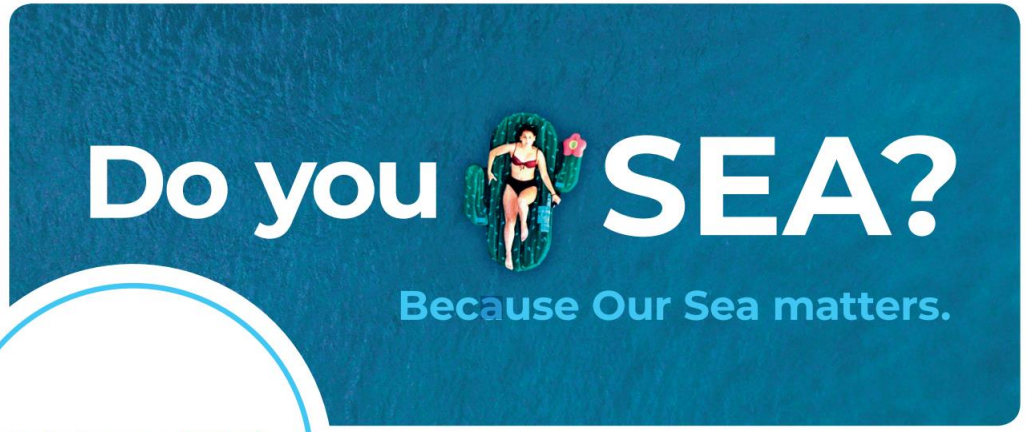


Pathogen and herbicide detection by innovative biosensor-based approaches

| Viviana Scognamiglio – IC/CNR |

AdSWiM

Interreg Italy-Croatia

AdSWiM Final Event On-line | 2021, December 14

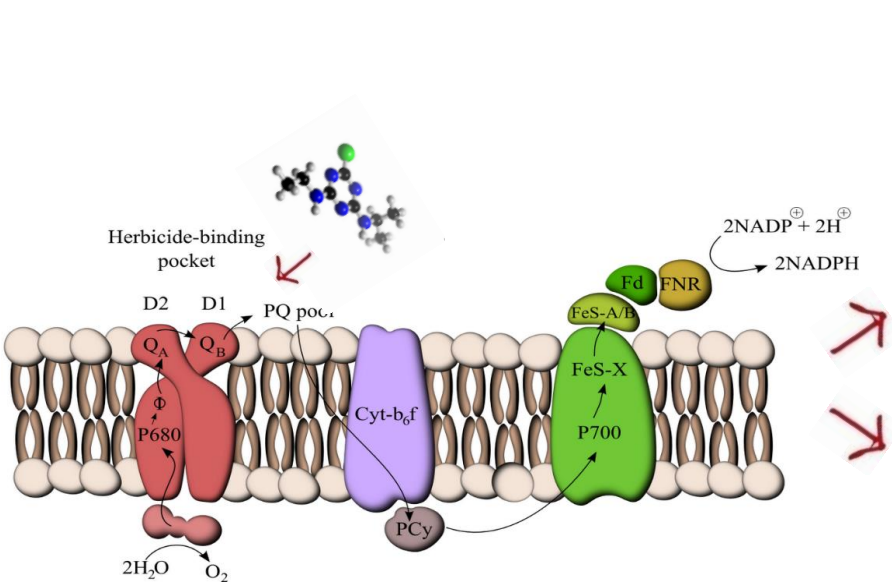
Description Activities WP 4.4

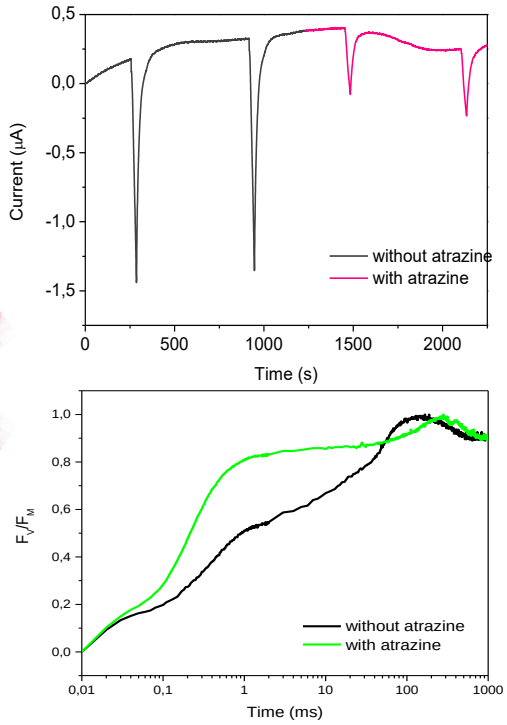
Task 4.4	Activity	Period	Comments
Task 4.4.1	Test of biotoxicity for pathogen by algal bioassays (IC-CNR)	M1-M24	1. Text of biotoxicity performed 2. Pathogen detection by algae in progress
Task 4.4.2	Analysis of pollutants achieved by biosensors based on synthetic molecules, produced by automated synthesis and functionally and structurally characterized by fluorescence spectroscopy and circular dichroism	M-1-M24	Biomimetics synthesised, characterised and used for the design of optical biosensor for pesticide detection
Task 4.4.3	Supports and strategies for biomolecules immobilization to develop biosensor device	M6-M24	Biomimetics immobilised and optosensor developed
Task 4.4.4	Sensor prototype set-up testing different materials (optical fibers, LEDs, photodiodes) and optimizing the algorithm for the fluorescence analysis (external expertise)	M6-M24	Sensor prototype realised by Biosensor s.r.l. and tested

Deliverables D4.4

Deliverables	Description
D4.4.1	1 Protocol assessing the microalgae capability to test biotoxicity
D4.4.2	1 Protocol of synthesis of mini-proteins and/or biomimetic peptide structurally and functionally characterized
D4.4.3	1 Protocol of immobilization on a proper substrate for biosensors optimization, defined
D4.4.4	1 Report of optical/electrochemical bioassay performances characterized

Chlamydomonas reinhardtii





Trends in Biotechnology
Volume 38, Issue 3, March 2020, Pages 334-347

Review

Biotechnological Advances in the Design of Algae-Based Biosensors

Amina Antonacci [1, 2], Viviana Scognamiglio [1, 2]

frontiers in CHEMISTRY
REVIEW ARTICLE
published: 12 June 2014
doi: 10.3389/fchem.2014.00036

Photosynthesis at the forefront of a sustainable life

Paul J. D. Janssen[1], Maya D. Lambreva[2], Nicolas Plumeré[3], Cecilia Bartolucci[2], Amina Antonacci[2], Katia Buonasera[2], Raoul N. Frese[4], Viviana Scognamiglio[2] and Giuseppina Rea[2]*

[1] Molecular and Cellular Biology - Unit of Microbiology, Institute for Environment, Health and Safety, Belgian Nuclear Research Centre SCK•CEN, Mol, Belgium
[2] Institute of Crystallography, National Research Council of Italy, Rome, Italy
[3] Center for Electrochemical Sciences-CES, Ruhr-Universität Bochum, Bochum, Germany
[4] Division of Physics and Astronomy, Department of Biophysics, VU University Amsterdam, Amsterdam, Netherlands

Analytical and Bioanalytical Chemistry
June 2009, 394:1081 | Cite as

Chlamydomonas reinhardtii genetic variants as probes for fluorescence sensing system in detection of pollutants

Authors Authors and affiliations

V. Scognamiglio, D. Raffi, M. Lambreva, G. Rea, A. Tibuzzi, G. Pezzotti, U. Johanningmeier, M. T. Giardi

ELSEVIER
Journal of Hazardous Materials
Volume 373, 5 July 2019, Pages 483-492

An eco-designed paper-based algal biosensor for nanoformulated herbicide optical detection

Viviana Scognamiglio [a], Amina Antonacci [a], Fabiana Arduini [b], Danila Moscone [b], Estefania V.R. Campos [c], Leonardo F. Fraceto [c], Giuseppe Palleschi [b]

Sensors and Actuators B 257 (2018) 658–665
Contents lists available at ScienceDirect
Sensors and Actuators B: Chemical
journal homepage: www.elsevier.com/locate/snb

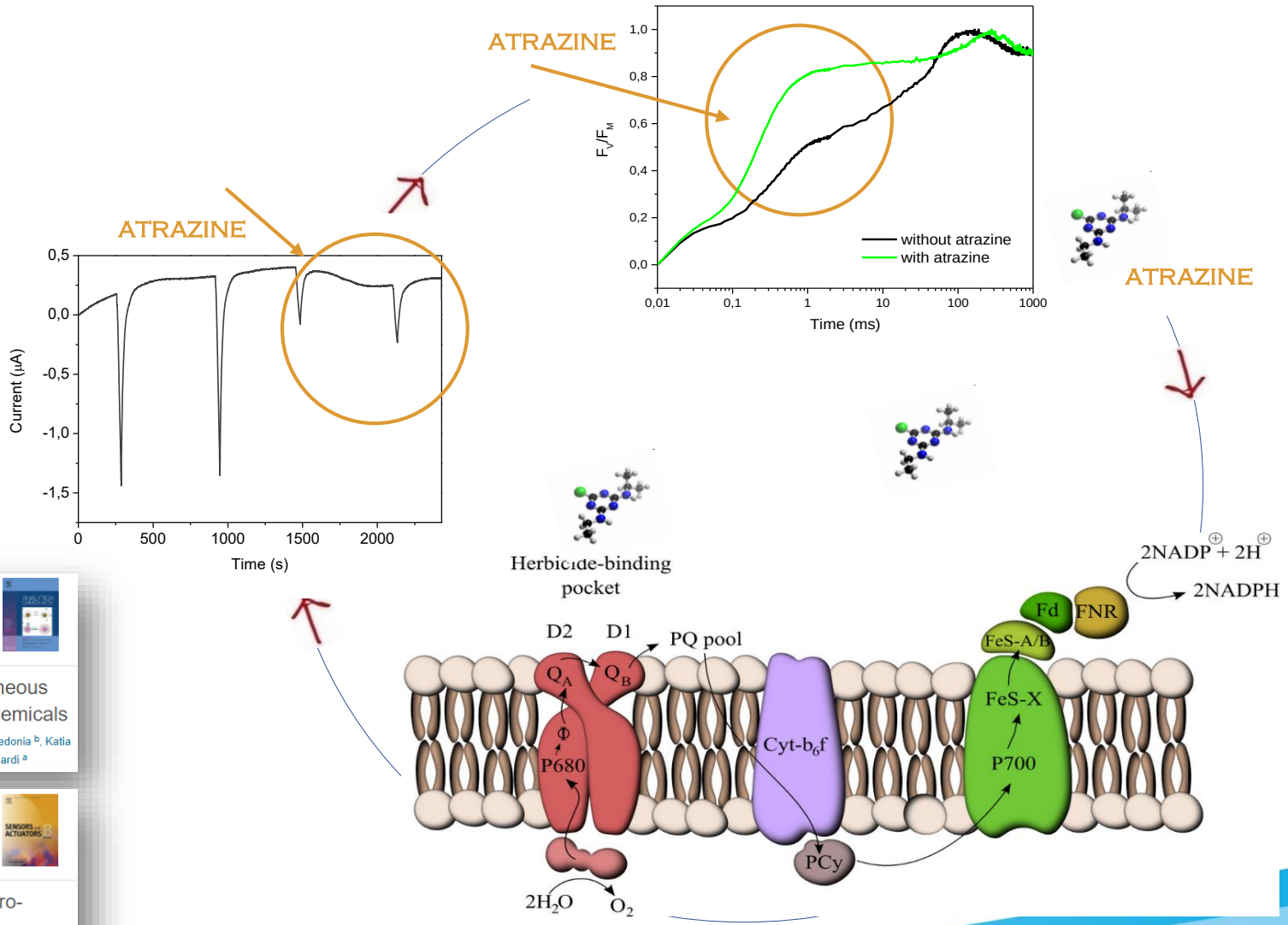
Research Paper

A whole cell optical bioassay for the detection of chemical warfare mustard agent simulants

Amina Antonacci[a], Maya D. Lambreva[a], Fabiana Arduini[b], Danila Moscone[b], Giuseppe Palleschi[b], Viviana Scognamiglio[a,*]

[a] Institute of Crystallography, Department of Chemical Sciences and Materials Technologies, Via Salaria Km 29.3, 00015 Monterotondo Scalo, Rome, Italy
[b] University of Rome "Tor Vergata", Department of Chemical Science and Technologies, Via della Ricerca Scientifica, 00133 Rome, Italy

PHOTO-ELECTROCHEMICAL PRINCIPLE FOR BIOSENSOR DESIGN



Analytica Chimica Acta
Volume 751, 2 November 2012, Pages 161-170

Towards an integrated biosensor array for simultaneous and rapid multi-analysis of endocrine disrupting chemicals

Viviana Scognamiglio [a], Italo Pezzotti [b], Gianni Pezzotti [b], Juan Cano [b], Ivano Manfredonia [b], Katia Buonasera [a], Fabiana Arduini [c], Danila Moscone [c], Giuseppe Palleschi [c], Maria Teresa Giardi [a]

Sensors and Actuators B: Chemical
Volume 176, January 2013, Pages 275-283

A new embedded biosensor platform based on micro-electrodes array (MEA) technology

Viviana Scognamiglio [a], Ittalo Pezzotti [b], Gianni Pezzotti [b], Juan Cano [b], Ivano Manfredonia [b], Katia Buonasera [a], Giuseppe Rodio [b], Maria Teresa Giardi [a]

Trends in Biotechnology
Volume 38, Issue 3, March 2020, Pages 334-347

Review

Biotechnological Advances in the Design of Algae-Based Biosensors

Amina Antonacci [1, 2], Viviana Scognamiglio [1, 2]

Algae-Based Biosensors

target

photosynthetic herbicides:

- **triazines** *e.g. atrazine, prometryn, terbuthylazine, simazine*
- **ureic** *e.g. diuron, linuron, isoproturon*

Heavy metals:

- *copper (Cu^{2+})*
- *mercury (Hg^{2+})*

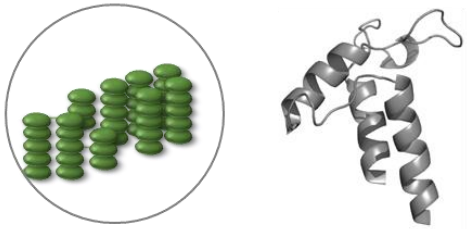
Chemical warfare agent simulants:

- *bis-2-chloroethyl amine*
- *2-chloroethyl ethyl sulphide*

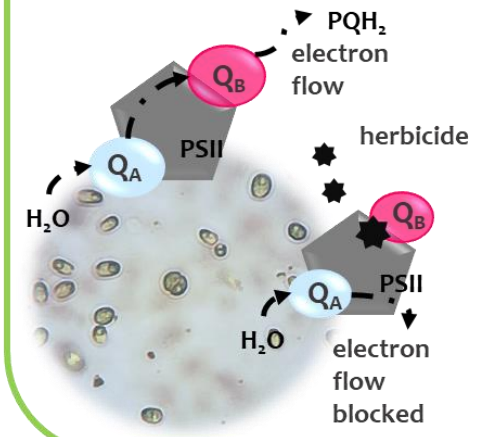
bioelement

thylakoid membranes

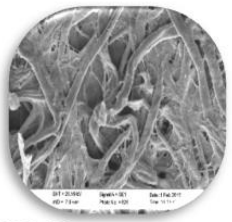
artificial peptide



whole cells & photosystem II

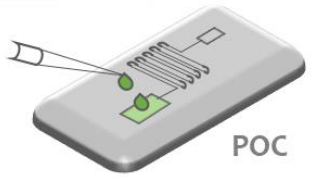


support



paper

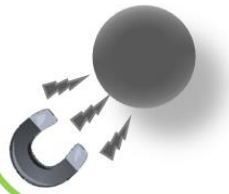
SPEs

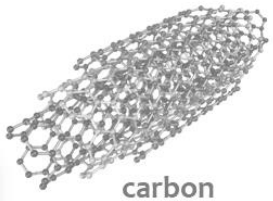


POC

nanomaterials

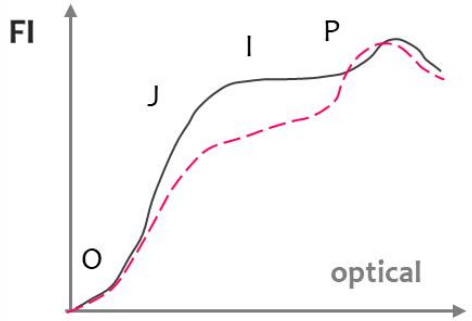
magnetic nanoparticles

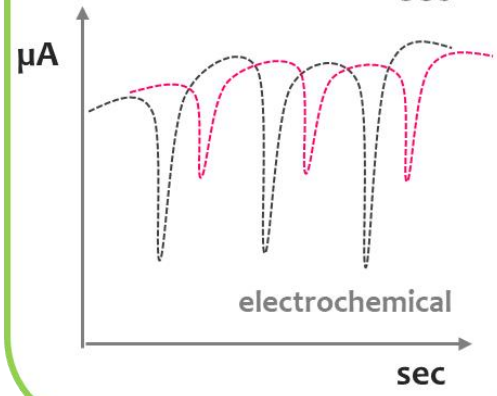




carbon nanotubes

transduction





Trends in Biotechnology

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CellPress

Review

Biotechnological Advances in the Design of Algae-Based Biosensors

Amina Antonacci [1, 2], Viviana Scognamiglio [1, 2]

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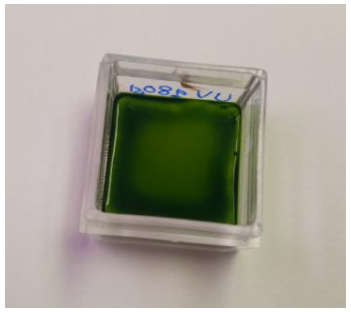
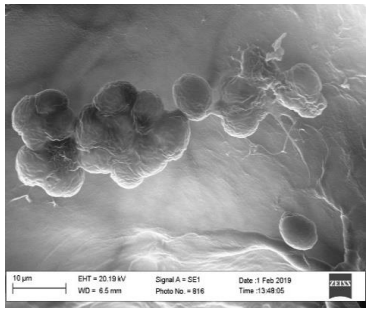
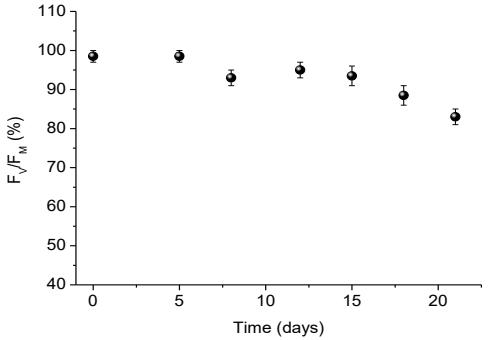
C. reinhardtii immobilisation on diverse supports

Algae cells immobilised on paper soaked with agar

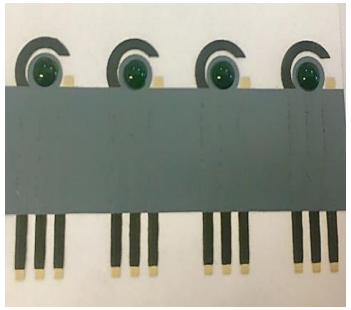


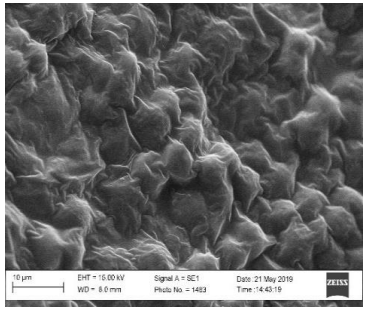


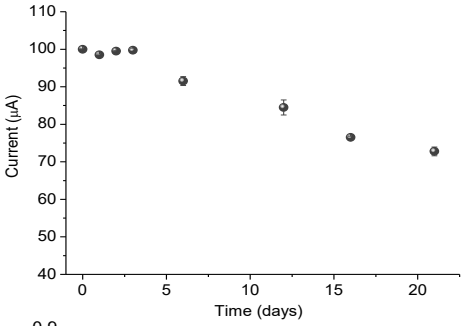


21 days
80 % activity

Algae cells immobilised in calcium/alginate on Carbon Black SPEs printed at Tor Vergata University - Prof. Fabiana Arduini

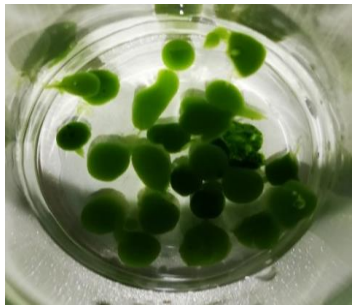


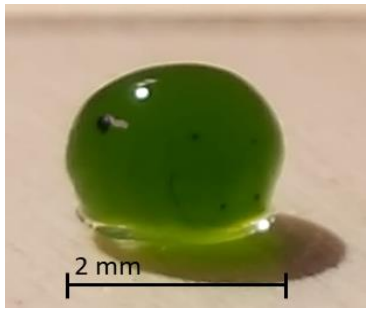


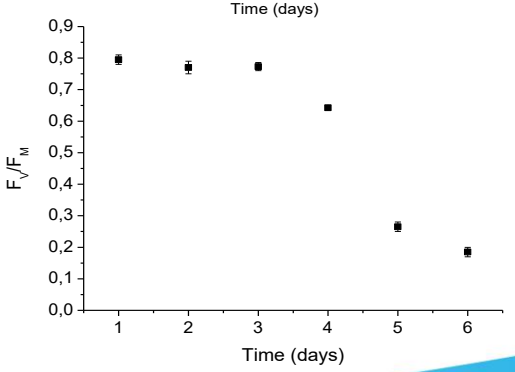


21 days
70 % activity

Algae cells immobilised on calcium/alginate beads







4 days
60 % activity

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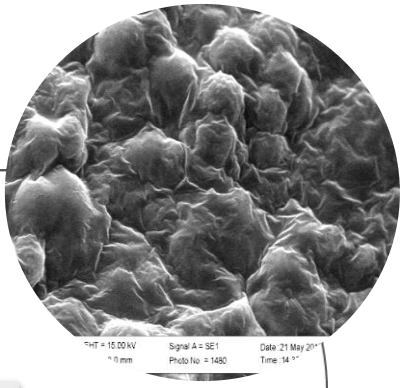
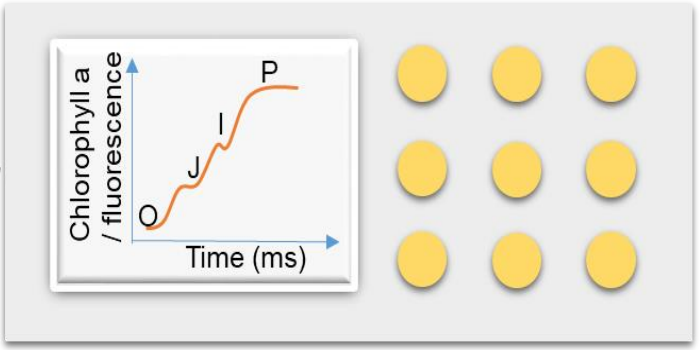
Electrochemical algae-based biosensor



excitation source

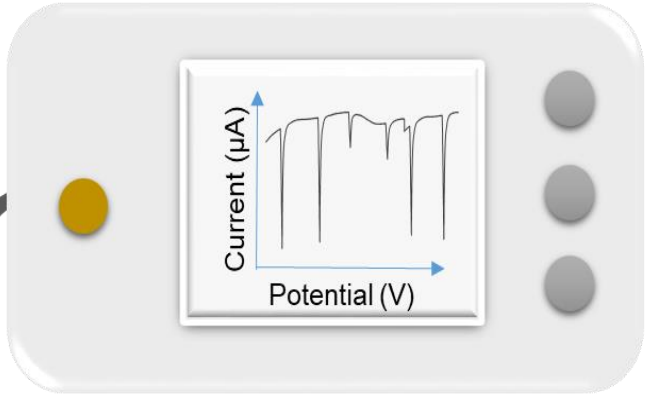


Chl fluorometer

algae

CB

paper-SPE



potentiostat

measurement chamber

DUAL OPTO-ELECTROCHEMICAL PROTOTYPE FOR ALGAL BIOSENSING

BIOSENSOR

Interreg Italy - Croatia AdSWiM
European Regional Development Fund
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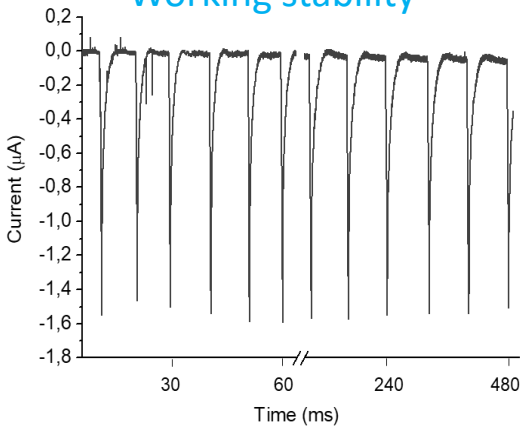
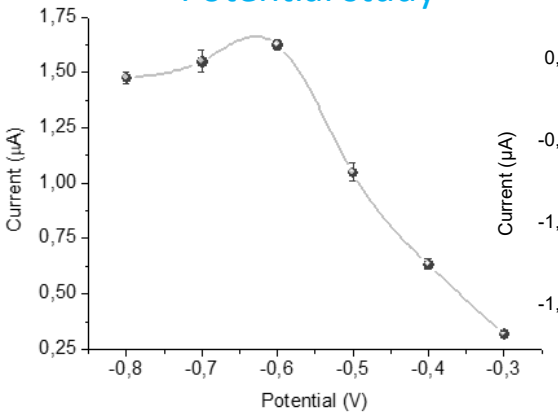
Optimization of the biosensor parameters

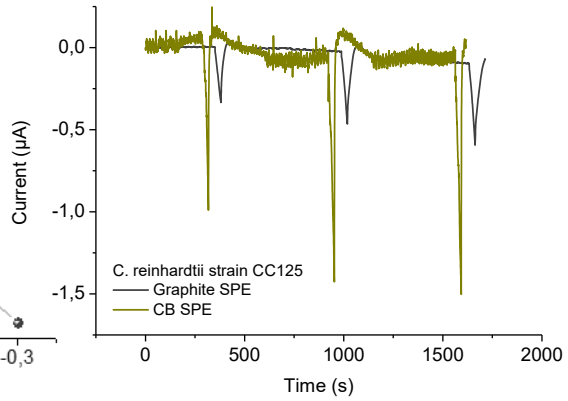
Working stability



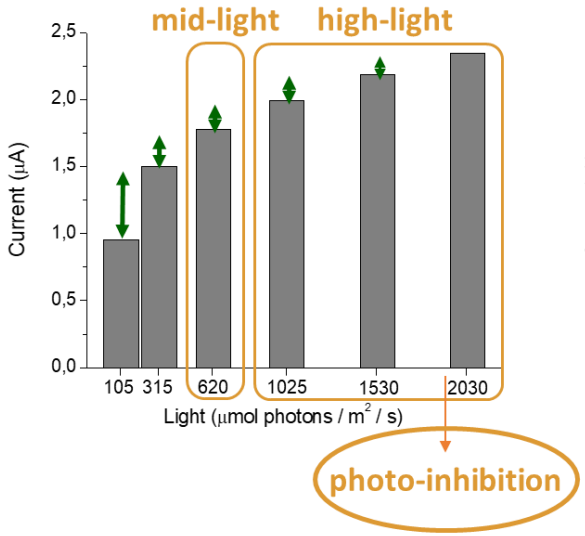
Potential study



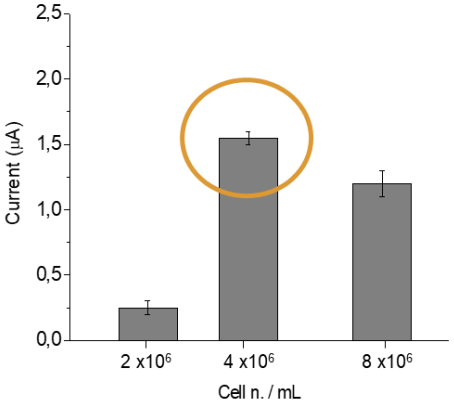
CB figure of merit



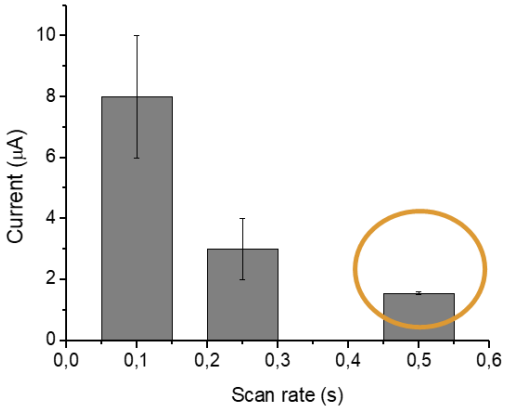
current *vs* light



current *vs* cell n.



current *vs* scan rate



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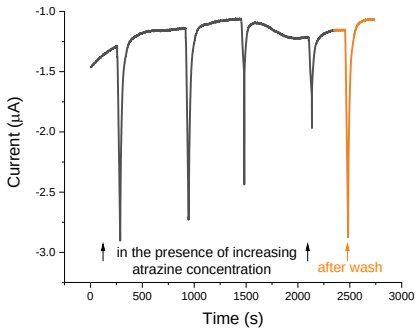
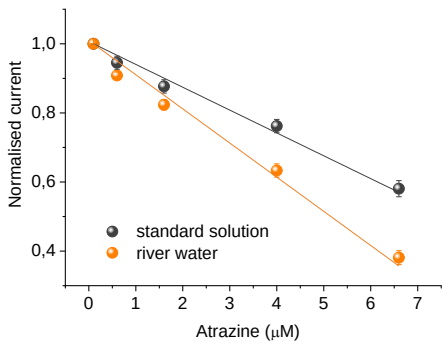
Opto-Electrochemical response towards herbicides

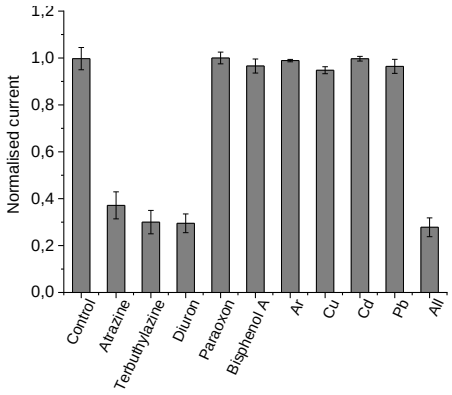
Recovery after wash



Matrix effect

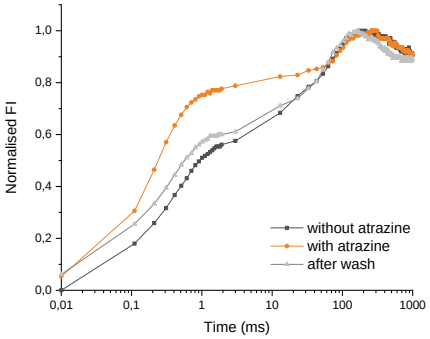


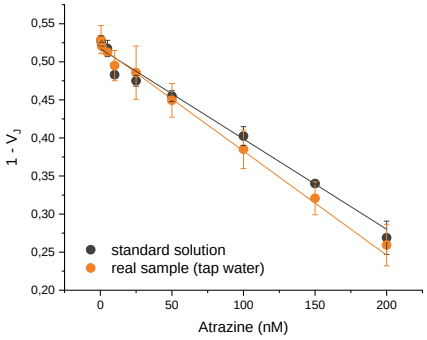
Interferents

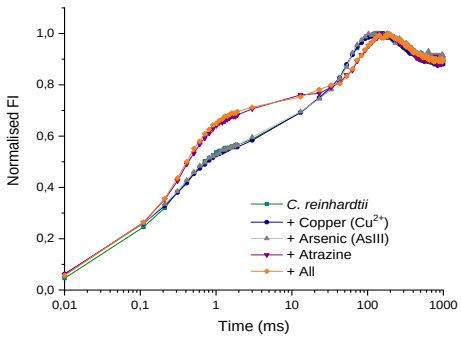


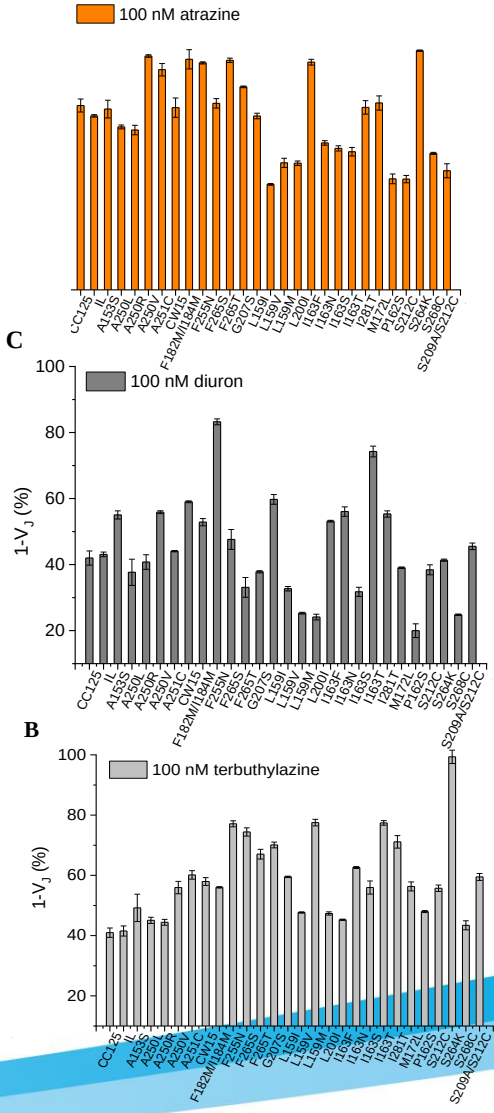
Electrochemical method

Optical method









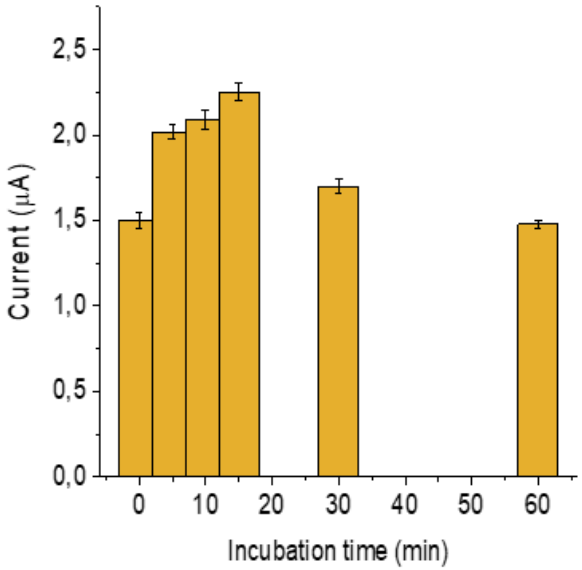
A dual electro-optical biosensor based on *Chlamydomonas reinhardtii* immobilised on paper-based nanomodified screen-printed electrodes for herbicide monitoring

Amina Antonacci, Raouia Attaallah, Fabiana Arduini, Aziz Amine, Maria Teresa Giardi & Viviana Scognamiglio

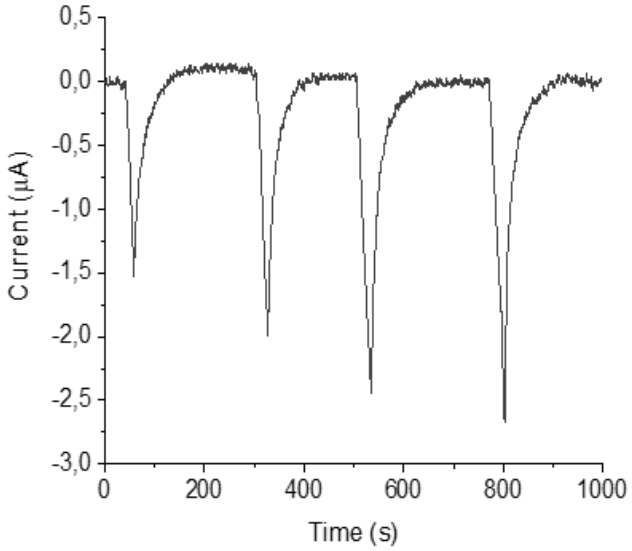
Journal of Nanobiotechnology **19**, Article number: 145 (2021) | Cite this article

Electrochemical response towards pathogens

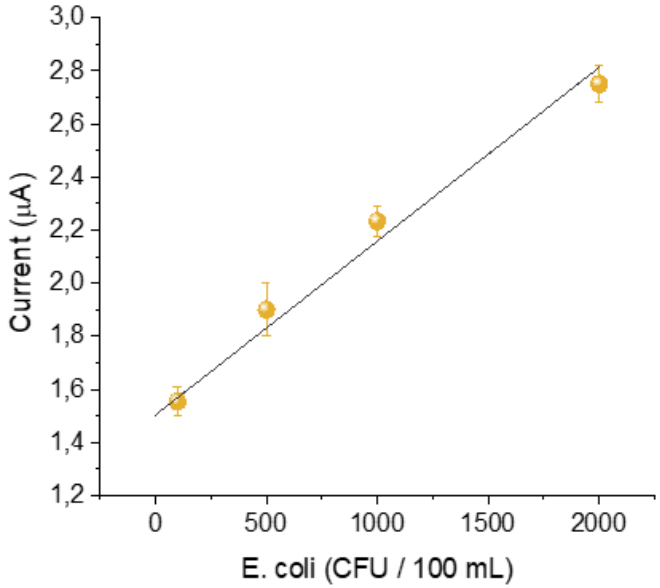
Incubation time

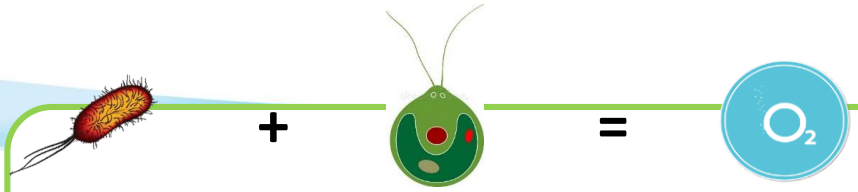


Amperogram



Calibration curve





Aerobic bacteria can **promote algal growth** by reducing the photosynthetic oxygen tension within the microenvironment of the algal cells.
FEMS Microbiology Ecology, 18(1), 35-43.

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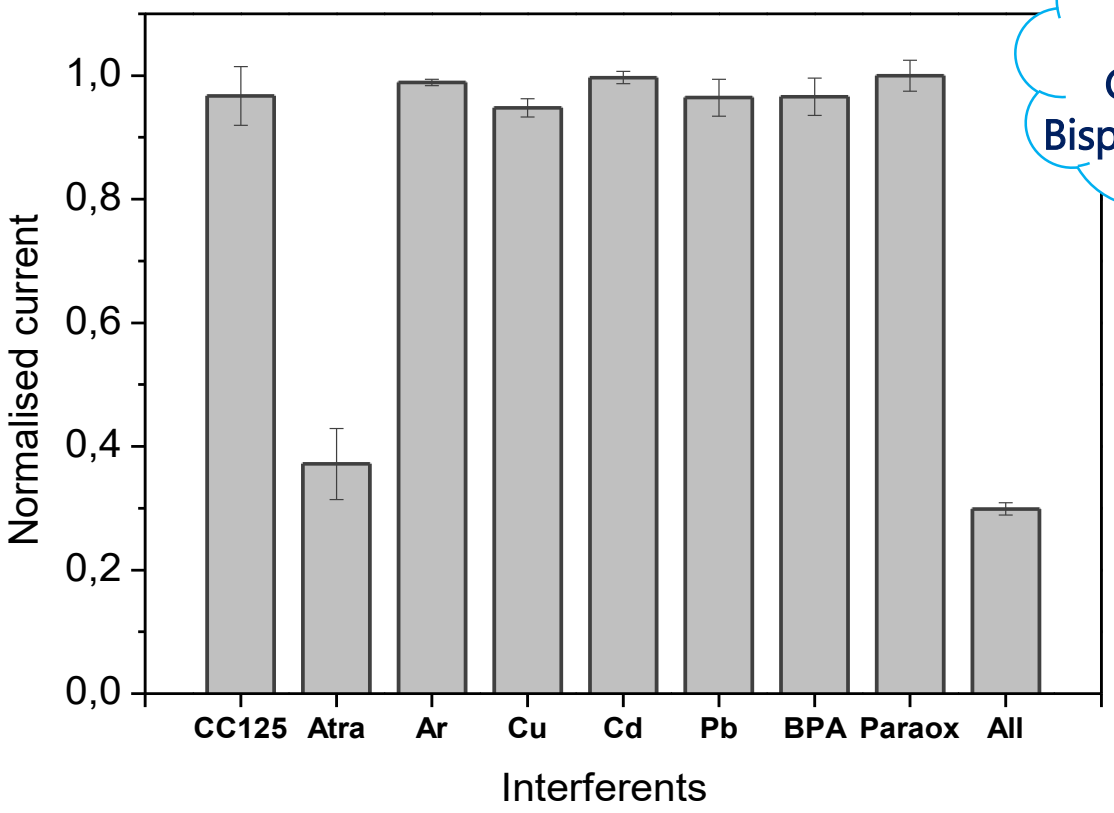
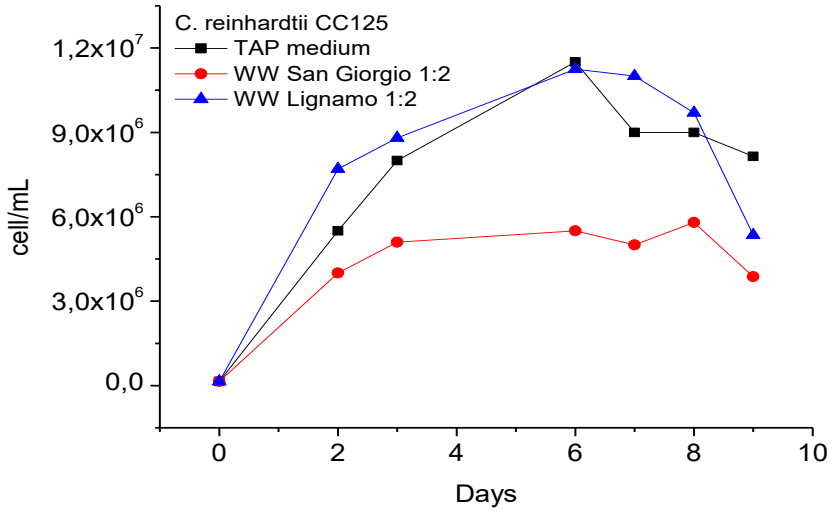
Interference study

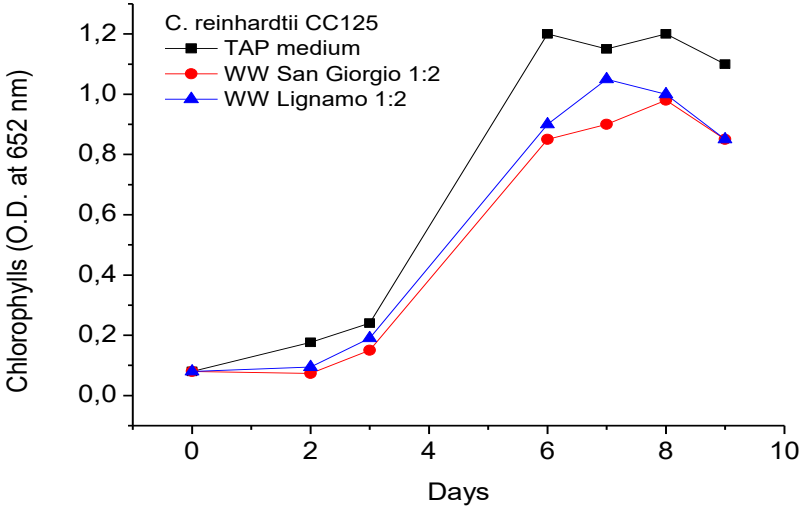


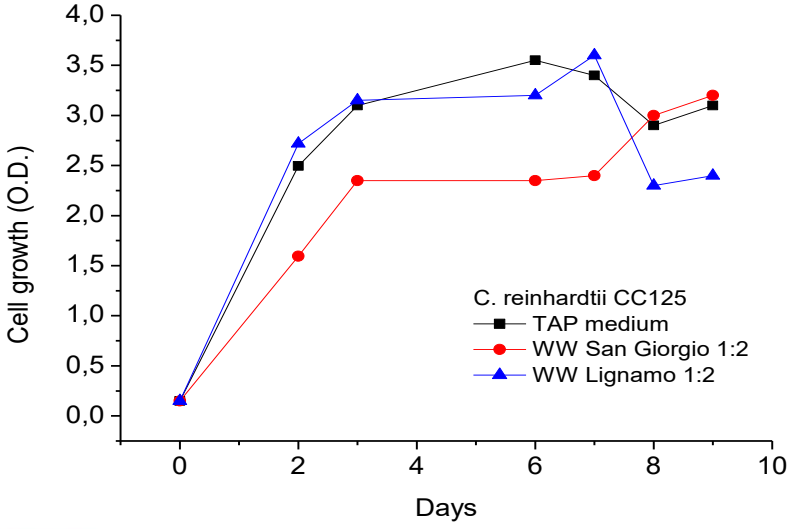
Atrazine, arsenic,
Copper
Cadmium, Lead
Bisphenol A, Paraoxon

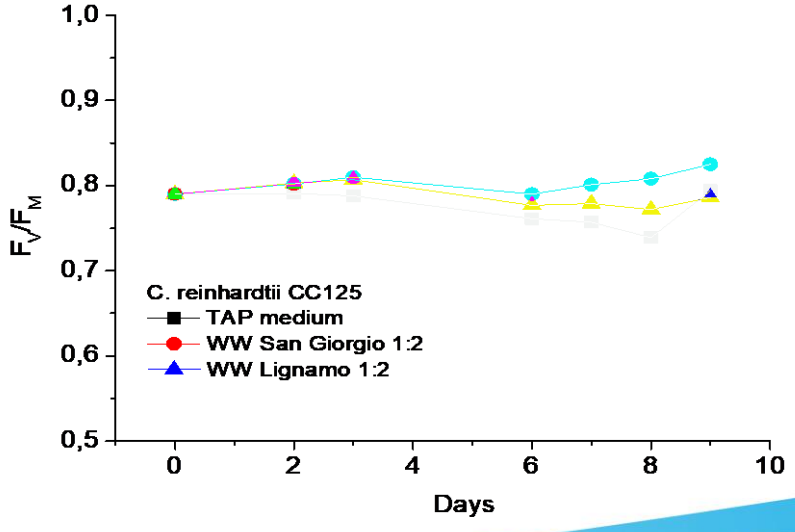
Light: repeated cycles of dark (10 min) and light (315 µmol photons m^{-2} s^{-1} - 30 s)
Buffer: 50 mM Tricine, 20 mM CaCl2, 5 mM MgCl2, 50 mM NaCl, 70 mM sucrose, pH 7.2
Measurement volume: 200 µL, Applied potential: -0.6 V – scan rate: 0.5 s

Wastewater matrix effect

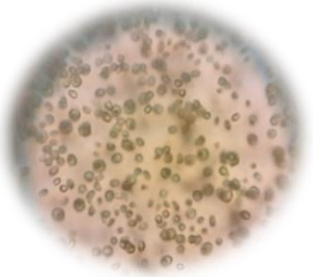




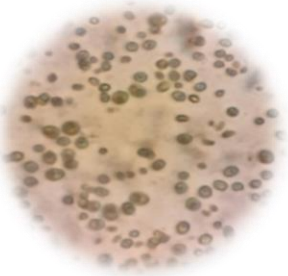




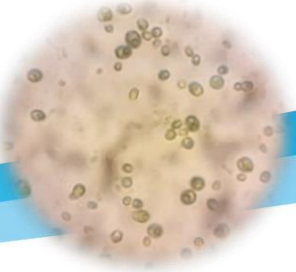
Growth medium 7 days



Lignano WW 7 days



San Giorgio WW 7 days



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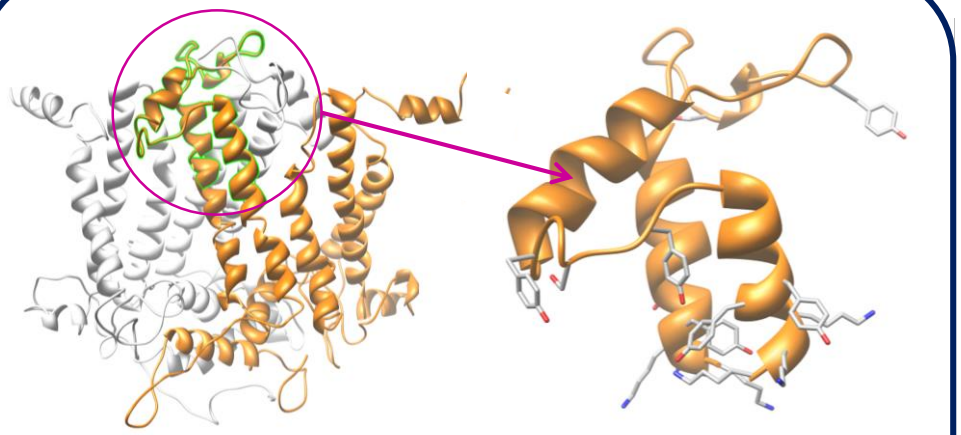
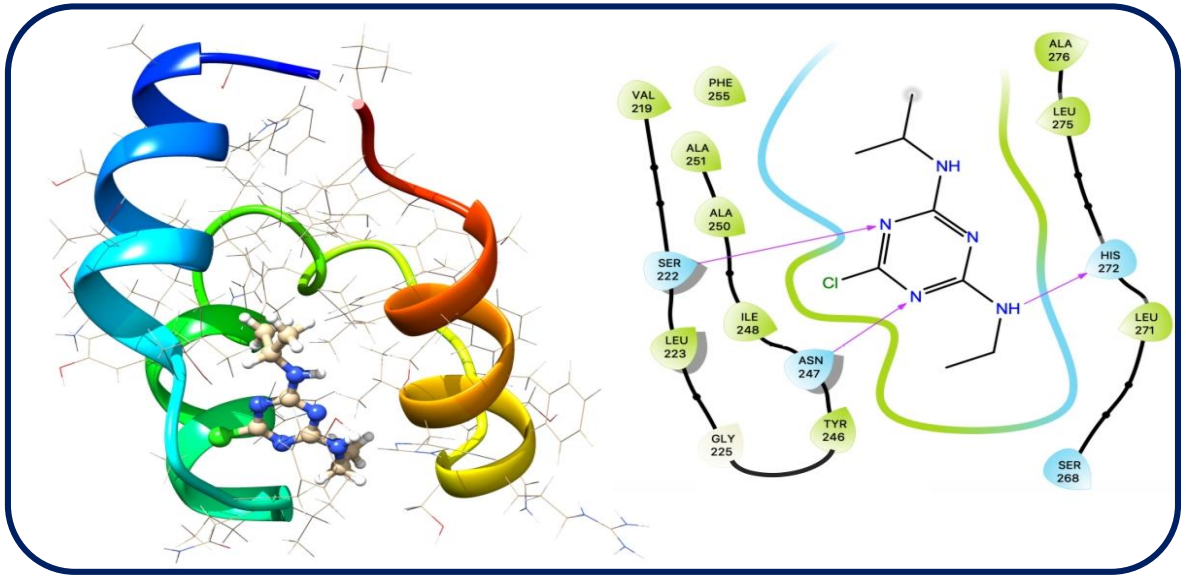
Design of artificial biomimetics bioinspired to PSII D1 protein from *C. reinhardtii*



D1/D2 protein

D1 biomimetic peptide

2D structure highlighting the H-bond (in purple) interactions



Most probable equilibrium structure of the complex between ATZ and D1_50res

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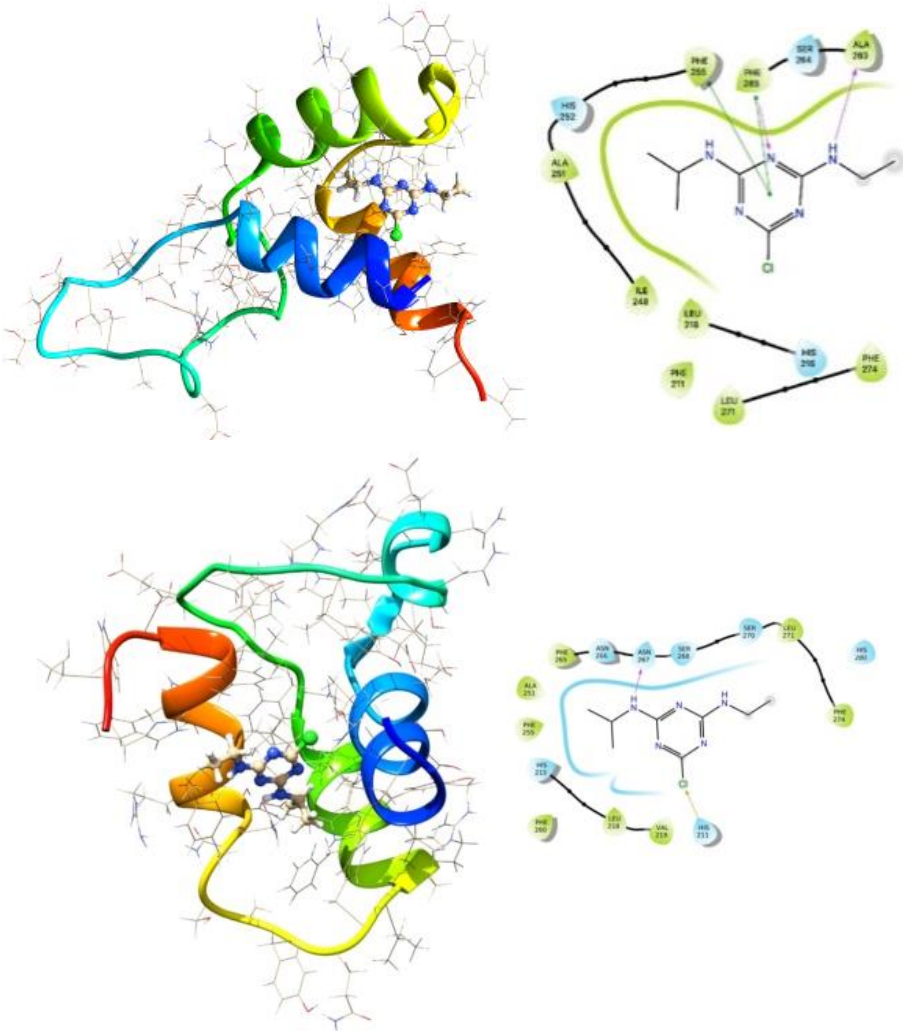
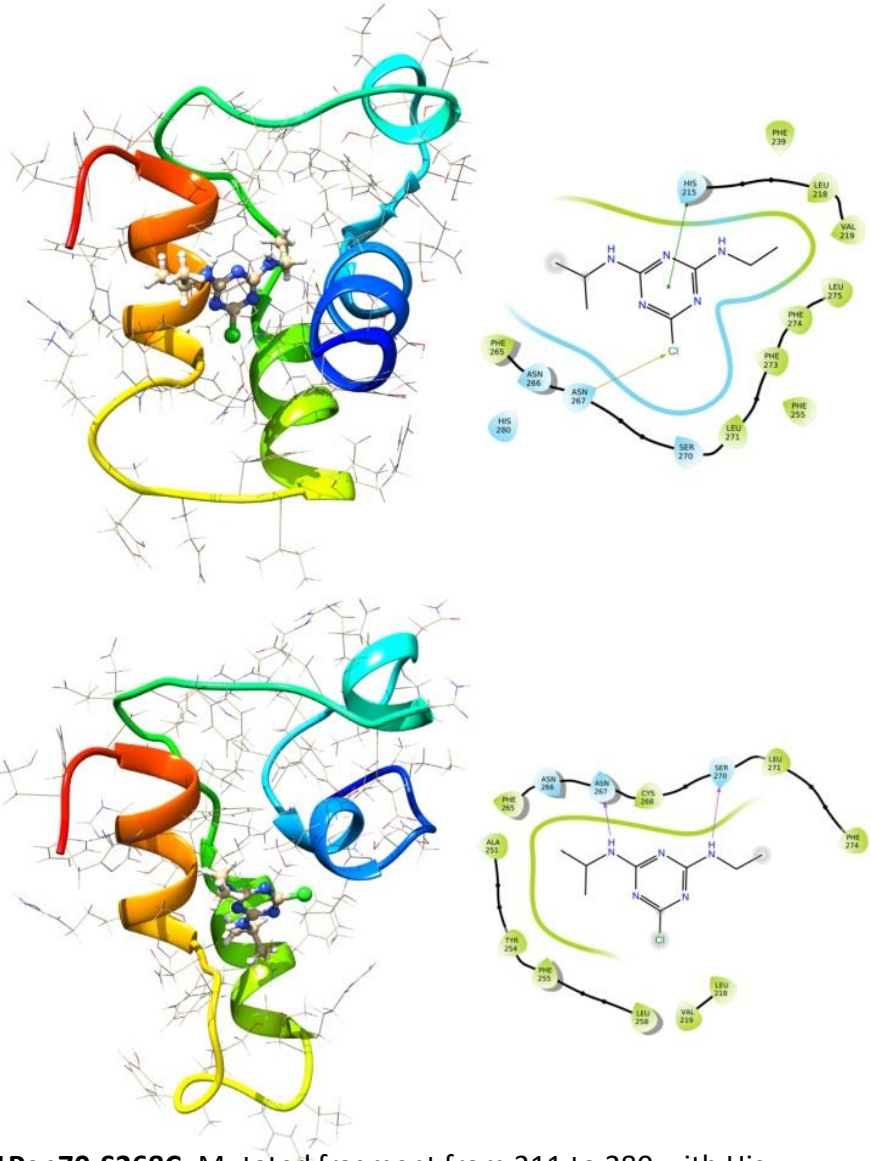
D1Pep70-WT: Wild-type fragment from 211 to 280 mimicking D1 plastoquinone-binding niche
Sequence:FSAMHGSLVTSSLIRETTENESANEGYRFGQEEETYNIVAAHGYF GRLIFQYASFNNSRSLHFFLAAWPV
Interactions/bonds: P255 H-bond; A263 H-bond; P265 π-π stacking



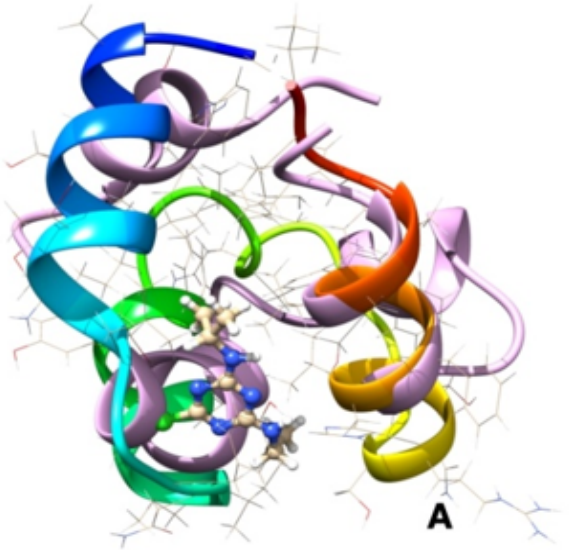
D1Pep70-H: Wild-type fragment from 211 to 280 with His replacement at N- and C- terminal
Sequence:HSAMHGSLVTSSLIRETTENESANEGYRFGQEEETYN IVAAHGYFGRLIFQYASFNNSRSLHFFLAAWPH
Interactions/bonds: A267 H-bond; H211 polar interactions

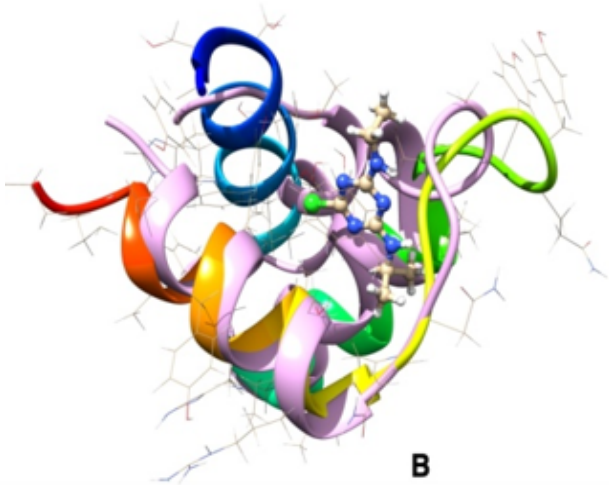
D1Pep70-S264K: Mutated fragment from 211 to 280 with His replacement at N- and C- terminal and substitution of Ser 264 with Lys
Sequence:HSAMHGSLVTSSLIRETTENESANEGYRFGQEEETYNIVAAHGYFG RLIFQYAKFNNSRSLHFFLAAWPH
Interactions/bonds: H215 apolar; ASN267 polar



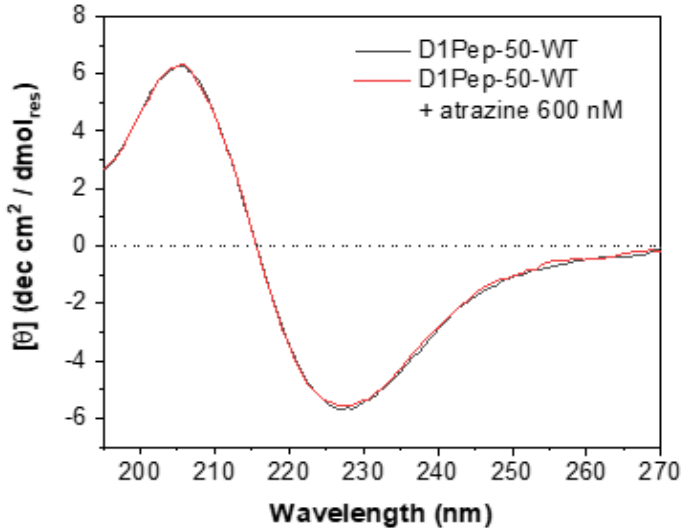
D1Pep70-S268C: Mutated fragment from 211 to 280 with His replacement at N- and C- terminal and substitution of Ser 268 with Cys
Sequence:HSAMHGSLVTSSLIRETTENESANEGYRFGQEEETYNIVAAHGYFG RLIFQYASFNNCRSLHFFLAAWPH
Interactions/bonds: A267 H-bond; S270 H-bond

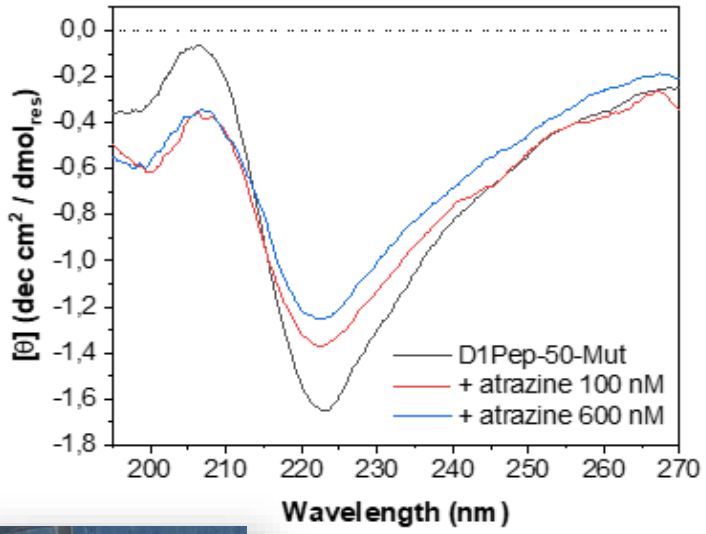
MD



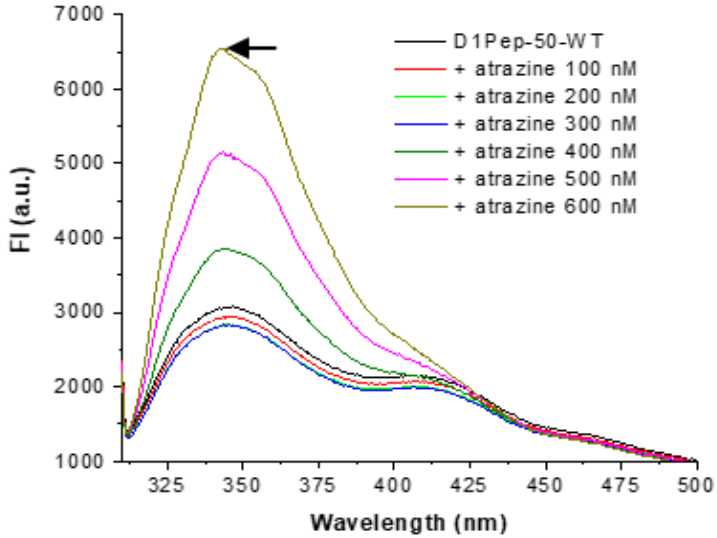


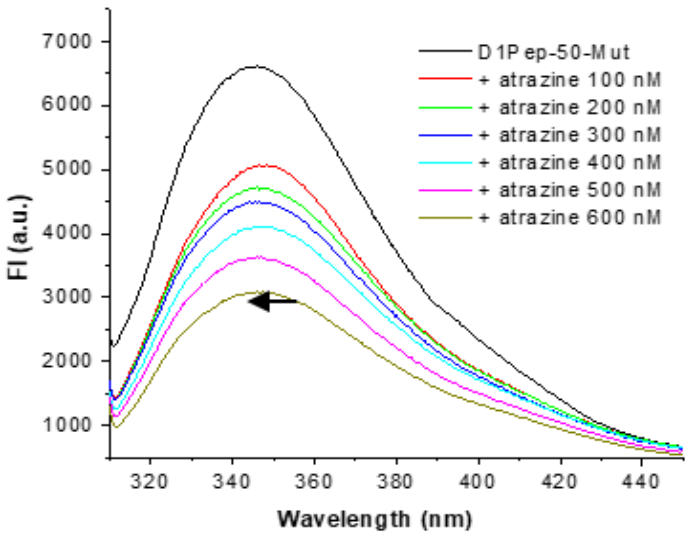
CD





FS





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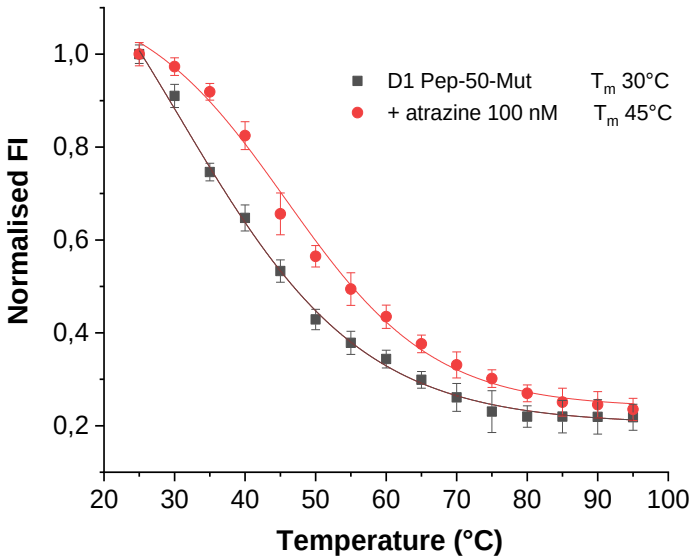
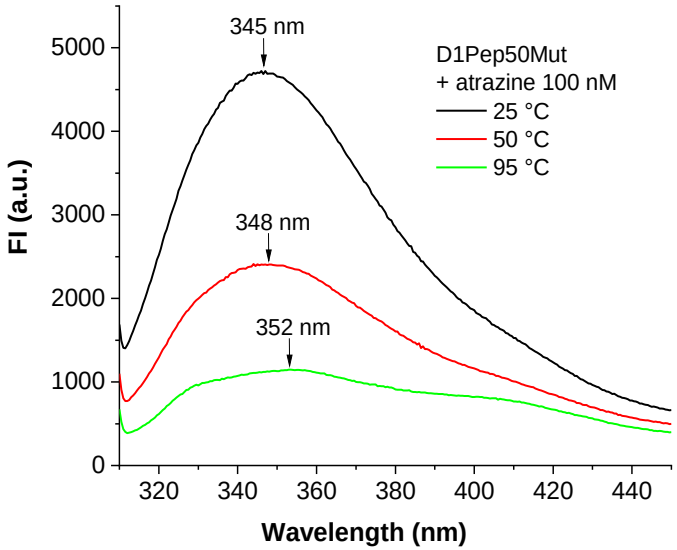
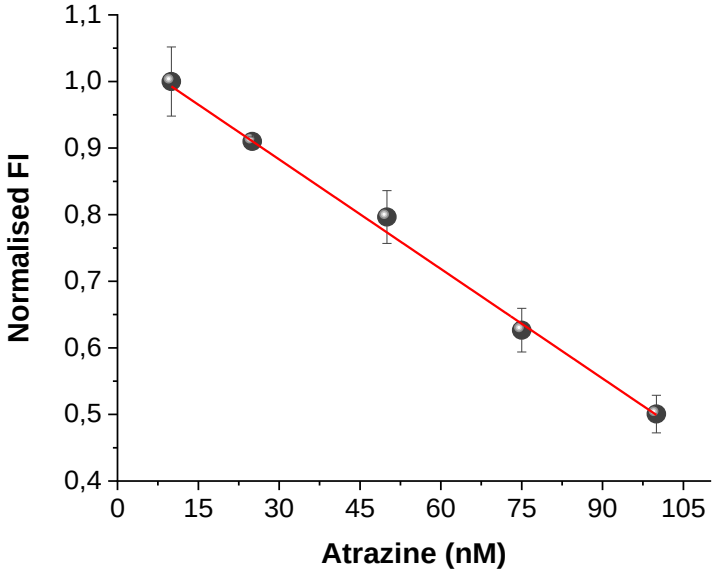
Fluorescence investigations of the D1 biomimetic peptides ability to bind atrazine



Changes in fluorescence intensity at 345 nm by temperature-induced conformational transitions with/without atrazine



Changes in wavelength by temperature-induced conformational transitions with/without atrazine



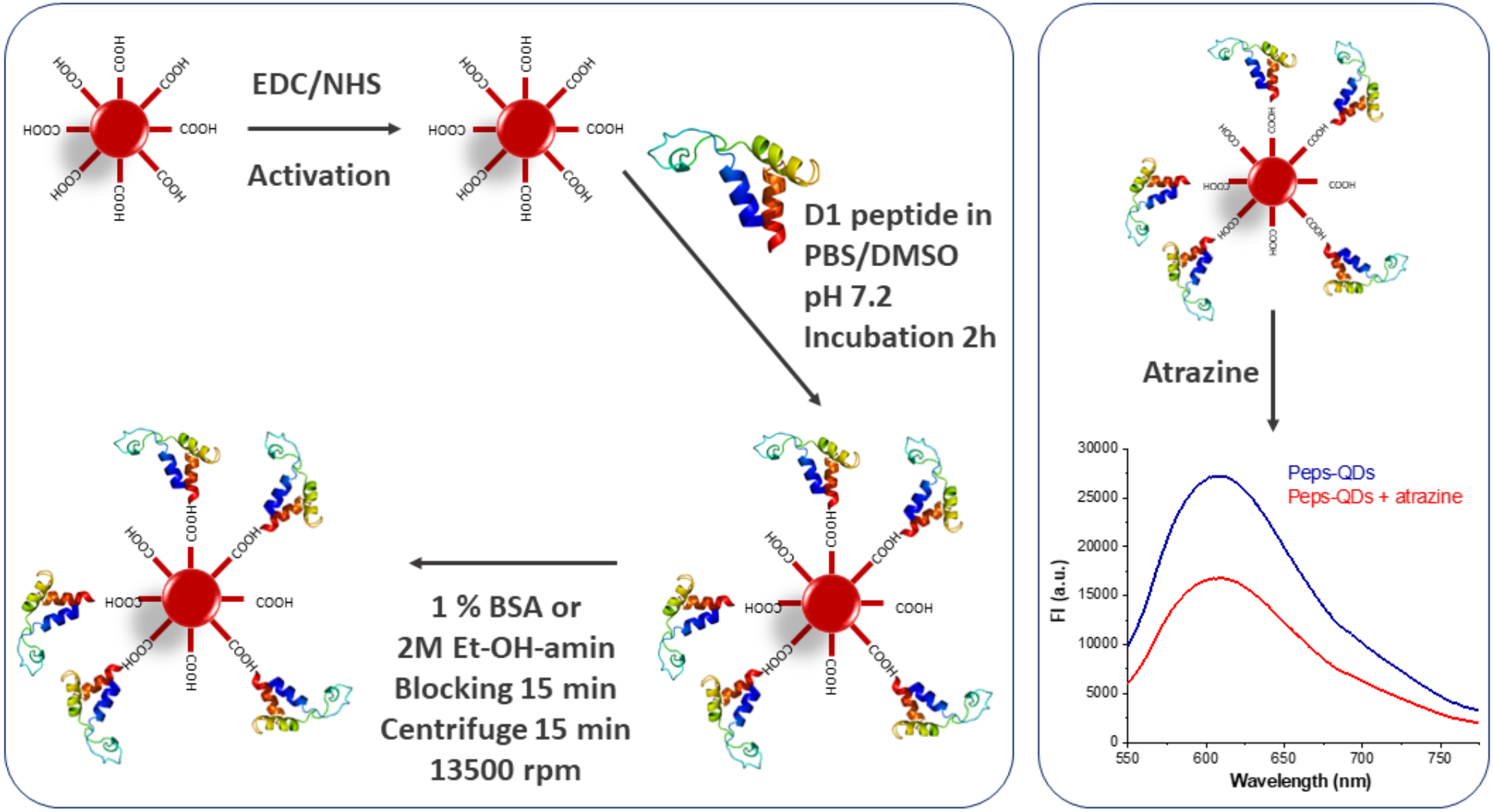
Calibration curve for atrazine with 100 nM as the maximum concentration (molar ratio peptide/atrazine 1:2)

ELSEVIER
International Journal of Biological Macromolecules
Volume 163, 15 November 2020, Pages 817-823

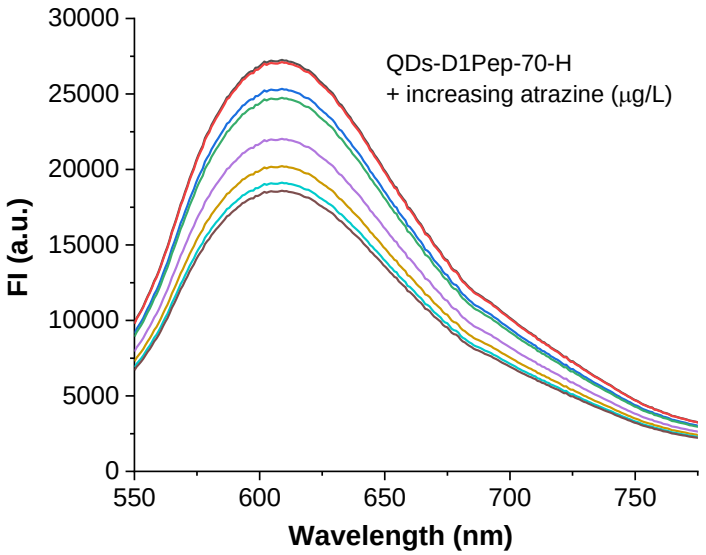
Novel atrazine-binding biomimetics inspired to the D1 protein from the photosystem II of *Chlamydomonas reinhardtii*

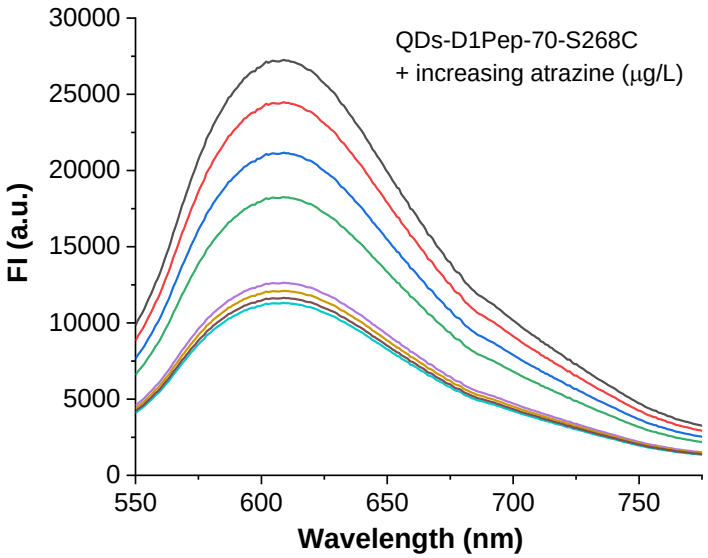
Amina Antonacci [a, 1], Fabrizio Lo Celso [b, c, 1], Giampaolo Barone [d], Pietro Calandra [e], Jörg Grunenberg [f], Maria Moccia [a], Emanuela Gatto [g], Maria Teresa Giardi [a, h], Viviana Scognamiglio [a, *]

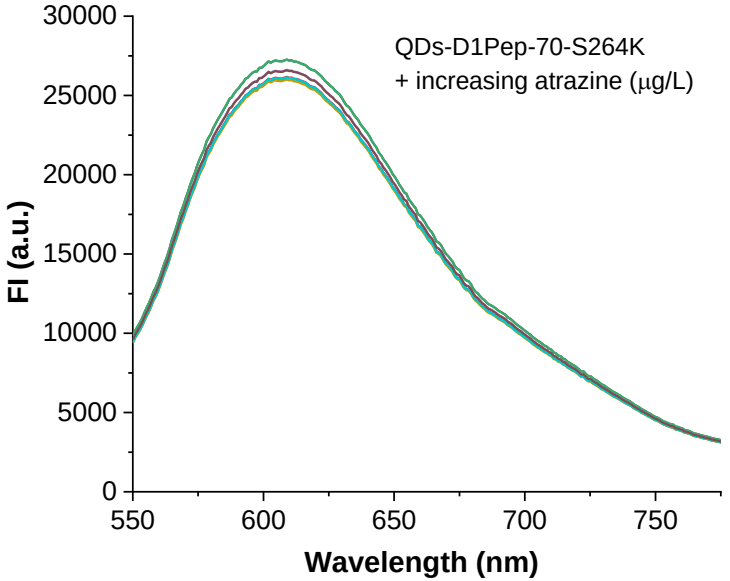
OPTOSENSOR REALIZATION BASED ON QUANTUM DOTS FUNCTIONALIZED BIOMIMETIC PEPTIDES

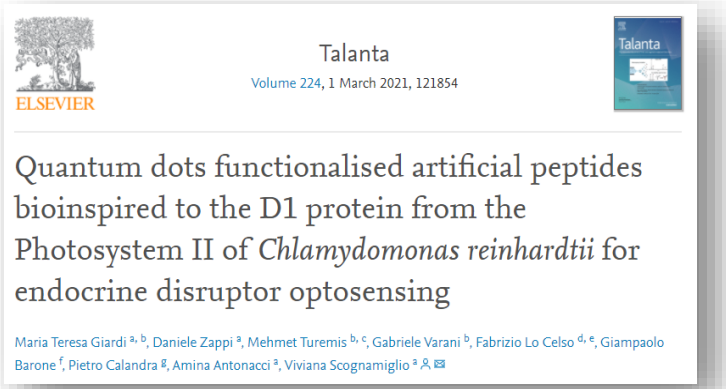


Fluorescence response of quantum dots functionalized biomimetic peptides







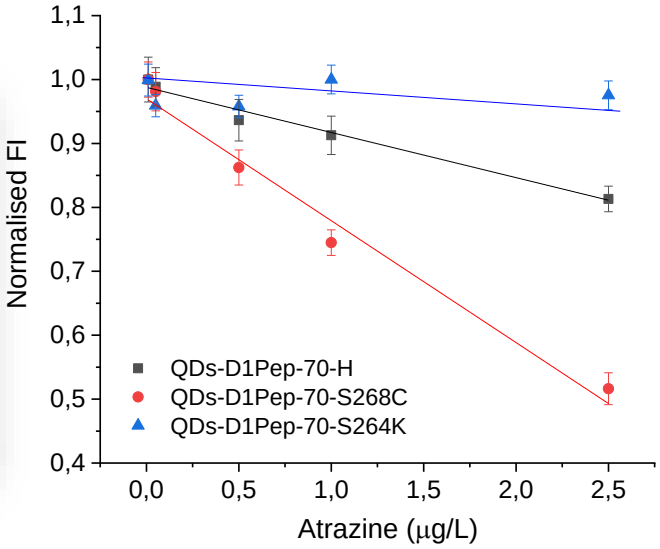

ELSEVIER

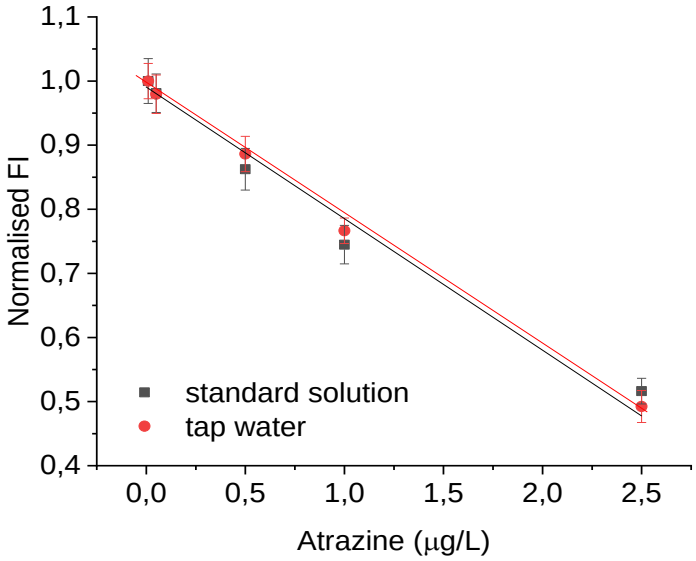
Talanta

Volume 224, 1 March 2021, 121854

Quantum dots functionalised artificial peptides bioinspired to the D1 protein from the Photosystem II of *Chlamydomonas reinhardtii* for endocrine disruptor optosensing

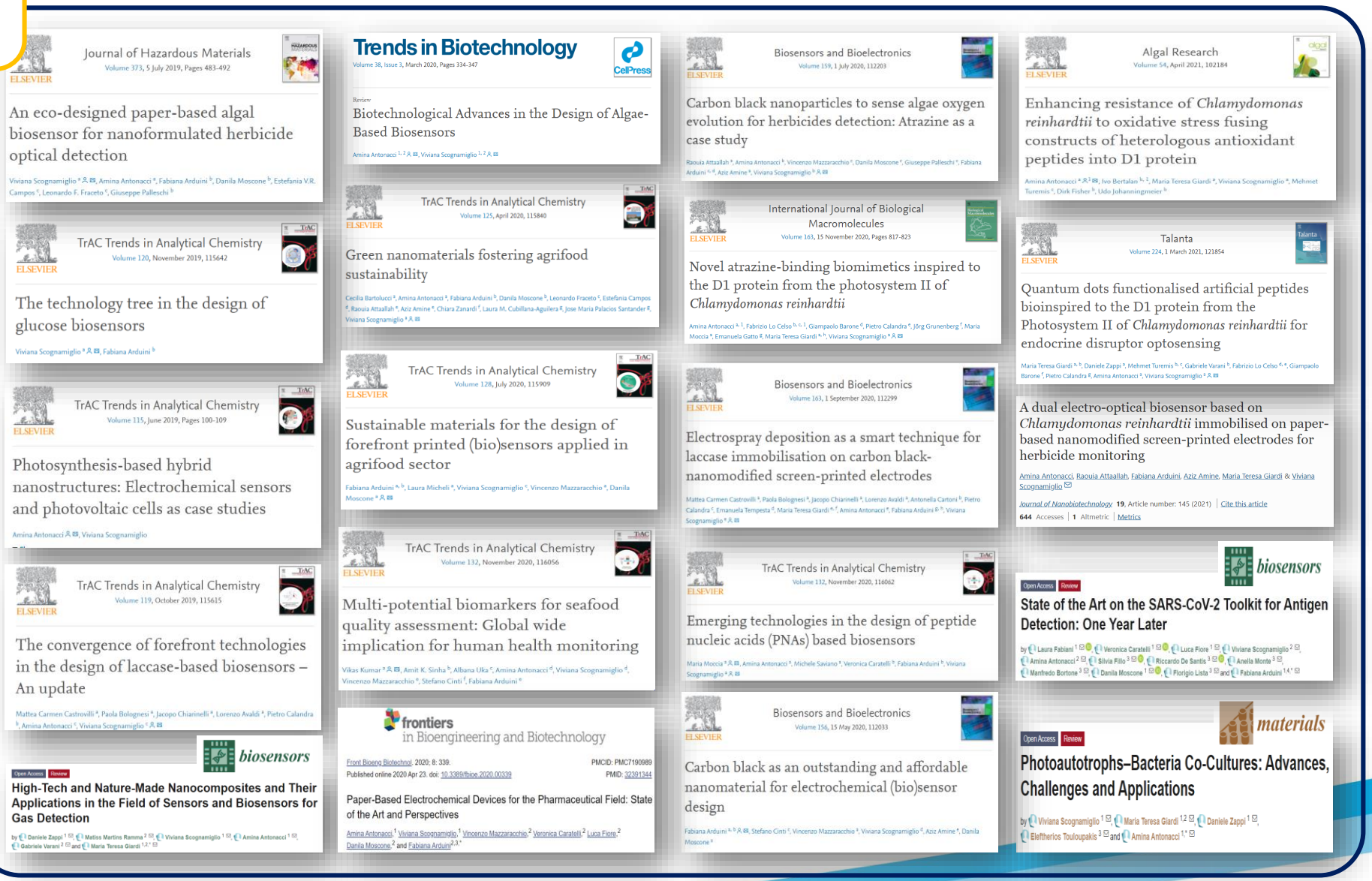
Maria Teresa Giardi [a, b], Daniele Zappi [a], Mehmet Turemis [b, c], Gabriele Varani [b], Fabrizio Lo Celso [d, e], Giampaolo Barone [f], Pietro Calandra [g], Amina Antonacci [a], Viviana Scognamiglio [a]





DETECTION LIMITS: 0.04 AND 0.017 µG/L - MRL 0.6-2 µG/L 2013/39/EU SURFACE WATER

Dissemination 2019 - 2021



Journal of Hazardous Materials
Volume 373, 5 July 2019, Pages 483-492

An eco-designed paper-based algal biosensor for nanoformulated herbicide optical detection

Viviana Scognamiglio [a], Amina Antonacci [a], Fabiana Arduini [b], Danila Moscone [b], Estefania V.R. Campos [c], Leonardo F. Fraceto [c], Giuseppe Palleschi [b]

TrAC Trends in Analytical Chemistry
Volume 120, November 2019, 115642

The technology tree in the design of glucose biosensors

Viviana Scognamiglio [a], Fabiana Arduini [b]

TrAC Trends in Analytical Chemistry
Volume 115, June 2019, Pages 100-109

Photosynthesis-based hybrid nanostructures: Electrochemical sensors and photovoltaic cells as case studies

Amina Antonacci, Viviana Scognamiglio

TrAC Trends in Analytical Chemistry
Volume 119, October 2019, 115615

The convergence of forefront technologies in the design of laccase-based biosensors – An update

Mattea Carmen Castrovilli [a], Paola Bolognesi [a], Jacopo Chiarinelli [a], Lorenzo Avaldi [a], Pietro Calandra [b], Amina Antonacci [c], Viviana Scognamiglio [c]

biosensors
Open Access Review

High-Tech and Nature-Made Nanocomposites and Their Applications in the Field of Sensors and Biosensors for Gas Detection

by Daniele Zappi [1], Matiss Martins Ramma [2], Viviana Scognamiglio [1], Amina Antonacci [1], Gabriele Varani [2] and Maria Teresa Giardi [1,2,*]

Trends in Biotechnology
Volume 38, Issue 3, March 2020, Pages 334-347

Review

Biotechnological Advances in the Design of Algae-Based Biosensors

Amina Antonacci [1,2], Viviana Scognamiglio [1,2]

TrAC Trends in Analytical Chemistry
Volume 125, April 2020, 115840

Green nanomaterials fostering agrifood sustainability

Cecilia Bartolucci [a], Amina Antonacci [a], Fabiana Arduini [b], Danila Moscone [b], Leonardo Fraceto [c], Estefania Campos [d], Raouia Attaallah [e], Aziz Amine [e], Chiara Zanardi [f], Laura M. Cubillana-Aguilera [g], Jose Maria Palacios Santander [g], Viviana Scognamiglio [a]

TrAC Trends in Analytical Chemistry
Volume 128, July 2020, 115909

Sustainable materials for the design of forefront printed (bio)sensors applied in agrifood sector

Fabiana Arduini [a, b], Laura Micheli [a], Viviana Scognamiglio [c], Vincenzo Mazzaracchio [a], Danila Moscone [a]

TrAC Trends in Analytical Chemistry
Volume 132, November 2020, 116056

Multi-potential biomarkers for seafood quality assessment: Global wide implication for human health monitoring

Vikas Kumar [a], Amit K. Sinha [b], Albana Uka [c], Amina Antonacci [d], Viviana Scognamiglio [d], Vincenzo Mazzaracchio [e], Stefano Cinti [f], Fabiana Arduini [e]

frontiers in Bioengineering and Biotechnology

Front Bioeng Biotechnol. 2020; 8: 339.
Published online 2020 Apr 23. doi: 10.3389/fbioe.2020.00339
PMCID: PMC7190989
PMID: 32391344

Paper-Based Electrochemical Devices for the Pharmaceutical Field: State of the Art and Perspectives

Amina Antonacci [1], Viviana Scognamiglio [1], Vincenzo Mazzaracchio [2], Veronica Caratelli [2], Luca Fiore [2], Danila Moscone [2] and Fabiana Arduini [2,3,*]

Biosensors and Bioelectronics
Volume 159, 1 July 2020, 112203

Carbon black nanoparticles to sense algae oxygen evolution for herbicides detection: Atrazine as a case study

Raouia Attaallah [a], Amina Antonacci [a], Vincenzo Mazzaracchio [c], Danila Moscone [c], Giuseppe Palleschi [c], Fabiana Arduini [c, d], Aziz Amine [a], Viviana Scognamiglio [a]

International Journal of Biological Macromolecules
Volume 163, 15 November 2020, Pages 817-823

Novel atrazine-binding biomimetics inspired to the D1 protein from the photosystem II of *Chlamydomonas reinhardtii*

Amina Antonacci [a, 1], Fabrizio Lo Celso [b, c, 1], Giampaolo Barone [d], Pietro Calandra [e], Jörg Grunenberg [f], Maria Moccia [a], Emanuela Gatto [g], Maria Teresa Giardi [a, h], Viviana Scognamiglio [a]

Biosensors and Bioelectronics
Volume 163, 1 September 2020, 112299

Electrospray deposition as a smart technique for laccase immobilisation on carbon black-nanomodified screen-printed electrodes

Mattea Carmen Castrovilli [a], Paola Bolognesi [a], Jacopo Chiarinelli [a], Lorenzo Avaldi [a], Antonella Cartoni [b], Pietro Calandra [c], Emanuela Tempesta [d], Maria Teresa Giardi [e, f], Amina Antonacci [e], Fabiana Arduini [g, h], Viviana Scognamiglio [a]

TrAC Trends in Analytical Chemistry
Volume 132, November 2020, 116062

Emerging technologies in the design of peptide nucleic acids (PNAs) based biosensors

Maria Moccia [a], Amina Antonacci [a], Michele Saviano [a], Veronica Caratelli [b], Fabiana Arduini [b], Viviana Scognamiglio [a]

Biosensors and Bioelectronics
Volume 156, 15 May 2020, 112033

Carbon black as an outstanding and affordable nanomaterial for electrochemical (bio)sensor design

Fabiana Arduini [a, b], Stefano Cinti [c], Vincenzo Mazzaracchio [a], Viviana Scognamiglio [d], Aziz Amine [e], Danila Moscone [a]

Algal Research
Volume 54, April 2021, 102184

Enhancing resistance of *Chlamydomonas reinhardtii* to oxidative stress fusing constructs of heterologous antioxidant peptides into D1 protein

Amina Antonacci [a, 2], Ivo Bertalan [b, 1], Maria Teresa Giardi [a], Viviana Scognamiglio [a], Mehmet Turemis [c], Dirk Fisher [b], Udo Johanningmeier [b]

Talanta
Volume 224, 1 March 2021, 121854

Quantum dots functionalised artificial peptides bioinspired to the D1 protein from the Photosystem II of *Chlamydomonas reinhardtii* for endocrine disruptor optosensing

Maria Teresa Giardi [a, b], Daniele Zappi [a], Mehmet Turemis [b, c], Gabriele Varani [b], Fabrizio Lo Celso [d, e], Giampaolo Barone [f], Pietro Calandra [g], Amina Antonacci [a], Viviana Scognamiglio [a]

A dual electro-optical biosensor based on *Chlamydomonas reinhardtii* immobilised on paper-based nanomodified screen-printed electrodes for herbicide monitoring

Amina Antonacci, Raouia Attaallah, Fabiana Arduini, Aziz Amine, Maria Teresa Giardi & Viviana Scognamiglio

Journal of Nanobiotechnology 19, Article number: 145 (2021) | Cite this article
644 Accesses | 1 Altmetric | Metrics

biosensors
Open Access Review

State of the Art on the SARS-CoV-2 Toolkit for Antigen Detection: One Year Later

by Laura Fabiani [1], Veronica Caratelli [1], Luca Fiore [1], Viviana Scognamiglio [2], Amina Antonacci [2], Silvia Fillo [3], Riccardo De Santis [3], Anella Monte [3], Manfredo Bortone [3], Danila Moscone [1], Florigio Lista [3] and Fabiana Arduini [1,4,*]

materials
Open Access Review

Photoautotrophs–Bacteria Co-Cultures: Advances, Challenges and Applications

by Viviana Scognamiglio [1], Maria Teresa Giardi [1,2], Daniele Zappi [1], Eleftherios Touloupakis [3] and Amina Antonacci [1,*]

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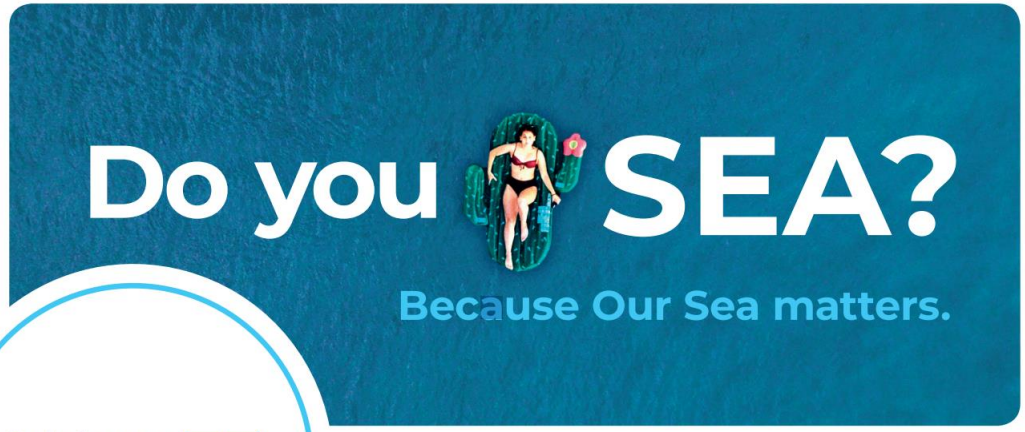
Description_Activities_4.4

Communication activities

- LA NOTTE DEI RICERCATORI- September 2019
- REMTECH September 2020
- SEALOGY November 2020
- Workshop AdSWiM/Desir February 2021
- BIOSENSORS2020 CONFERENCE July 2021
- REMTECH September 2021
- Lesson on Biosensor for UPESP, Brasil September 2021
- SEALOGY November 2021
- Workshop ECOMAP Project November 2021
- International Workshop Green Christmas December 2021



AdSWiM

Interreg Italy-Croatia

| Viviana Scognamiglio – IC/CNR |
| Sabina Susmel - Università di Udine |

Workshop “Nuove tecnologie per sensori e biosensori @ Area della Ricerca di Roma 1”

On-line | 2021, February 25

Description_Activities_4.4

Communication activities concerning WP4 (oral communication)

Oral communication schedule for July, 27 2021
at the 30th Anniversary World Congress on Biosensors

Abstract Reference Number: BIOS2020_0904
Title: "**Bioinspired herbicide binding proteins from Chlamydomonas reinhardtii as novel synthetic biomimetics for sensing applications**"
Authors: Viviana Scognamiglio and Amina Antonacci

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