pulmonary disease (COPD), Legionnaires' disease and building- related illness (BRI). Besides these unspecific adverse health effects, some VOCs are proven to be carcinogenic (e.g., benzene, styrene) or are suspected to be carcinogenic (e.g., formaldehyde). Furthermore, the actual concentrations of gaseous pollutants can also be amplified by other external factors including poor ventilation, humidity, and temperature. Air quality monitoring should be generally performed with specialized equipment and analytical methods by regulatory agencies and researchers. However, low-cost, and easy to use sensors able to monitor the various environments in real time, alerting people if necessary, are becoming a likely strategy. A strategy carried out within BRIC16 ID12 Project, used sensors based on polymeric fibers since extremely attractive for their low cost and great versatility of the raw materials that could be easily modulated, depending on the transducer used and the analytes. More in detail, the attention was focused on the challenging goal of developing miniaturized conductive sensors for measuring gases and VOCs by employing suitable scaffolds of eco-friendly (polyhydroxy alkanoate-PHA) and sustainable (recycled) nanomaterials (polystyrene-PS). The conductivity was achieved by introducing inside fibers mesoporous graphitized carbon (MGC, i.e. mesoporous graphene). The selectivity of fibers was modified by encapsulating macromolecules sensitive to several classes of gas and VOCs.

Therefore, heterocyclic compounds of tetraphenylporphyrins (TPPs) were synthesized and solubilized within selected polymer blends solutions and subjected to electrospun deposition on interdigitated metal electrodes. More specifically, Me-TPP within PS-PHB-MGC fibers had a key role to make the sensors more conductive and sensitive to several VOCs, especially to aromatic hydrocarbons. Conversely, MGC within PS-PHB fibers increased their sensitivity to electron withdrawing gas (NO_2) and selectivity could be set by changing the sensor working temperature (30°-100°C).

References

Avossa J, Paolesse R, Di Natale C, Zampetti E, Bertoni G, De Cesare F, ScarasciaMugnozza G, Macagnano A (2019). Electrospinning of Polystyrene/Polyhydroxybutyrate Nanofibers Doped with Porphyrin and Graphene for Chemiresistor Gas Sensors. NANOMATERIALS, vol. 9, ISSN: 2079-4991, doi: 10.3390/nano9020280

Avossa, Joshua, Zampetti, Emiliano, De Cesare, Fabrizio, Bearzotti, Andrea, Scarascia-Mugnozza, Giuseppe, Vitiello, Giuseppe, Zussman, Eyal, Macagnano, Antonella (2018). Thermally driven selective nanocomposite PS-PHB/MGC nanofibrous conductive sensor for Air Pollutant detection. FRONTIERS IN CHEMISTRY, vol. 6, ISSN: 2296-2646, doi: 10.3389/fchem.2018.00432

Bearzotti A, Macagnano A, Papa P, Venditti I, Zampetti E (2017). A study of a QCM sensor based on pentacene for the detection of BTX vapors in air. SENSORS AND ACTUATORS. B, CHEMICAL, vol. 240, p. 1160-1164, ISSN: 0925-4005, doi: 10.1016/j.snb.2016.09.097

Macagnano A, Avossa J (2020). Chapter 11 - Nanostructured composite materials for advanced chemical sensors. In: (a cura di): Vincenzo Guarino, Maria Letizia Focarete, Dario Pisignano, Advances in Nanostructured Materials and Nanopatterning Technologies Applications for Healthcare, Environmental and Energy. p. 297-332, Amsterdam:Elsevier, ISBN: 9780128168653, doi: 10.1016/B978-0-12-816865-3.00011-1

Zampetti E, Papa P, Avossa J, Bearzotti A, Balducci C, Tranfo G, Macagnano A (2021). Low-Cost Benzene Toluene Xylene Measurement Gas System Based on the Mini Chromatographic Cartridge. SENSORS, vol. 21, ISSN: 1424-8220, doi: 10.3390/s21010125

Active & intelligent PAckaging materials and display cases as a tool for preventive conservation of Cultural Heritage.

APACHE Project

SENSITIVE AND SELECTIVE ELECTROCHEMICAL SENSORS FOR MONITORING OF MUSEUM CRATE ATMOSPHERE

D. Trucchi on behalf of DiaTHEMA Lab of CNR-ISM, CNR-ISMN, and Ionvac Process Srl

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The development of low-cost sensitive and selective sensors for correctly monitoring the atmosphere immersing artistic and historic artifacts is one of the main aim of the frontier technology applied to cultural heritage. The attention is especially put to monitor the presence of formic and acetic acids, formaldehyde and acetaldehyde, as well as of relative humidity. Within the framework of the APACHE project, such challenge is tackled by developing strip nanostructured materials on nanostructured substrates such as polyimide to obtain enhanced-sensitivity, flexible, and low production cost sensors. The selectivity to the pollutants is obtained by the combination of the different materials composing a multi-strip sensor, each one with its own sensitivity to each pollutant. The final aim is building a fingerprint of the combined responses to each specific pollutant so to identify it and quantify its concentration. The presentation will report the present state-of-the-art technology, so to successively discuss the technology and results achieved under the APACHE project.

AQUALITY Project

LIPOSOME-BASED SENSOR FOR THE DETECTION OF BACTERIA IN DRINKING WATER

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Within the EU project AQUALITY: Online industrial water quality analysis system for rapid and accurate detection of pathogens, we proposed the use of engineered liposomes for detecting bacteria in drinking water. Our approach exploits a surface potential-sensitive fluorophore, 4-heptadecylumbelliferone (C17-HC, Chart 1) embedded in cationic liposomes. The interaction between liposomes and bacteria involves a change in the surface potential experienced by C17-HC and switches on an optical signal.
We prepared and characterized, by DLS, zeta-potential and fluorescence experiments, a large number of cationic liposomes formulated with a natural phospholipid 1,2-dipalmitoyl-sn-glycero-3-phosphocholine (DPPC) or 1,2-dioleoyl-sn-glycero-3-phosphocholine (DOPC), C17-HC, and one of three synthetic cationic components (Chart 1), differing from each other for the number of unsaturations on the polar ammonium head. Then we evaluated the ability of liposomes to produce a fluorescent signal upon interaction with three bacterial strains, Staphylococcus aureus, Escherichia coli and Enterococcus faecalis; moreover, we analyzed the fluorescent response of each liposome formulation in the presence of the three bacterial strains at the same time, in order to simulate a real scenario. We found that interaction with bacteria triggers an optical signal in six of the evaluated formulations, resulting responsive down to 102 CFU/mL of bacteria suspended in pipeline water coming from the water main of 1 Rome (Italy).

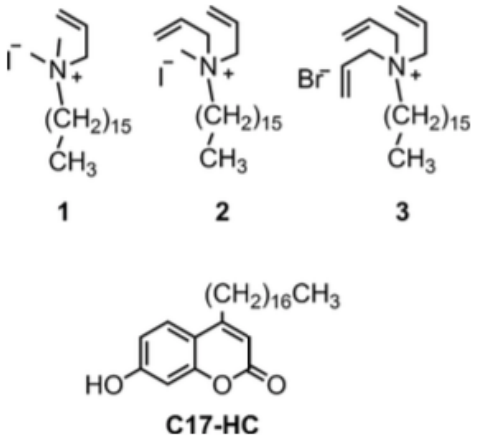

Chart 1. Fluorescent probe C17-HC and cationic amphiphiles 1–3

References.

[1] M. Petaccia, C. Bombelli, F. Paroni Sterbini, M. Papi, L. Giansanti, F. Bugli, M. Sanguinetti, G. Mancini, *Liposome-based sensor for the detection of bacteria* Sensors and Actuators, B: Chemical (2017), 248, 247-256

RESPIRE project

RADON REAL TIME MONITORING SYSTEM AND PROACTIVE INDOOR REMEDIATION - LIFE-RESPIRE

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According to the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), radon (Rn) is the most important source of ionizing radiation related to indoor air quality. The most important health effect of Rn exposure is the increased risk of lung cancer, second only to cigarette smoking (World Health Organization). The most recent European directive regarding human exposure to natural radiation (2013/59/EURATOM) deals primarily with indoor Rn, and encourages national action plans to identify buildings (i.e., areas) where annual Rn average is expected to exceed the national reference level defined at 300 Bq/m3 (i.e., Radon Prone Areas, RPA) and propose remediation. As the direct measurements of soilgas Rn, coupled with geological data, are well recognised to define the Geogenic Radon Potential (GRP) of an area (i.e., an estimate of the Rn originating from geological sources), the GRP can then be used to guide indoor surveys; as indoor Rn values are often highly variable. LIFE-RESPIRE objectives are:
- To demonstrate in 4 significant areas, with different GRP in Italy and Belgium, a cost-effective and eco-friendly solution for Rn real-time measurement and remediation to keep indoor Rn levels below 100 Bq/m3 level (as indicated in European Directive 2013/59/EURATOM). RESPIRE project will implement an intelligent, adaptable and versatile hybrid Rn remediation system composed by sensors, an Air Quality Balancer (SNAP) and an external additional fan-system (eolian and/or electric) working on positive pressure method. A control model based on an IoT protocol will be implemented;
- To construct a real time LIFE-RESPIRE geodatabase of collected continuous Rn measurements, coupled with other geological, geochemical and building characteristics data, that could be integrated within the framework of the European Atlas of Natural Radiation (promoted by the Joint Research Centre-JRC of the European Commission);
- To provide local authorities with Rn hazard guidelines and real-time WebGis radon maps for land use planning and health risk assessment, helping to prepare relevant national action plans (see Articles 54, 74 and 103 in 2013/59/EURATOM).
The LIFE-RESPIRE project will improve the use of geochemical monitoring of Rn for the assessment and the protection of human health from exposure to natural radioactivity. The visibility of the proposal and the availability of collected data are guaranteed by the WebGIS geodatabase that will be accessible to all stakeholders and several derived Web Mapping Applications to be used by the public and the authorities.