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Paper-based electrochemical (bio)sensors: where we are and where we are going

Fabiana Arduini, 25<sup>th</sup> March 2025

Paper-based as sustainable substrate

Paper-based origami device for multiple analysis

Paper-based lab on a chip

Paper-based devices for solid samples

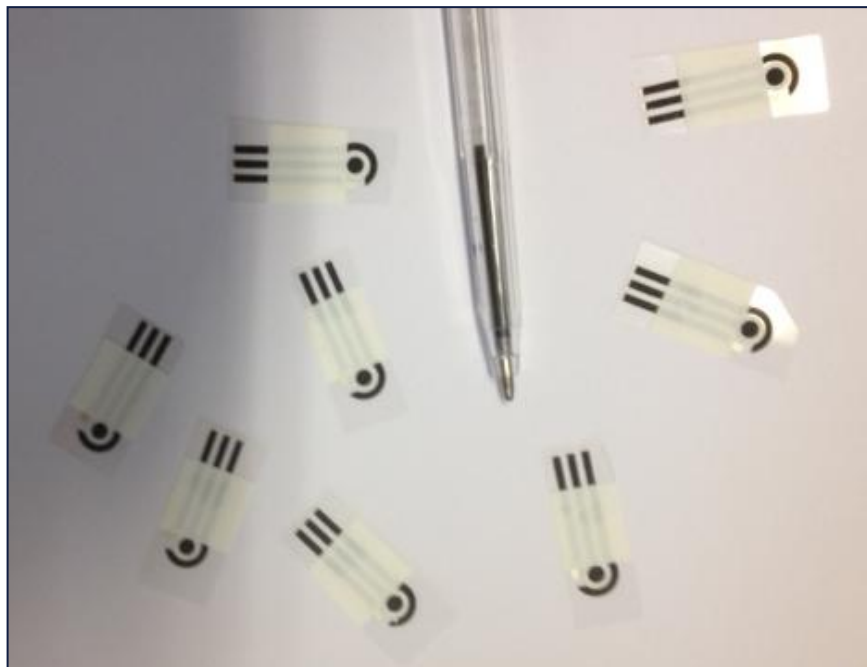


Paper-based reagent free device

Paper as reactor

Paper-based devices for aerosol samples

Paper in hybrid systems



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

Fabiana Arduini<sup>a,b,\*</sup>, Stefano Cinti<sup>c</sup>, Vincenzo Mazzeracchio<sup>a</sup>, Viviana Scognamiglio<sup>d</sup>, Aziz Amine<sup>e</sup>, Danila Moscone<sup>a</sup>

<sup>a</sup> University of Rome "Tor Vergata", Department of Chemical Science and Technologies, Via della Ricerca Scientifica, 00133, Rome, Italy  
<sup>b</sup> SENSEMED via Renato Rascol 30, 00128, Rome, Italy  
<sup>c</sup> University of Naples Federico II, Department of Pharmacy, Naples, Italy  
<sup>d</sup> Institute of Crystallography, Department of Chemical Sciences and Materials Technologies, Via Salaria Km 29.3, 00015, Monterotondo Scalo, Rome, Italy  
<sup>e</sup> Faculty of Sciences and Techniques, Hassan II University of Casablanca, Morocco



Anal. Chem. 2010, 82, 3-10

analytical  
chemistry  
feature

### Diagnostics for the Developing World: Microfluidic Paper-Based Analytical Devices

Andres W. Martinez, Scott T. Phillips, and George M. Whitesides

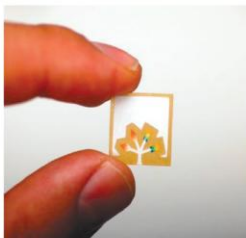
Harvard University

Emanuel Carrilho

Universidade de São Paulo (Brazil)/Harvard University

Microfluidic paper-based analytical devices ( $\mu$ PADs) are a new class of point-of-care diagnostic devices that are inexpensive, easy to use, and designed specifically for use in developing countries. (To listen to a podcast about this feature, please go to the Analytical Chemistry multimedia page at [pubs.acs.org/page/ancham/audio/index.html](http://pubs.acs.org/page/ancham/audio/index.html).)

The first step in proper prevention and treatment of disease is accurate diagnosis, but diagnostic technologies that are successful in the economically developed world often are difficult to use in developing countries. People who live in these countries frequently cannot afford even modestly expensive tests, and basic infrastructure—i.e., reliable power, refrigeration, and trained personnel—is often not available.<sup>1-5</sup> Currently, diagnosis usually requires a trained healthcare worker to recognize symptoms or interpret analyses. By developing effective technologies in health-related diagnostics for developing countries and coupling these technolo-



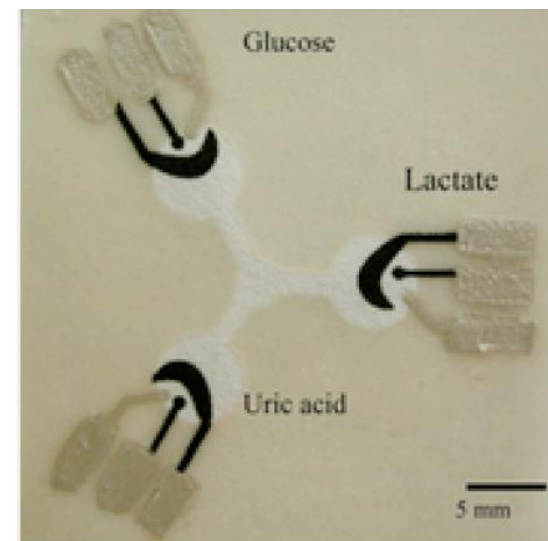
**(RE)-ASSURED criteria:**  
Affordable  
Sensitive  
Specific  
User-friendly  
Rapid and Robust  
Equipment-free  
Delivered to those who need it



## Electrochemical Detection for Paper-Based Microfluidics

Wijitar Dungchai,<sup>†</sup> Orawon Chailapakul,<sup>\*,†,‡</sup> and Charles S. Henry<sup>\*,§</sup>

Sensor Research Unit, Department of Chemistry, Faculty of Science, Chulalongkorn University, Patumwan, Bangkok, 10330, Thailand, Center of Excellence for Petroleum, Petrochemicals, and Advanced Materials, Chulalongkorn University, Patumwan, Bangkok, 10330, Thailand, and Department of Chemistry, Colorado State University, Fort Collins, Colorado 80523-1872

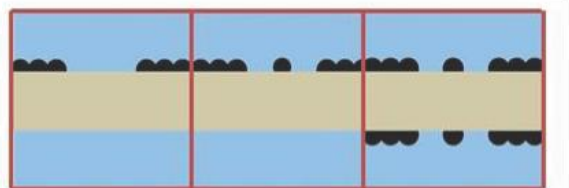


nature protocols **PROTOCOL**  
<https://doi.org/10.1038/s41596-019-0186-y>

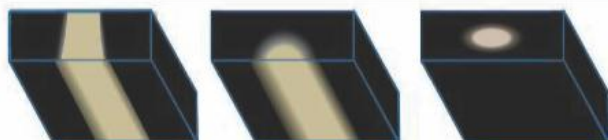
## Preparation of paper-based devices for reagentless electrochemical (bio)sensor strips

Stefano Cinti<sup>1\*</sup>, Danila Moscone<sup>2</sup> and Fabiana Arduini<sup>2\*</sup>

### 1. Print

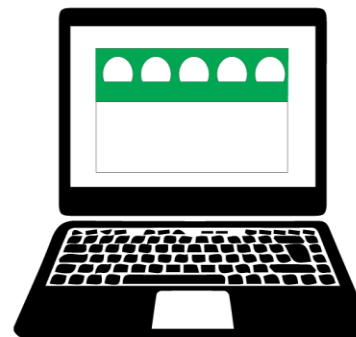


### 2. Heat

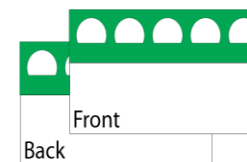


channel type :      open      hemi      fully enclosed

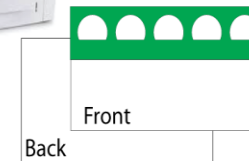
paper      wax



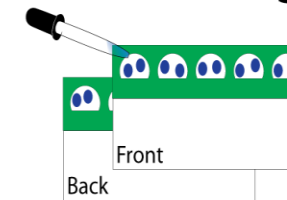
Drawing



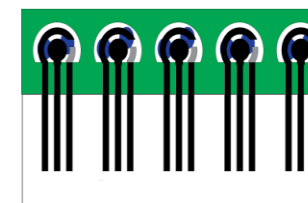
Heating



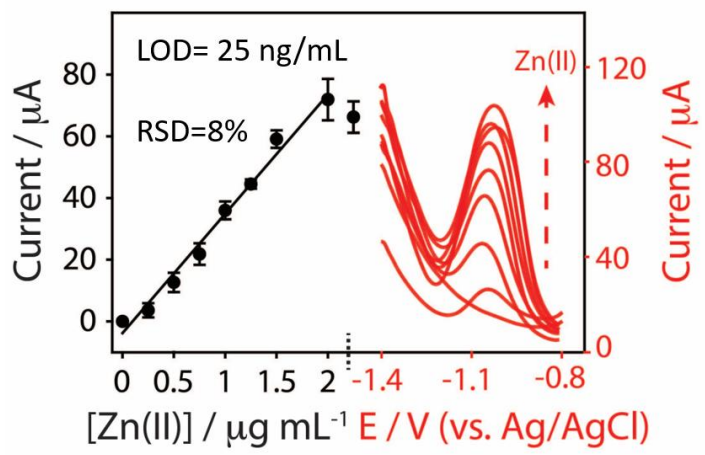
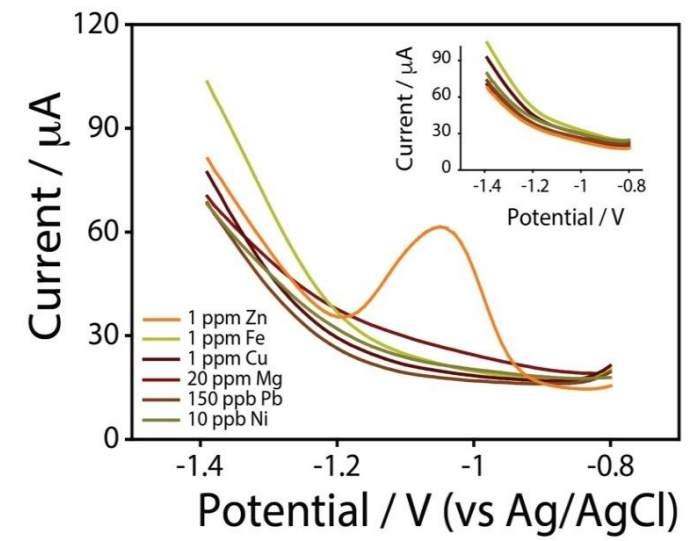
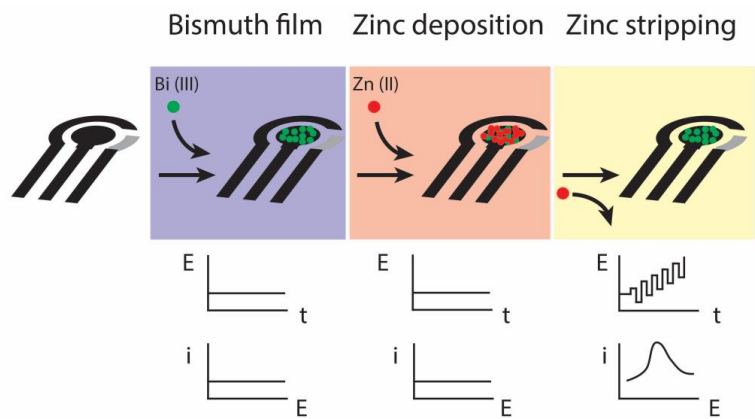
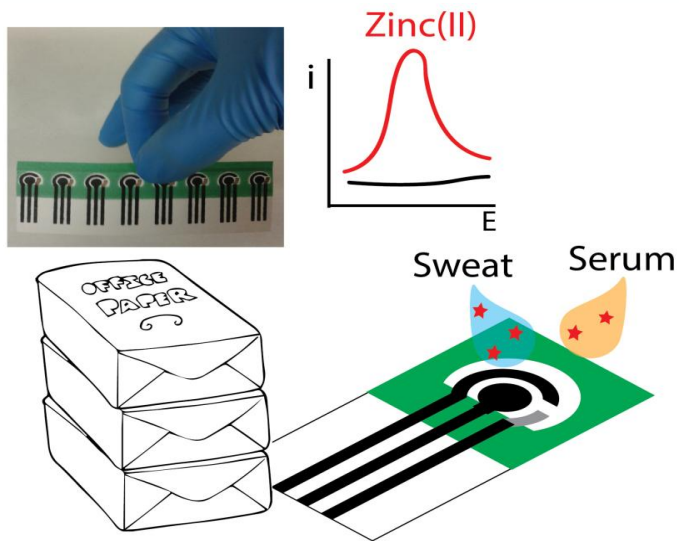
Wax Printing



Modifying



Screen-Printing



Serum (0.5/1  $\mu\text{g/mL}$ ):  
95 $\pm$ 9 % and 103 $\pm$ 9 %.

Sweat (0.5/1  $\mu\text{g/mL}$ ):  
97 $\pm$ 9 % and 96 $\pm$ 11 %.

TrAC Trends in Analytical Chemistry  
Volume 29, Issue 11, December 2010, Pages 1295-1304

Bismuth-modified electrodes for lead detection

Fabiana Arduini, Josefina Quintana Calvo, Giuseppe Palleschi, Danila Moscone, Aziz Amine

Sensors and Actuators B 233 (2017) 1199-1206

Contents lists available at ScienceDirect

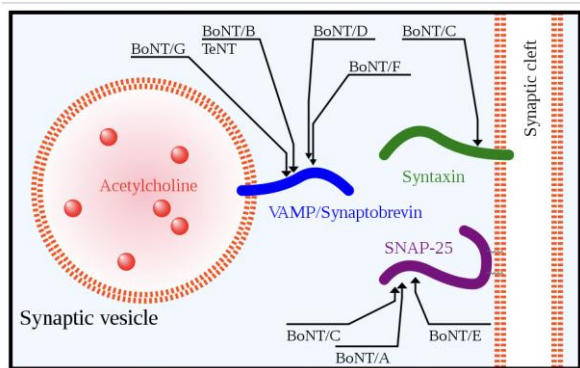
Sensors and Actuators B: Chemical

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

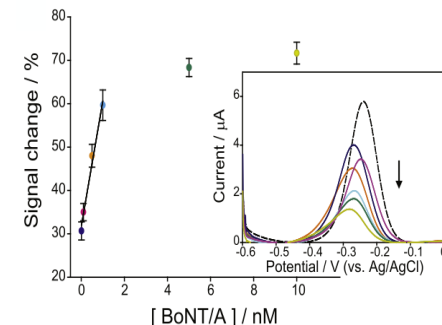
Sustainable monitoring of Zn(II) in biological fluids using office paper  
Stefano Cinti, Benedetta De Lellis, Danila Moscone, Fabiana Arduini  
University of Rome 'Tor Vergata', Department of Chemical Science and Technology, Via della Ricerca Scientifica, 00133 Rome, Italy



Funded by the European Union

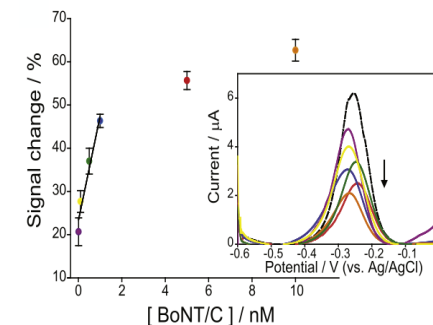


We designed our biosensor using synthetic peptide of a length of 14 aminoacids (Cys-Ahx-Lys-Thr-Arg-Ile-Asp-Glu-Ala-Asn-Gln-Arg-Ala-Thr-Lys(Methylene blue)-Met) containing the cleavage sites of the toxins between Gln and Arg for **BoNT/A**, and between Arg and Ala for **BoNT/C**. The peptide labelled with the electrochemical probe was immobilized on AuNP-modified electrode surface for the detection of BoNT/A and BoNT/C.



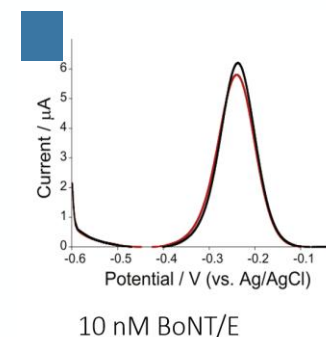
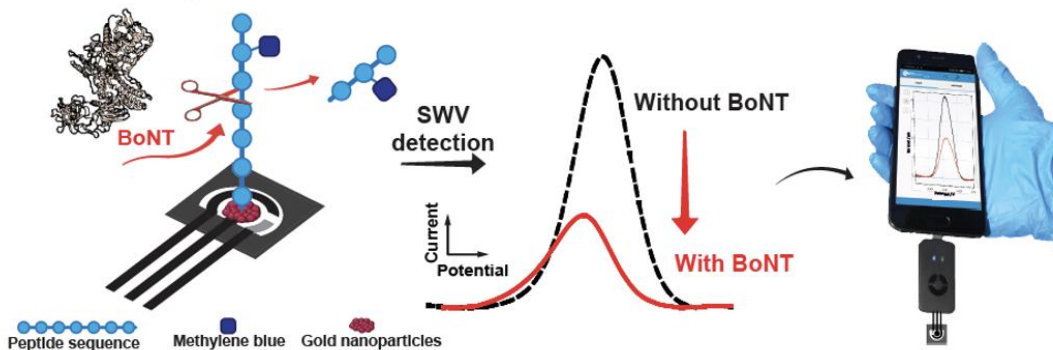
$$y = (31.7 \pm 1.1) + (29 \pm 2) x, R^2 = 0.954$$

LOD = 10 pM



$$y = (23.1 \pm 1.3) + (24.2 \pm 2.4) x, R^2 = 0.912$$

LOD = 10 pM



Biosensors and Bioelectronics 183 (2021) 113209

Contents lists available at ScienceDirect

Biosensors and Bioelectronics

ELSEVIER

journal homepage: <http://www.elsevier.com/locate/sbs>

Paper-based electrochemical peptide sensor for on-site detection of botulinum neurotoxin serotype A and C

Veronica Caratelli<sup>a</sup>, Silvia Fillo<sup>b</sup>, Nino D'Amore<sup>c</sup>, Ornella Rossetto<sup>d,e</sup>, Marco Pirazzini<sup>f</sup>, Maria Moccia<sup>g</sup>, Concetta Avitabile<sup>h</sup>, Daniela Moscone<sup>i</sup>, Florio Lisa<sup>j</sup>, Fabiana Arduini<sup>k,l</sup>

<sup>a</sup> For University, Department of Chemical Science and Technology, Via della Ricerca Scientifica, 00135, Rome, Italy

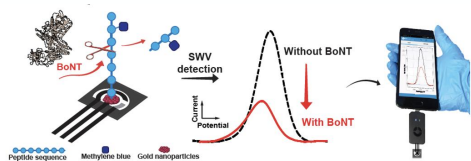
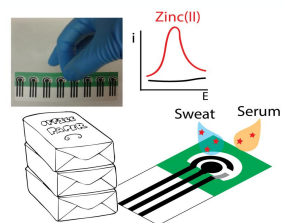
<sup>b</sup> Scientific Department, Army Medical Center, Via Salaria 1024, 00144, Rome, Italy

<sup>c</sup> Department of Chemical Science, University of Padua, Via Ugo Bassi 64/A, 35121, Padova, Italy

<sup>d</sup> CNR Institute of Nanotechnology, Via Spinoza 2, 35122, Padova, Italy

<sup>e</sup> Institute of Chemistry, National Research Council, Department of Chemical Science and Materials Technology, Via C. Amadeo 120/15, 70126, Bari, Italy

<sup>f</sup> IANIGLA, The Italian Research 36, 00135, Rome, Italy



Paper-based as sustainable substrate

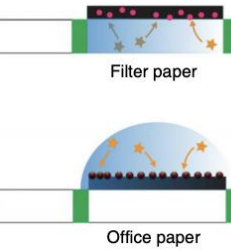
Paper-based origami device for multiple analysis

Paper-based lab on a chip

Paper-based devices for solid samples



Paper-based reagent free device



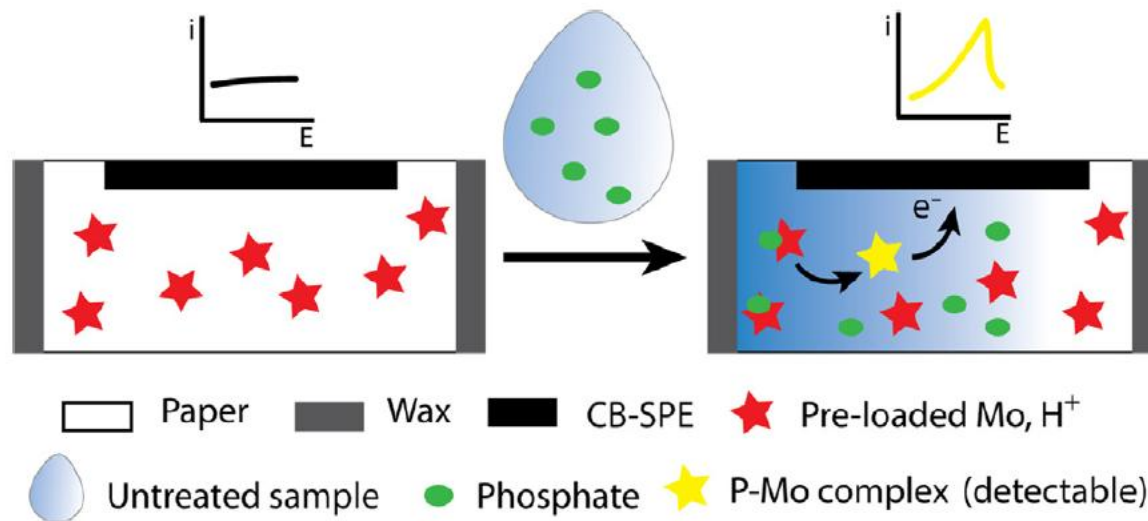
Paper as reactor

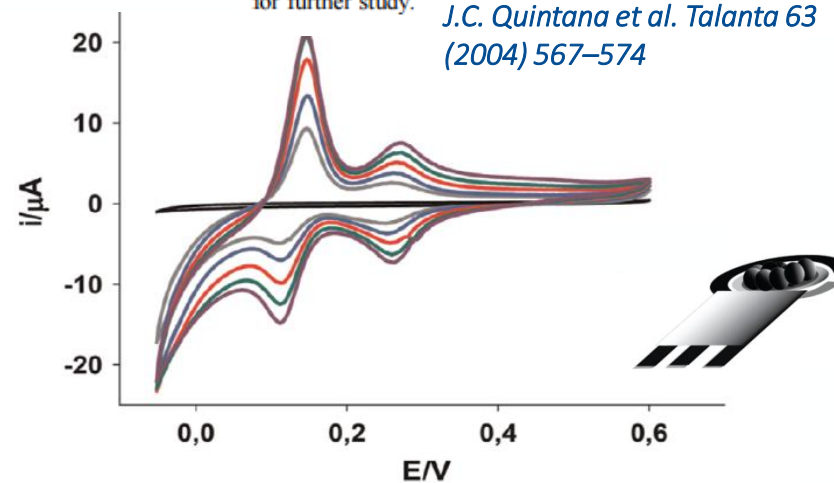
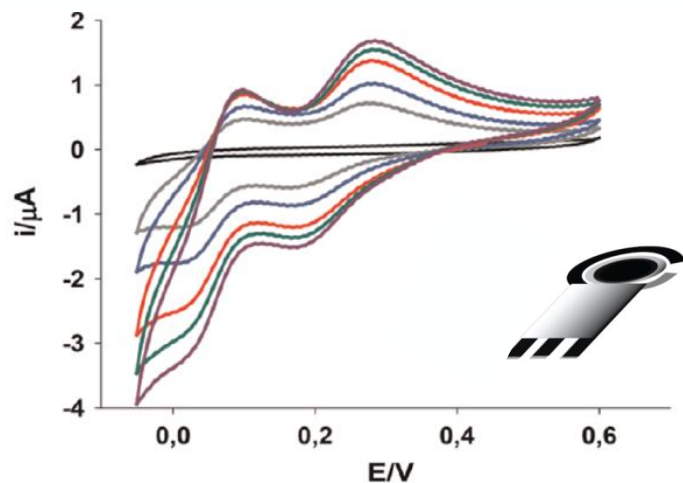
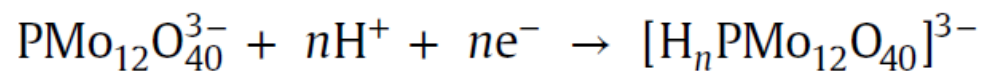
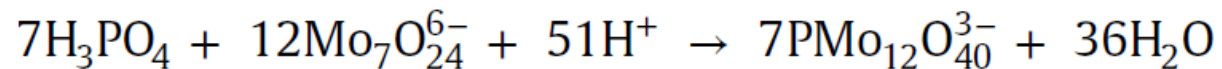
Paper-based devices for aerosol samples



Funded by the European Union





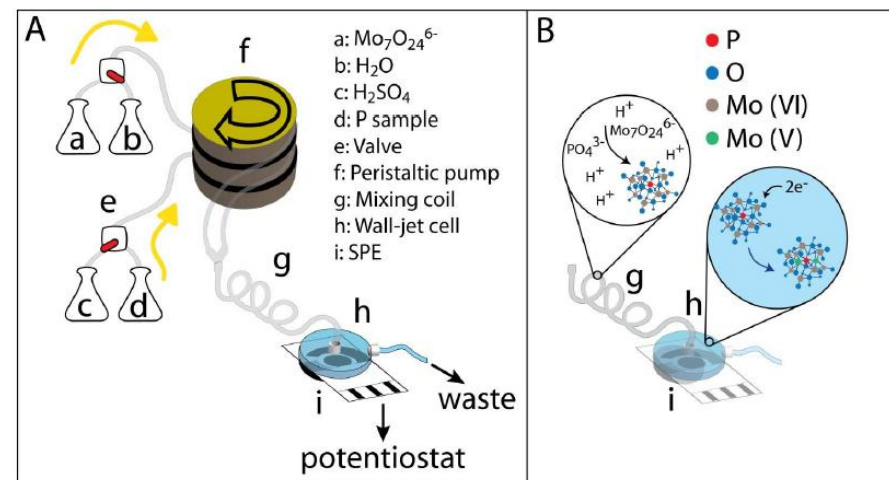
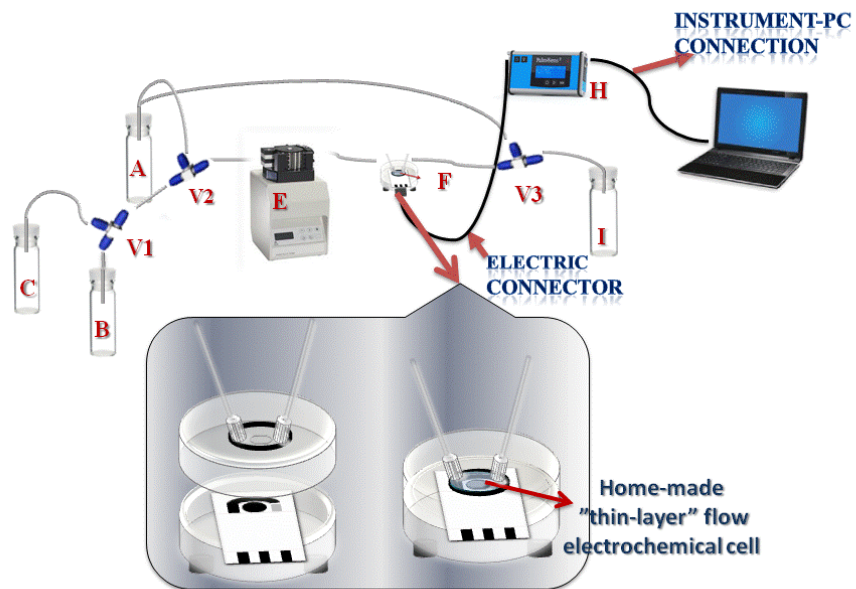


Two consecutive quasi-reversible reductions are observed in the potential range studied. The first reduction peak (0.32 V versus SCE) is smaller than the second is (0.17 V versus SCE). The reduction peak at 0.1–0.2 V was large but difficult to reproduce due to an apparent adsorption phenomenon [11]. In order to choose the best potential to be applied for amperometric determination of phosphate, a hydrodynamic voltammogram was recorded in the potential range 0.5–0.1 V versus Ag/AgCl (Fig. 3). Despite of the high current response at 0.1–0.2 V, we observed high noise of molybdate reduction and baseline drift at these applied potentials (0.1–0.2 V). Since the current response was stable at +0.3 V versus Ag/AgCl, this potential was adopted for further study.

*J.C. Quintana et al. Talanta 63 (2004) 567–574*

Cyclic voltammetry using bare SPE and CB-SPE in  $\text{H}_2\text{SO}_4$  0.1 M + KCl 0.1 M solution with molybdate (1 mM) in the absence and in the presence of phosphate 0.01 mM, 0.05 mM, 0.1 mM, 0.2 mM, scan rate 50 mV/s

*D. Talarico, F. Arduini\*, A. Amine, D. Moscone, G. Palleschi, Talanta 141 (2015) 267–272.*

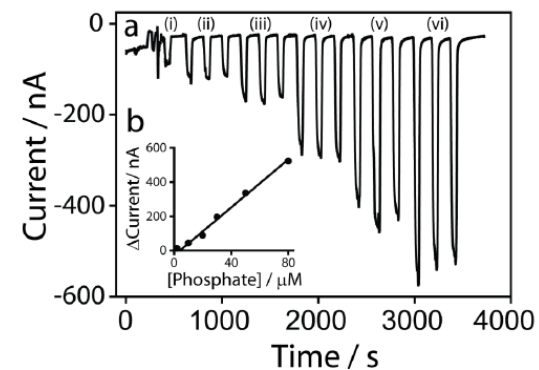
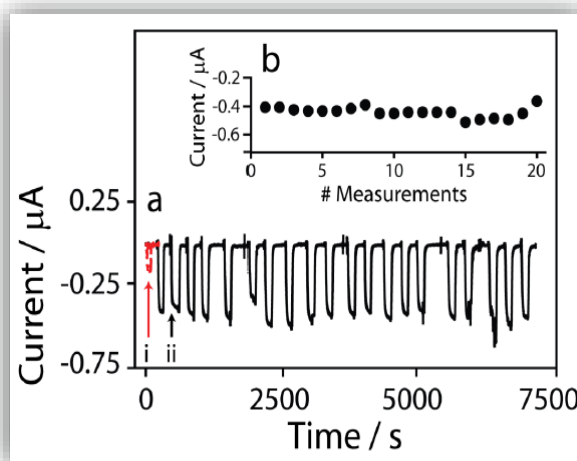


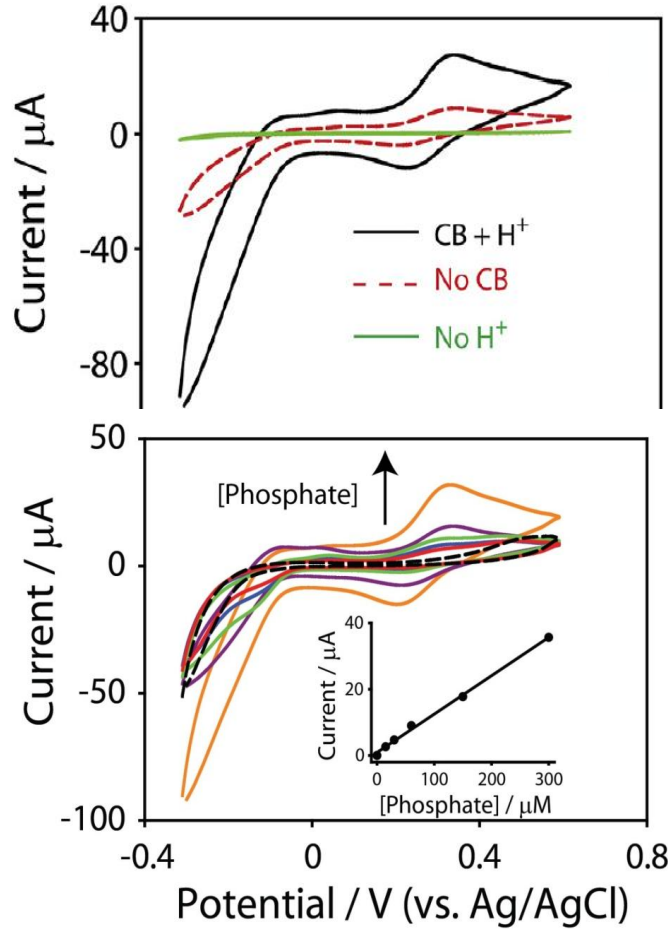
ENVIRONMENTAL  
Science & Technology

Article  
pubs.acs.org/est

Phosphate Detection through a Cost-Effective Carbon Black Nanoparticle-Modified Screen-Printed Electrode Embedded in a Continuous Flow System

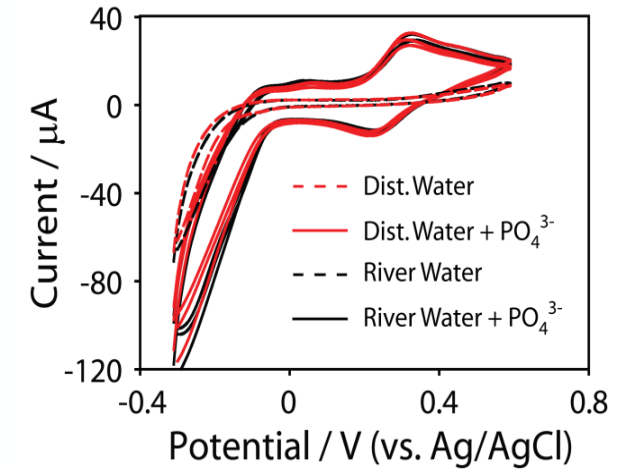
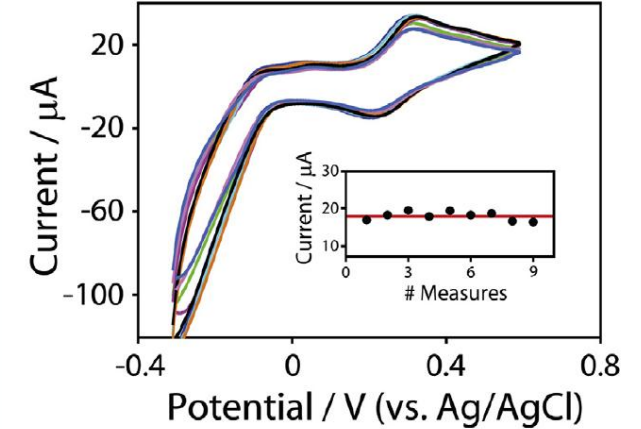
Daria Talarico,<sup>\*,‡</sup> Stefano Cinti,<sup>\*,‡</sup> Fabiana Arduini,<sup>\*,‡</sup> Aziz Amine,<sup>§</sup> Danila Moscone,<sup>‡</sup> and Giuseppe Palleschi<sup>‡</sup>



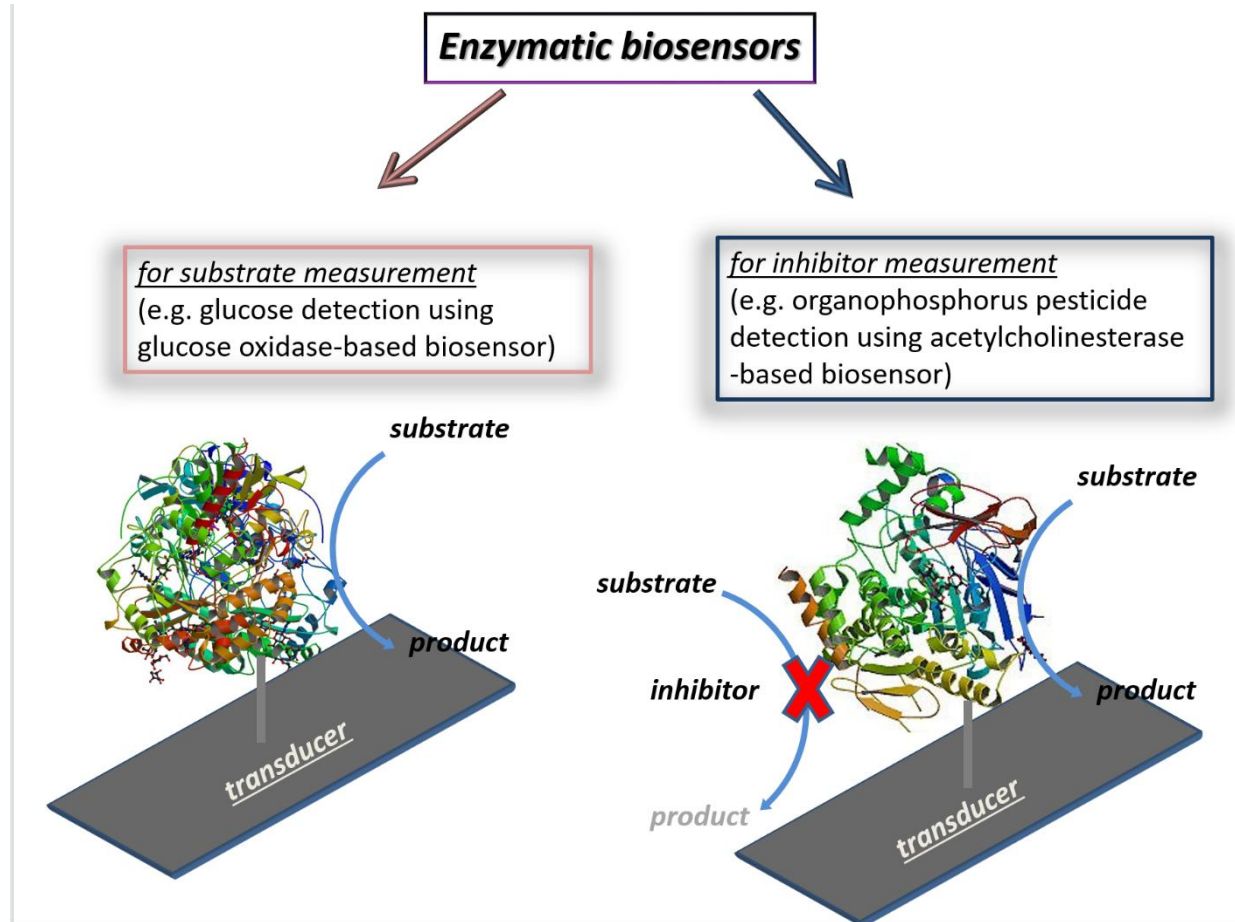


Linear range up to 100  $\mu\text{M}$ ,  
LOD=4  $\mu\text{M}$ ,  
RSD (inter)=6%

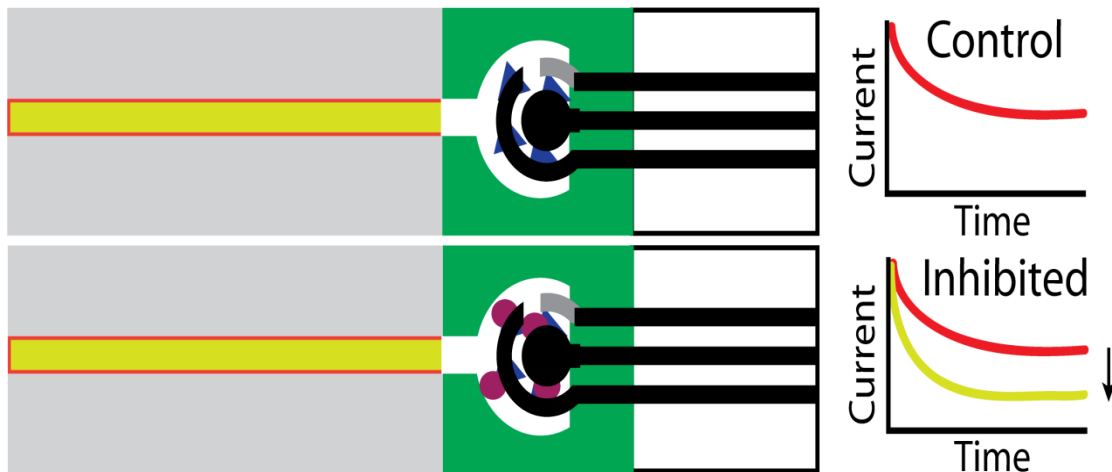
Cyclic voltammograms of CB-based ink screen-printed onto paper modified with 10  $\mu\text{L}$  containing 100 mM molybdate, 100 mM potassium chloride, and 100 mM sulfuric acid



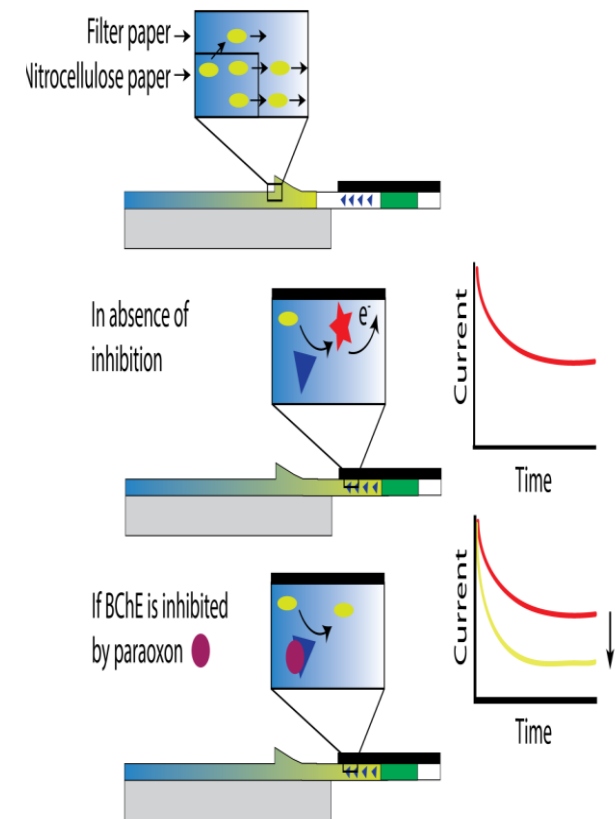
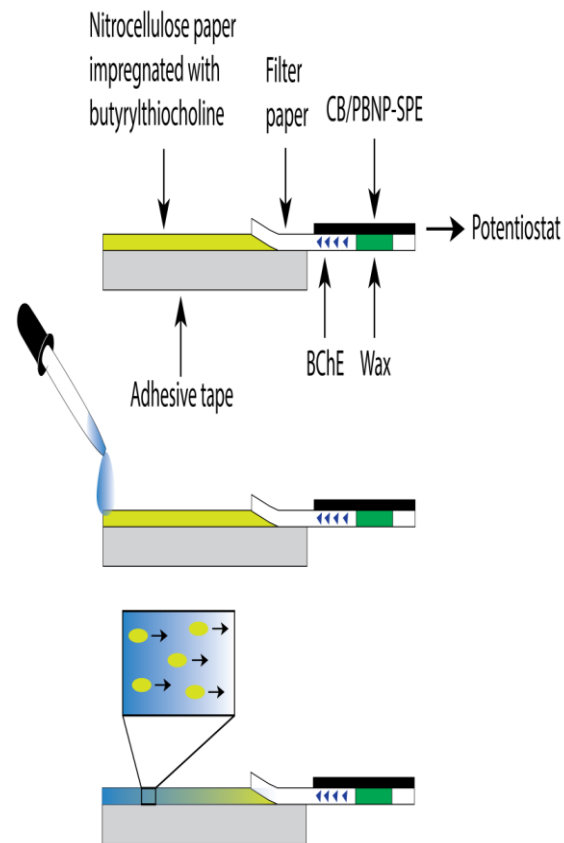
*S.Cinti, D. Talarico, G. Palleschi, D. Moscone, F. Arduini, Analytica Chimica Acta, 919 (2016) 78-84*

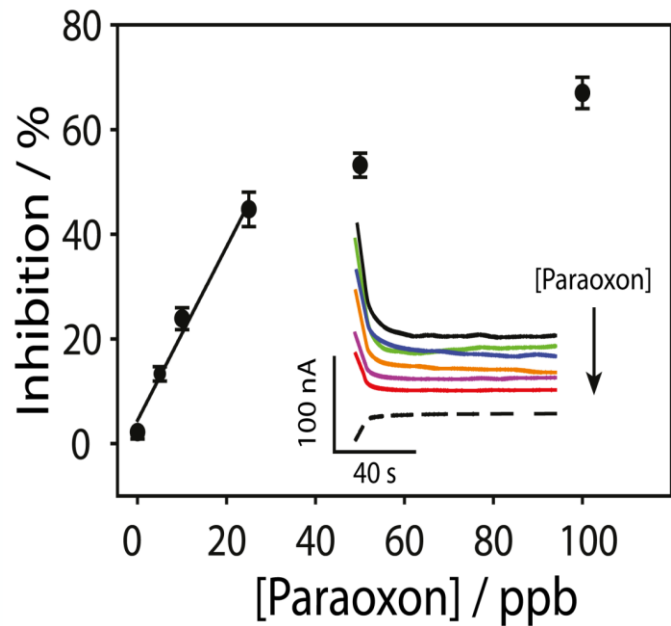


*A. Amine, F. Arduini, et al Biosensors and Bioelectronics 76 (2016) 180–194*



- CB/PBNP-SPE
- Adhesive tape
- Filter paper
- Butyrylthiocholine
- Nitrocellulose paper
- BChE (pH 8)
- Wax ink
- Paraoxon





$$I\% = (1.7 \pm 0.2) x + (4.4 \pm 1.3)$$

$$R^2 = 0.987$$

LOD = 3 ppb

(10% of inhibition)

Linear range up to 25 ppb

RSD = 9% (25 ppb)

## RIVER WATER

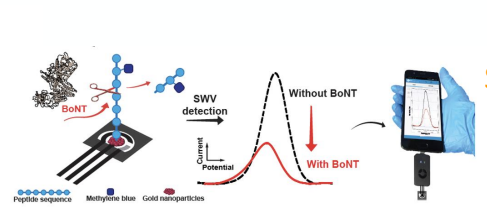
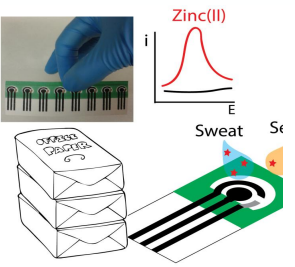


## WASTEWATER



River water Recovery %	Paraoxon added	Waste Water Recovery %
89 ± 8	25 ppb	92 ± 8
94 ± 8	50 ppb	96 ± 7

*S. Cinti, C. Minotti, D. Moscone, G. Palleschi, F. Arduini.  
Biosensors and Bioelectronics, 2017, 93, 46-51*

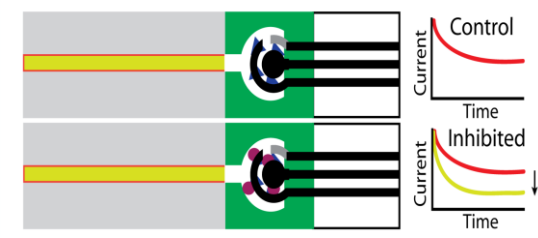


Paper-based as sustainable substrate

Paper-based origami device for multiple analysis



Paper-based reagent free device



Paper as reactor

Paper-based lab on a chip

Paper-based devices for aerosol samples

Paper-based devices for solid samples

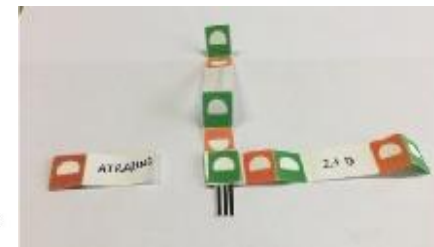
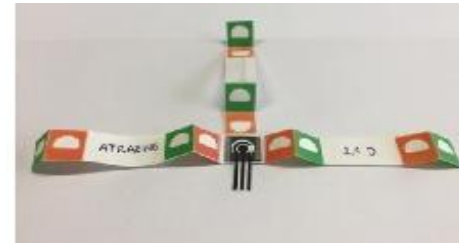
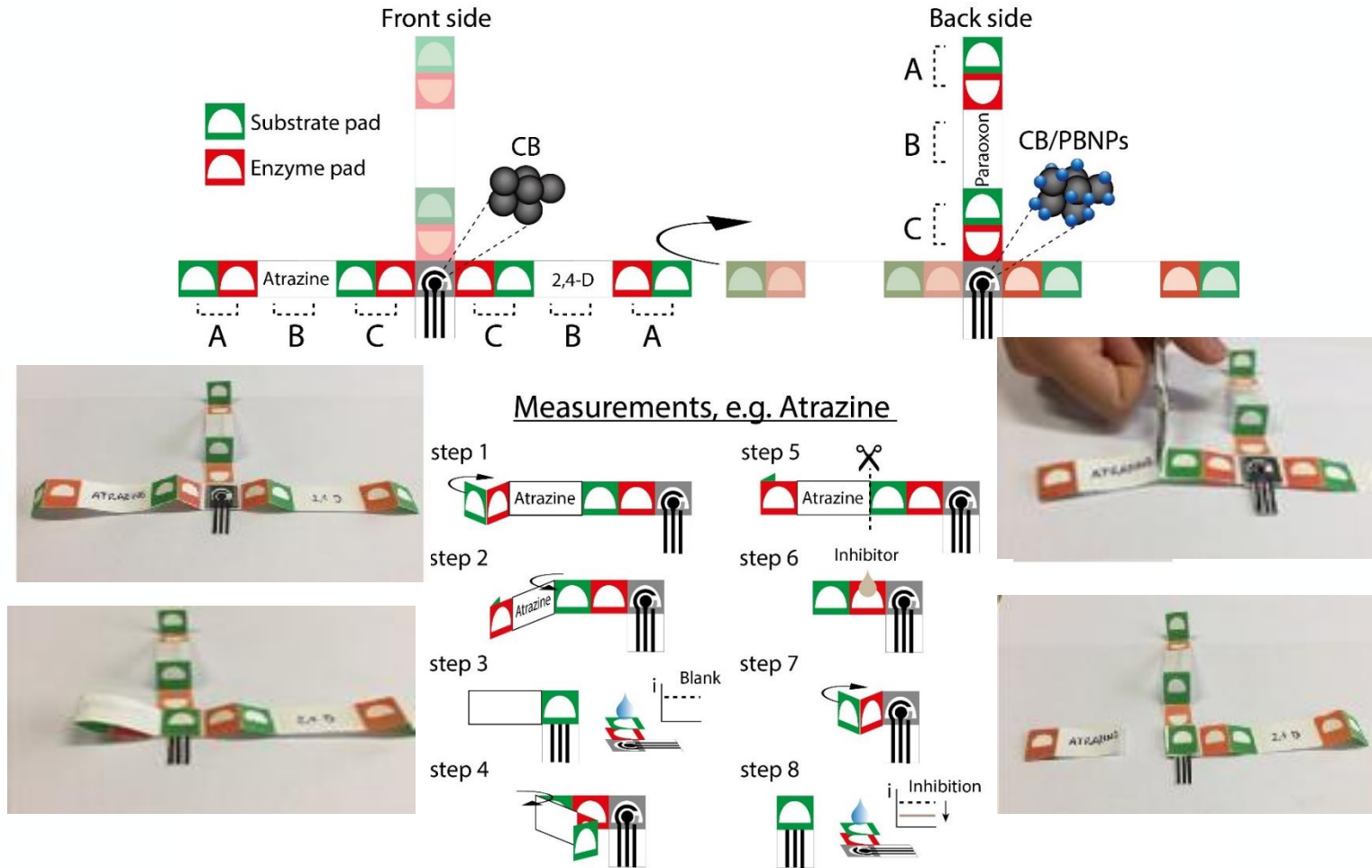
Paper in hybrid systems



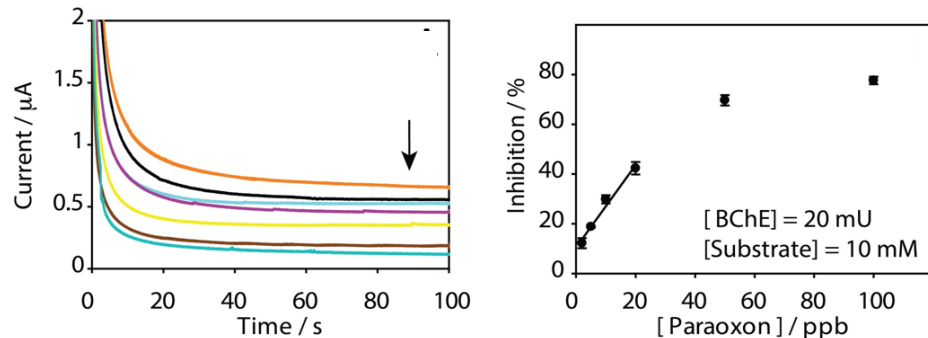
Funded by the European Union



Type of pesticide	Enzyme	Type of inhibition	Reference
Organophosphorus insecticides (e.g. Paraoxon)	Butyrylcholinesterase	Irreversible	Arduini et al., Microchim. Acta, 2010, 170, 193.
Phenoxy herbicides (e.g. 2,4 dichlorophenoxyacetic acid)	Alkaline phosphatase	Reversible	Mazzei et al., J. Electroanal. Chem., 2004, 574, 95.
Triazine herbicide (e.g. Atrazine)	Tyrosinase	Reversible	Tortolini et al., Sens. Actuat. B, 2016, 224, 552.

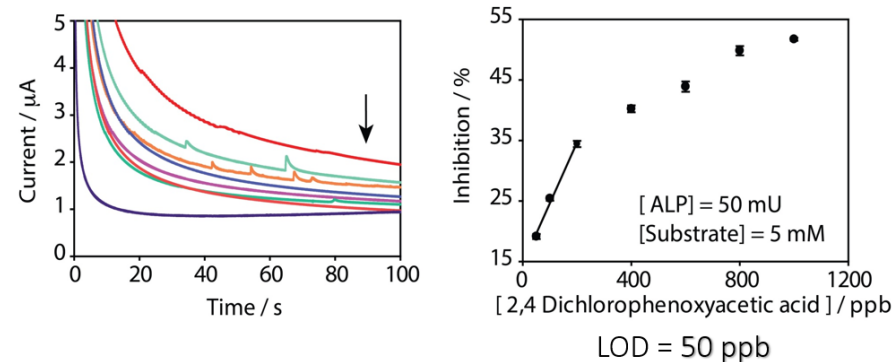


[Paraoxon] tested: 2, 5, 10, 20, 50, 100 ppb, in Aniëne river water.



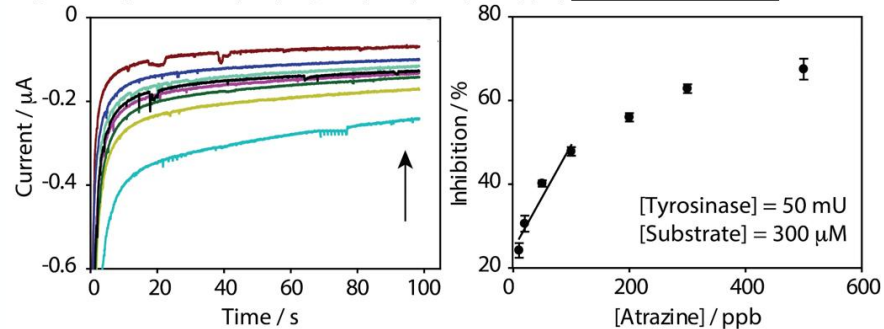
Recovery study: 10 ppb  $90 \pm 1\%$   
20 ppb  $88 \pm 2\%$

[2,4 D] tested: 50, 100, 200, 400, 600, 800, 1000 ppb, in Aniëne river water.

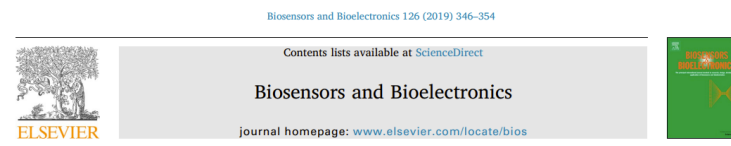


Recovery study: 100 ppb  $86 \pm 4\%$   
200 ppb  $93 \pm 2\%$

[Atrazine] tested: 10, 20, 50, 100, 200, 300, 500 ppb, in Aniëne river water.



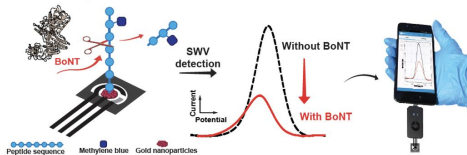
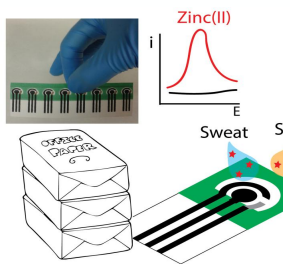
Recovery study: 50 ppb  $80 \pm 4\%$   
100 ppb  $92 \pm 3\%$



Origami multiple paper-based electrochemical biosensors for pesticide detection

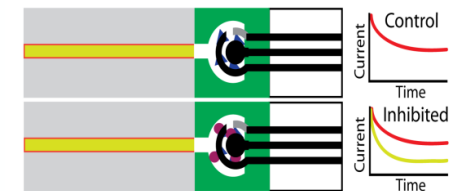
F. Arduini<sup>a,\*</sup>, S. Ginti<sup>a</sup>, V. Caratelli<sup>a</sup>, L. Amendola<sup>b</sup>, G. Palleschi<sup>a</sup>, D. Moscone<sup>a</sup>

<sup>a</sup> Department of Chemical Science and Technologies, University of Rome Tor Vergata, Via della Ricerca Scientifica, 00133 Rome, Italy  
<sup>b</sup> Arpalazio, Via Giuseppe Saredo 52, 00173 Rome, Italy



Paper-based as sustainable substrate

Paper-based reagent free device



Paper-based origami device for multiple analysis



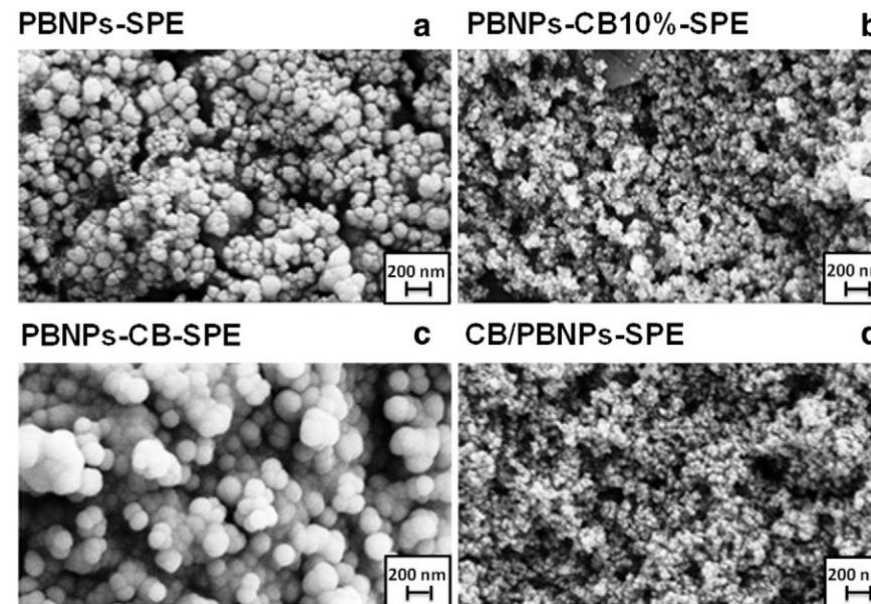
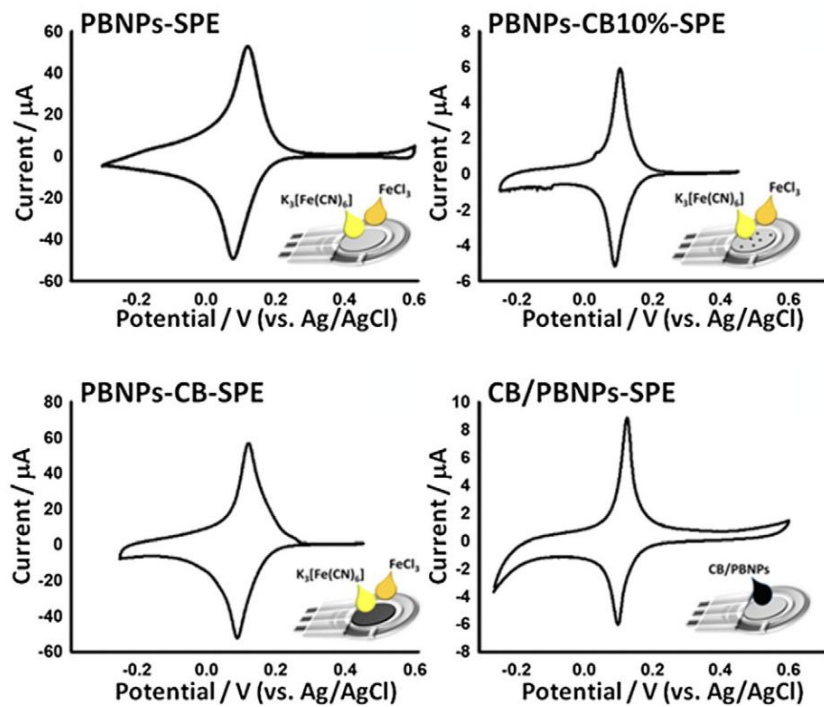
Paper as reactor

Paper-based lab on a chip

Paper-based devices for aerosol samples

Paper-based devices for solid samples

Paper in hybrid systems



Electrochemistry Communications 47 (2014) 63–66



Contents lists available at ScienceDirect

Electrochemistry Communications

journal homepage: [www.elsevier.com/locate/elecom](http://www.elsevier.com/locate/elecom)



Short communication

Carbon black assisted tailoring of Prussian Blue nanoparticles to tune sensitivity and detection limit towards H<sub>2</sub>O<sub>2</sub> by using screen-printed electrode



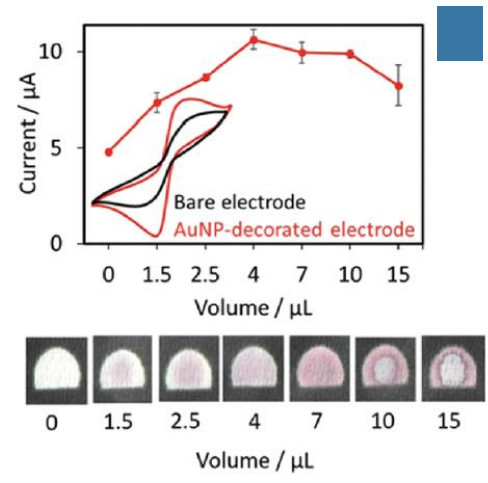
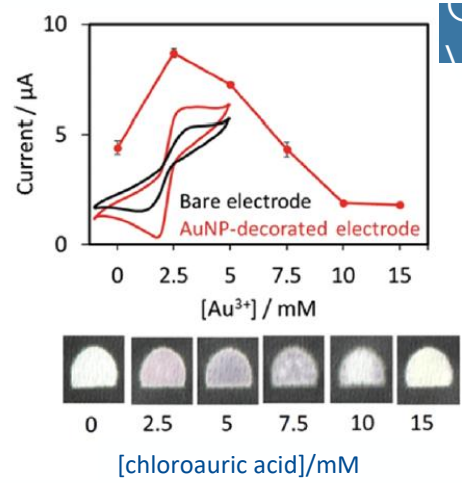
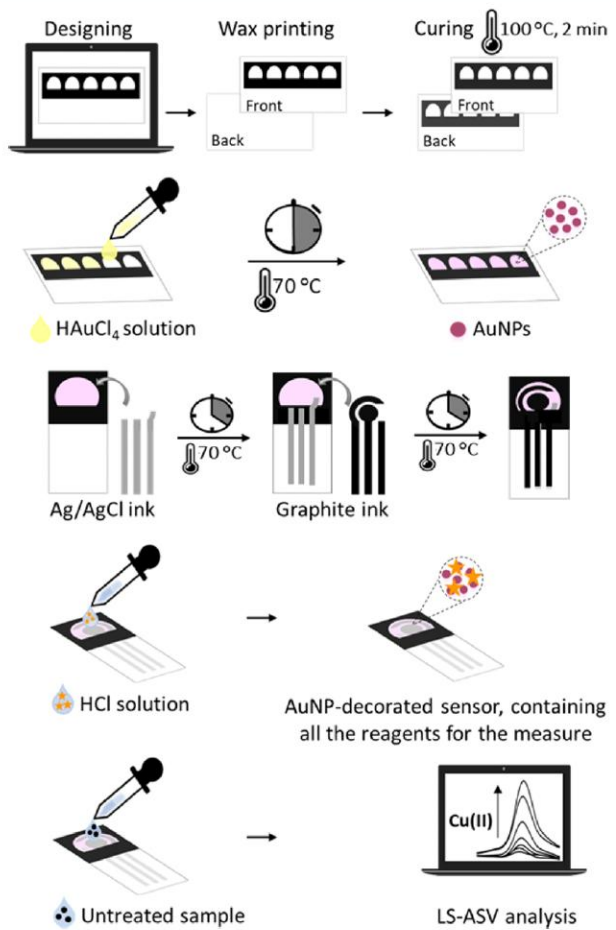
Stefano Cinti<sup>a,b</sup>, Fabiana Arduini<sup>a,b,\*</sup>, Giada Vellucci<sup>a,b</sup>, Ilaria Cacciotti<sup>c</sup>, Francesca Nanni<sup>d</sup>, Danila Moscone<sup>a,b</sup>

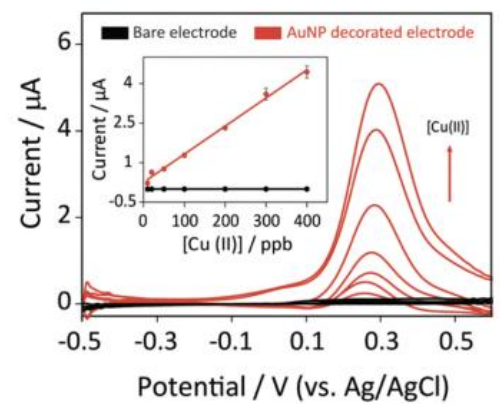
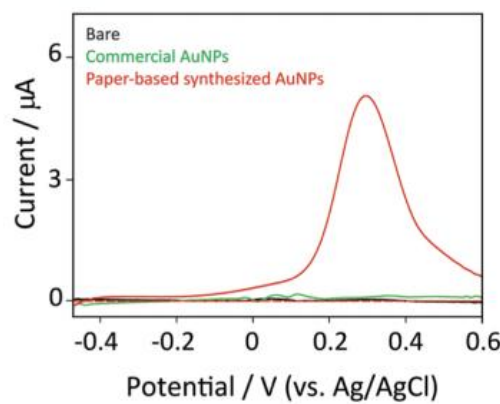
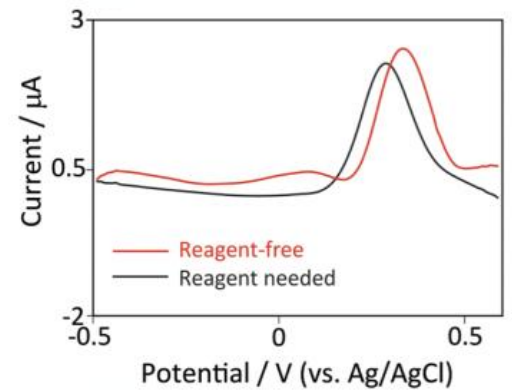
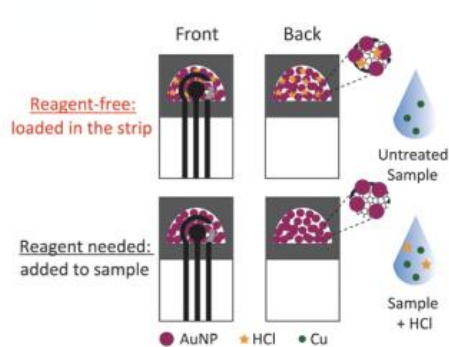
<sup>a</sup> Dipartimento di Scienze e Tecnologie Chimiche, Università di Roma Tor Vergata, Via della Ricerca Scientifica, 00133 Rome, Italy

<sup>b</sup> Consorzio Interuniversitario Biostrutture e Biosistemi "INBB", Viale Medaglie d'Oro, 305, Rome, Italy

<sup>c</sup> Università degli Studi di Roma "Niccolò Cusano", Udr INSTM, Via Don Carlo Gnocchi 3, 00166 Rome, Italy

<sup>d</sup> Dipartimento di Ingegneria dell'Impresa, Università di Roma Tor Vergata, Udr INSTM Roma-Tor Vergata, Via del Politecnico 1, 00133 Rome, Italy





sample	recoveries		
	spiked concentration (ppb)	recovery (%)	RSD (%)
sweat no. 1	50	101	6
	100	93	1
serum no. 1	100	112	4
	300	119	1

	copper ions found (ppb)		F-test		Student's t-test	
	AuNP-strip	AAS	exp. value	critical value	exp. value	critical value
sweat no. 2	384 ± 43	391 ± 10	18.49	19.00	0.275	2.776
serum no. 2	678 ± 18	704 ± 7	7.33		2.412	

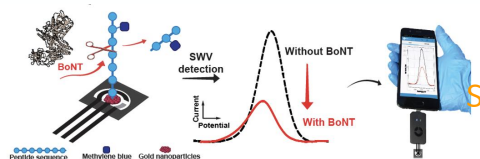
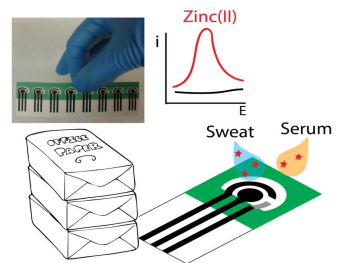
analytical chemistry

pubs.acs.org/ac Article

**Electroanalytical Sensor Based on Gold-Nanoparticle-Decorated Paper for Sensitive Detection of Copper Ions in Sweat and Serum**

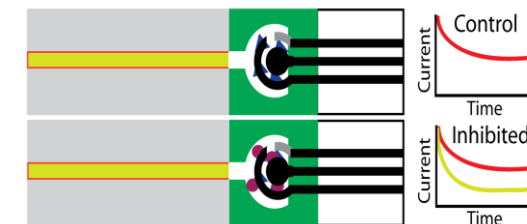
Neda Bagheri,<sup>†</sup> Vincenzo Mazzaracchio,<sup>‡</sup> Stefano Cinti,<sup>\*</sup> Noemi Colozza, Concetta Di Natale, Paolo Antonio Netti, Mohammad Saraji, Simona Roggero, Danila Moscone, and Fabiana Arduini<sup>#</sup>

Cite This: *Anal. Chem.* 2021, 93, 5225–5233 [Read Online](#)

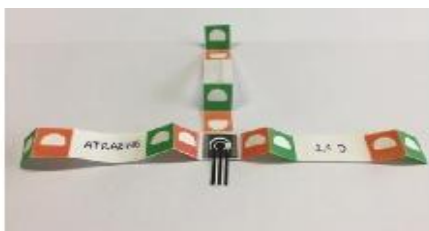


Paper-based as sustainable substrate

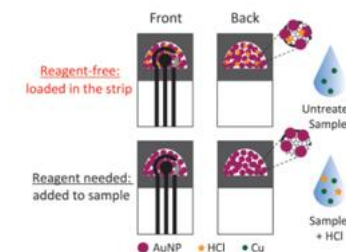
Paper-based reagent free device



Paper-based origami device for multiple analysis



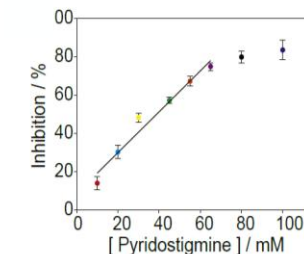
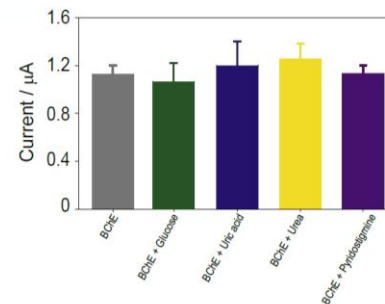
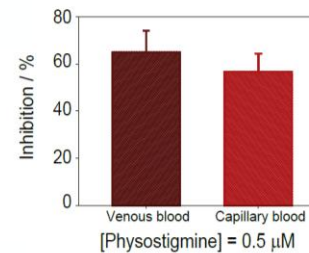
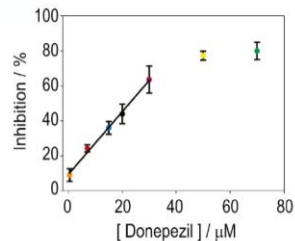
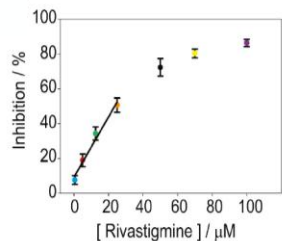
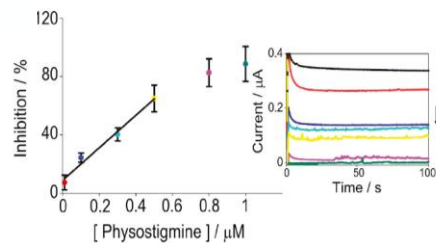
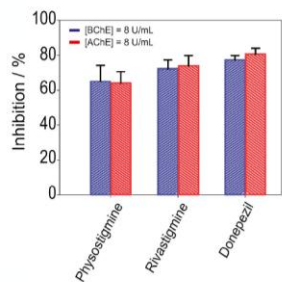
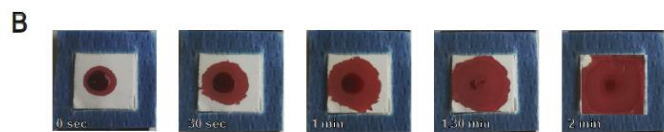
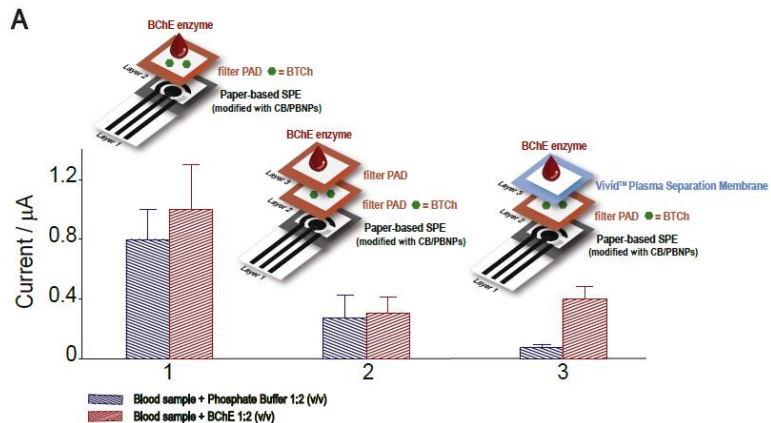
Paper as reactc



Paper-based lab on a chip

Paper-based devices for aerosol samples

Paper-based devices for solid samples



Biosensors and Bioelectronics 166 (2020) 112411

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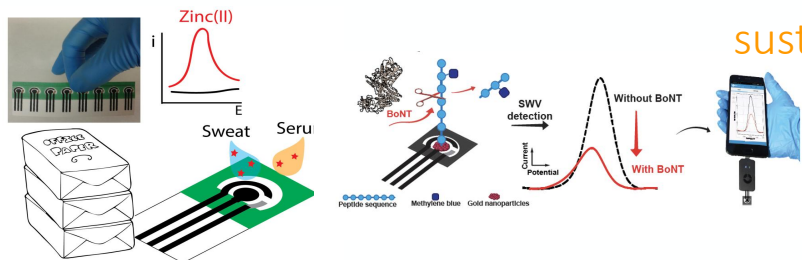
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Precision medicine in Alzheimer's disease: An origami paper-based electrochemical device for cholinesterase inhibitors

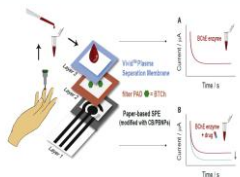
Veronica Caratelli<sup>a</sup>, Adriana Ciampaglia<sup>a</sup>, Jacopo Guiducci<sup>b</sup>, Giuseppe Sancesario<sup>b</sup>, Danila Moscone<sup>a</sup>, Fabiana Arduini<sup>a,c,\*</sup>

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<sup>c</sup> SENS@MATHS, Via Roma Nuova 26, 00132, Rome, Italy



Paper-based as sustainable substrate

Paper-based origami device for multiple analysis

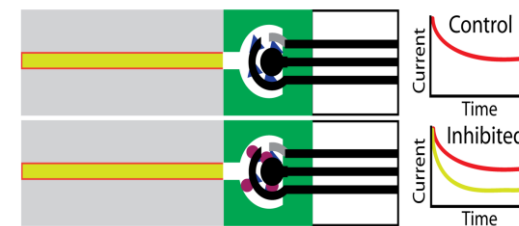


Paper-based lab on a chip

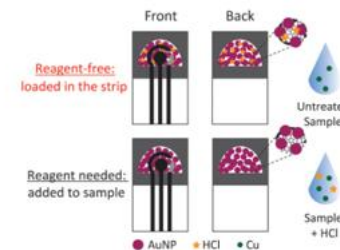
Paper-based devices for solid samples



Paper-based reagent free device



Paper as reactor



Paper-based devices for aerosol samples

Paper in hybrid systems

### **Towards a Portable Prototype Based on Electrochemical Cholinesterase Biosensor to be Assembled to Soldier Overall for Nerve Agent Detection**

*Fabiana Arduini,<sup>a,b</sup> Daniela Neagu,<sup>a,b</sup> Stefano Dall'Oglio,<sup>c</sup> Danila Moscone,<sup>a,b</sup> Giuseppe Palleschi<sup>a,b</sup>*

<sup>a</sup> Dipartimento di Scienze e Tecnologie Chimiche, Università di Roma Tor Vergata, Via della Ricerca Scientifica, 00133 Rome, Italy

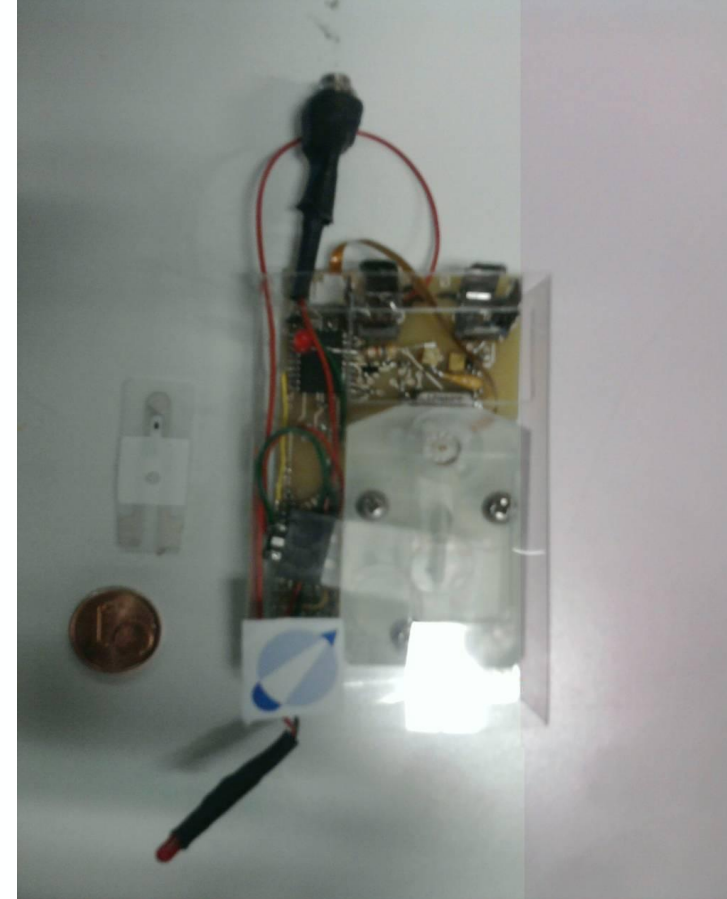
<sup>b</sup> Consorzio Interuniversitario Biostrutture e Biosistemi "INBB", Viale Medaglie d'Oro 305, 00136 Rome, Italy

<sup>c</sup> Strictes + AeG Company

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Received: September 25, 2011

Accepted: November 28, 2011



*Sensors* 2015, 15(2), 4353-4367; <https://doi.org/10.3390/s150204353>

Open Access Article

## A Choline Oxidase Amperometric Bioassay for the Detection of Mustard Agents Based on Screen-Printed Electrodes Modified with Prussian Blue Nanoparticles

Fabiana Arduini <sup>1,\*</sup> ✉, Viviana Scognamiglio <sup>2</sup> ✉, Corrado Covaia <sup>1</sup> ✉, Aziz Amine <sup>3</sup> ✉, Danila Moscone <sup>1</sup> ✉ and Giuseppe Palleschi <sup>1</sup> ✉

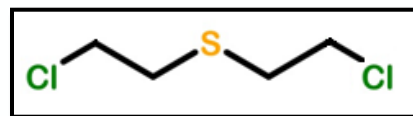
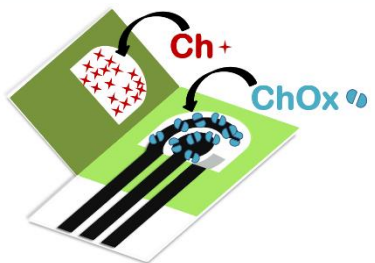
<sup>1</sup> Dipartimento di Scienze e Tecnologie Chimiche, Università di Roma Tor Vergata, Via Della Ricerca Scientifica, 00133 Rome, Italy

<sup>2</sup> Dipartimento Agroalimentare, IC-CNR Istituto di Cristallografia, Via Salaria Km 29.3, 00015 Monterotondo Scalo, Rome 00015, Italy

<sup>3</sup> Laboratoire Génie des Procédés et Environnement, Faculté de Sciences et Techniques, Université Hassan II —Mohammedia, B.P.146, Mohammadia 20850, Morocco

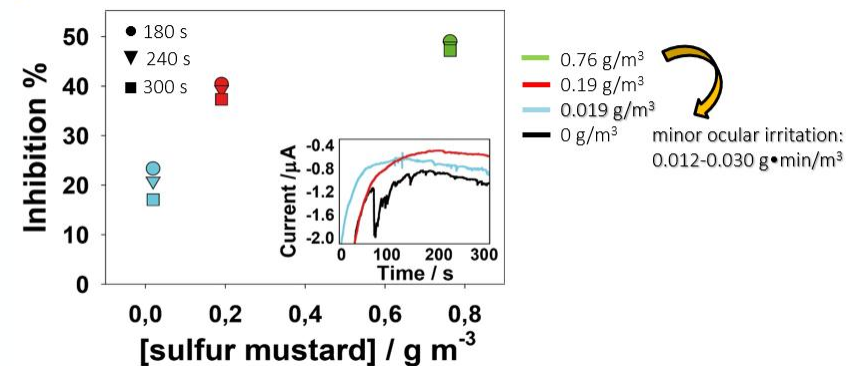
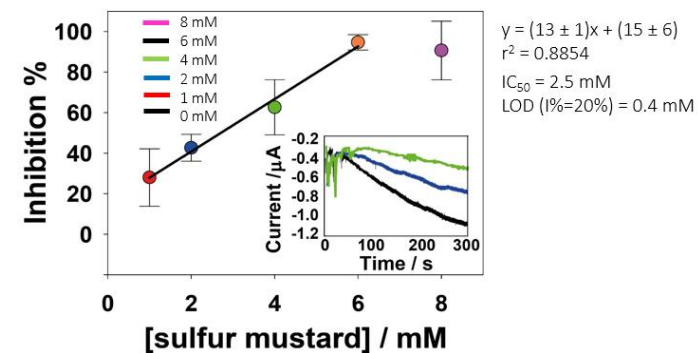
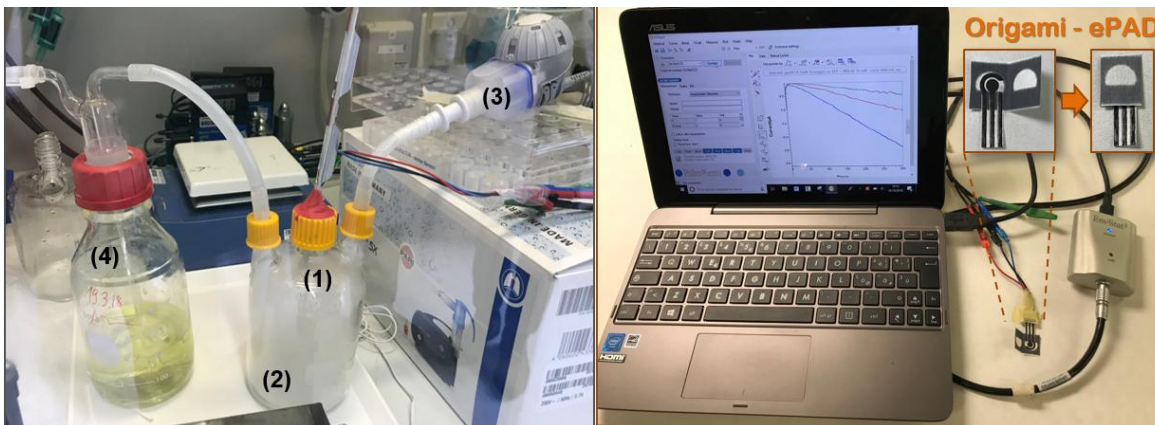
\* Author to whom correspondence should be addressed.

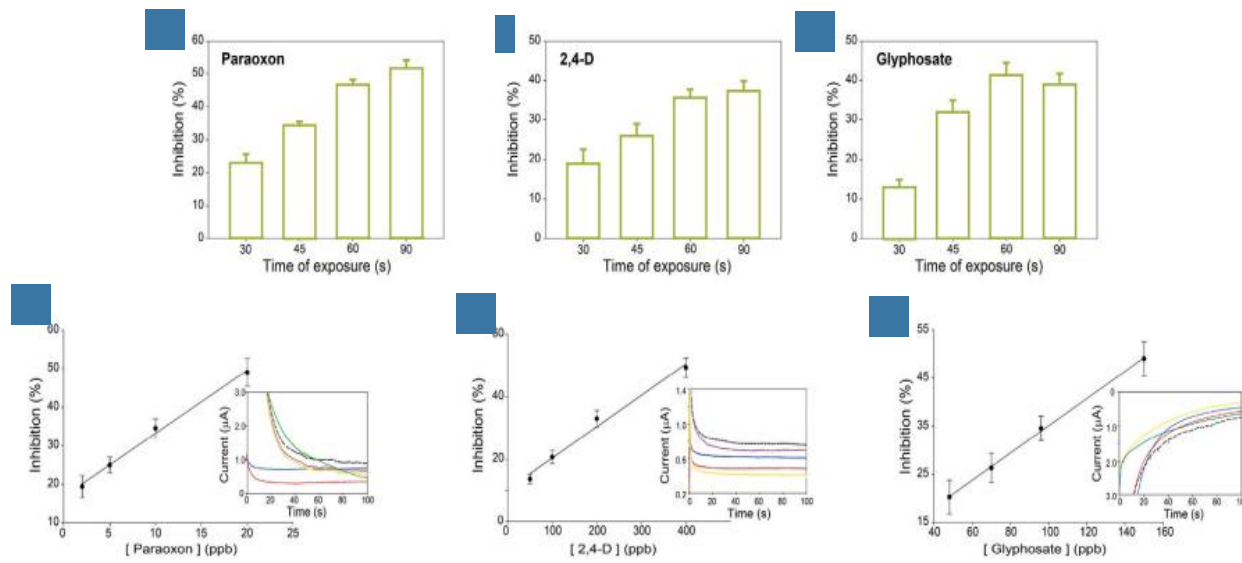
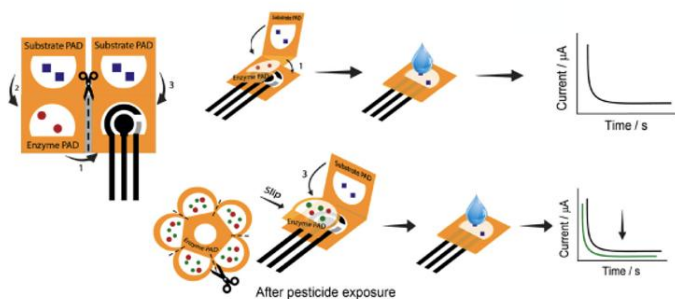




bis(2-chloroethyl) sulfide (SM)

Bundeswehr Institute of Pharmacology and Toxicology (Munich, Germany)





Recovery studies.

Inhibitor	Concentration added (ppb)	Concentration Found (ppb)*	Recovery %
Paraoxon	2 ppb	2.0 ± 0.7	100 ± 35
	5 ppb	5.0 ± 0.5	100 ± 10
	10 ppb	8.9 ± 0.4	89 ± 4
	20 ppb	19.4 ± 0.7	97 ± 4
	50 ppb	46 ± 4	92 ± 8
2,4-D	100 ppb	103 ± 1	103 ± 1
	200 ppb	208 ± 4	104 ± 2
	400 ppb	396 ± 3	99 ± 1
	150 ppb	157 ± 9	105 ± 6
Glyphosate	48 ppb	47 ± 1	98 ± 2
	70 ppb	72 ± 5	103 ± 7
	96 ppb	96 ± 1	100 ± 1
	150 ppb	157 ± 9	105 ± 6
	150 ppb	157 ± 9	105 ± 6

Biosensors and Bioelectronics 205 (2022) 114119

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journal homepage: [www.elsevier.com/locate/bios](http://www.elsevier.com/locate/bios)

A paper-based electrochemical device for the detection of pesticides in aerosol phase inspired by nature: A flower-like origami biosensor for precision agriculture

Veronica Caratelli<sup>a</sup>, Greta Fegatelli<sup>a</sup>, Danila Moscone<sup>a</sup>, Fabiana Arduini<sup>a,b,\*</sup>

<sup>a</sup> Tor Vergata University, Department of Chemical Science and Technology, Via Della Ricerca Scientifica, 00133, Rome, Italy

<sup>b</sup> SENSEMED, Via Renato Rascel 30, 00128, Rome, Italy



Funded by the European Union



## 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 <sup>a</sup>, Marco Saroglia <sup>b</sup>, Giuseppe Galatà <sup>c</sup>, Riccardo De Santis <sup>d</sup>, Silvia Fillo <sup>d</sup>, Vincenzo Luca <sup>d</sup>, Giovanni Faggioni <sup>d</sup>, Nino D'Amore <sup>d</sup>, Elisa Regalbuto <sup>d</sup>, Piero Salvatori <sup>e</sup>, Genciana Terova <sup>b</sup>, Danila Moscone <sup>a</sup>, Florio Lista <sup>d</sup>, Fabiana Arduini <sup>a, f</sup>

- <sup>a</sup> University of Rome "Tor Vergata", Department of Chemical Science and Technologies, Via della Ricerca Scientifica, 00133, Rome, Italy
- <sup>b</sup> University of Insubria, Department of Biotechnologies and Life Sciences, Varese, Italy
- <sup>c</sup> GTS Consulting S.r.l., Via Consolare Pompea 1, 98168, Messina, Italy
- <sup>d</sup> Scientific Department, Army Medical Center, Rome, Italy
- <sup>e</sup> UOC, Army Medical Center, Rome, Italy
- <sup>f</sup> SENSE4MED, Via Renato Rascel 30, 00128, Rome, Italy

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### Toward Continuous Monitoring of Breath Biochemistry: A Paper-Based Wearable Sensor for Real-Time Hydrogen Peroxide Measurement in Simulated Breath

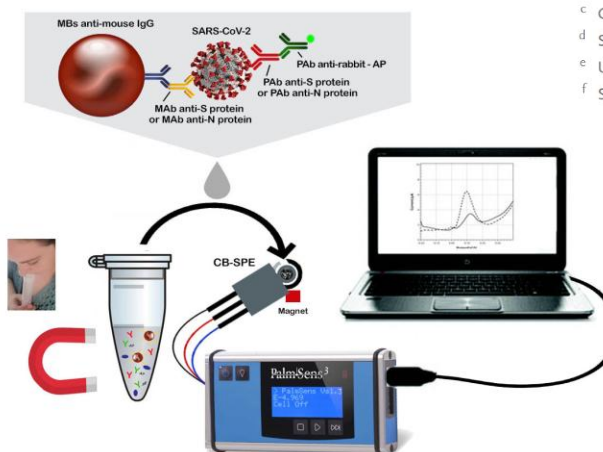
Daniela Maier, Elmar Laubender, Abhiraj Basavanna, Stefan Schumann, Firat Güder, Gerald A. Urban, and Can Dincer\*

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 Publication Date: October 15, 2019  
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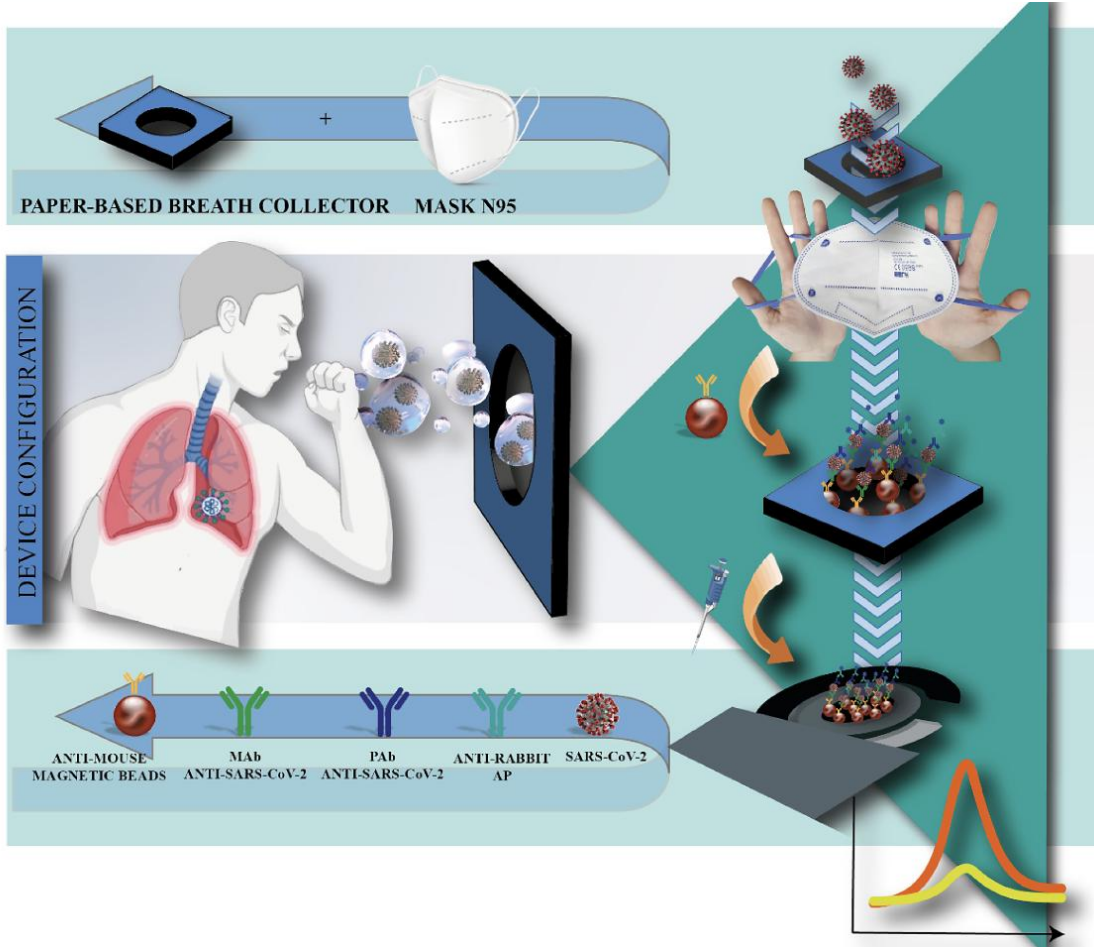
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Read Online | PDF (3 MB) | Supporting Info (2) | SUBJECTS: Oxides, Electrodes, ...



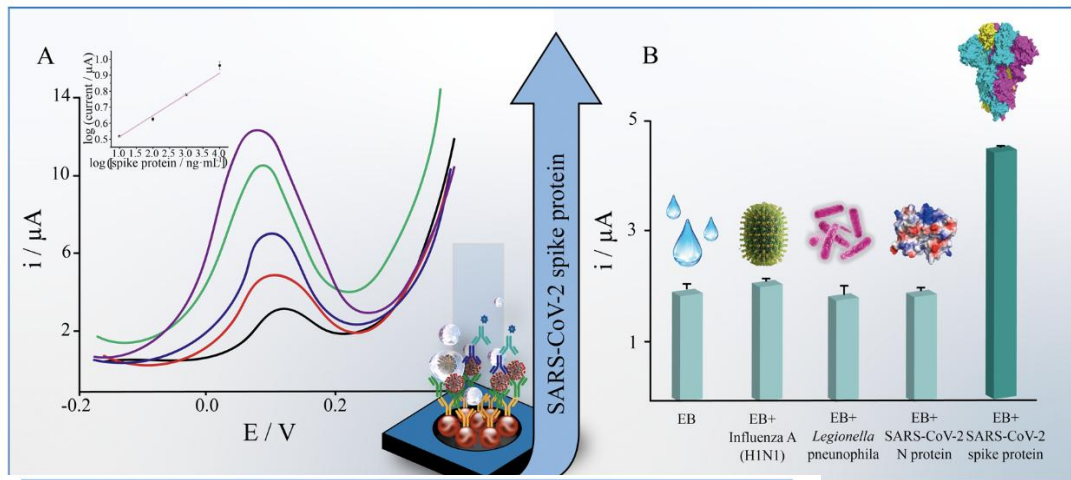
### Abstract

Exhaled breath contains a large amount of biochemical and physiological information concerning one's health and provides an alternative route to noninvasive medical diagnosis of diseases. In the case of lung diseases, hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>) is an important biomarker associated with asthma, chronic obstructive pulmonary disease, and lung cancer and can be detected in exhaled breath. The current method of breath analysis involves condensation of exhaled breath, is not continuous or real time, and requires two separate and bulky devices, complicating the periodic or long-term monitoring of a patient. We report the first disposable paper-based electrochemical wearable sensor that can monitor exhaled H<sub>2</sub>O<sub>2</sub> in artificial breath calibration-free and continuously, in real time, and can be integrated into a commercial respirator mask for on-site testing of exhaled breath. To



CENTRAL HOLE DIAMETER (mm)	NUMBER OF PAPER LAYERS			
	10	20	30	40
<b>5</b>				
	15 $\mu\text{L} \pm 10 \mu\text{L}$	29 $\mu\text{L} \pm 19 \mu\text{L}$	24 $\mu\text{L} \pm 32 \mu\text{L}$	15 $\mu\text{L} \pm 10 \mu\text{L}$
<b>12</b>				
	60 $\mu\text{L} \pm 3 \mu\text{L}$	66 $\mu\text{L} \pm 9 \mu\text{L}$	<b>95 <math>\mu\text{L} \pm 3 \mu\text{L}</math></b>	86 $\mu\text{L} \pm 6 \mu\text{L}$

- i) collect the exhaled breath sample
- ii) to act as the site for the incubation between the sample and the magnetic immunoprobe.

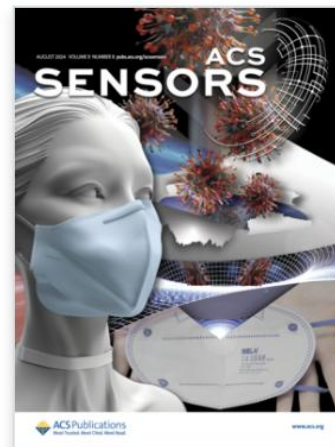


ARTICLE | August 2, 2024

### Functionalized N95 Face Mask with a Chemical-Free Paper-Based Collector for Exhaled Breath Analysis: SARS-CoV-2 Detection with a Printed Immunosensor as a Case Study

Click to copy article link

Laura Gutiérrez-Gálvez, Narjiss Seddaoui, Luca Fiore, Laura Fabiani, Tania García-Mendiola, Encarnación Lorenzo, and Fabiana Arduini\*



**ACS Sensors**

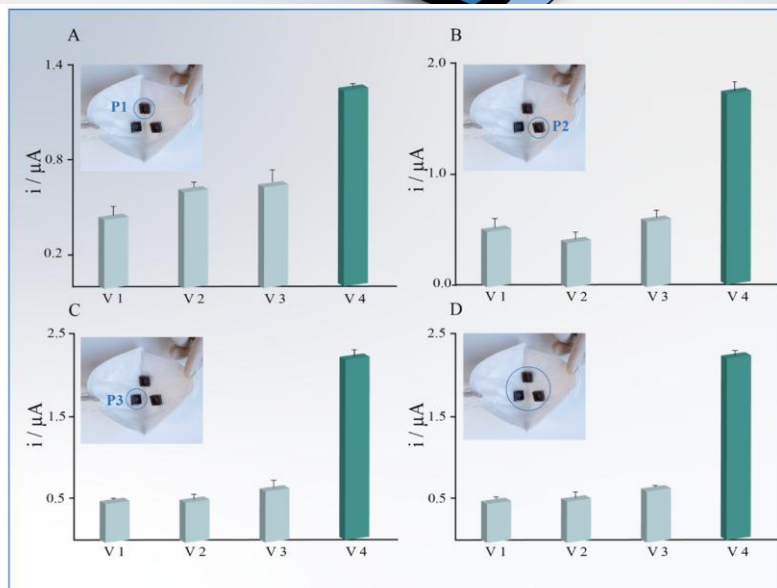
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<https://doi.org/10.1021/acssensors.4c00981>

Published August 2, 2024

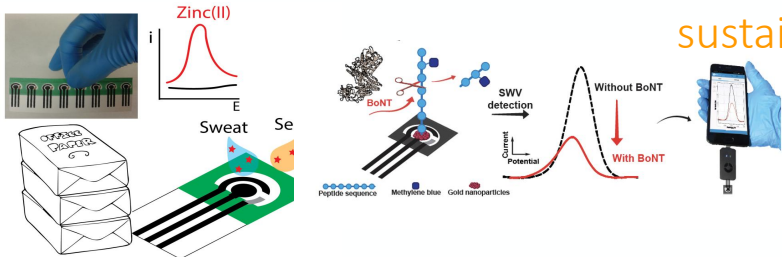
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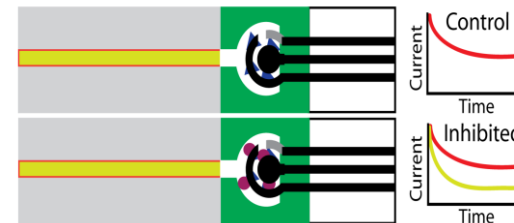


Two men (V1 and V2), one woman (V3), and one man (V4) who tested positive for COVID-19 (cycle threshold equal to 31 using RT-PCR)

Paper-based as sustainable substrate



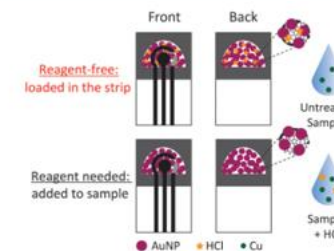
Paper-based reagent device



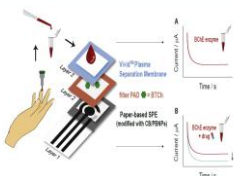
Paper-based origami device for multiple analysis



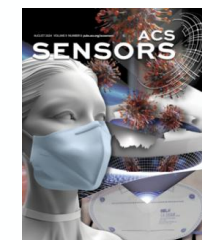
Paper as reactor



Paper-based lab on a chip

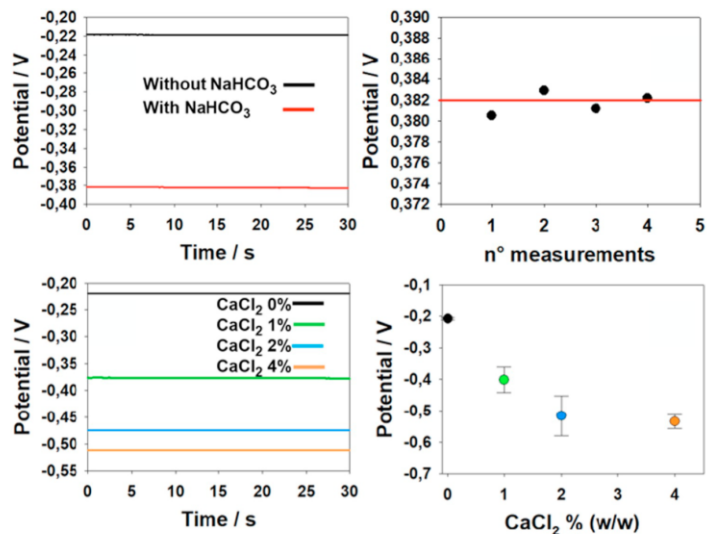
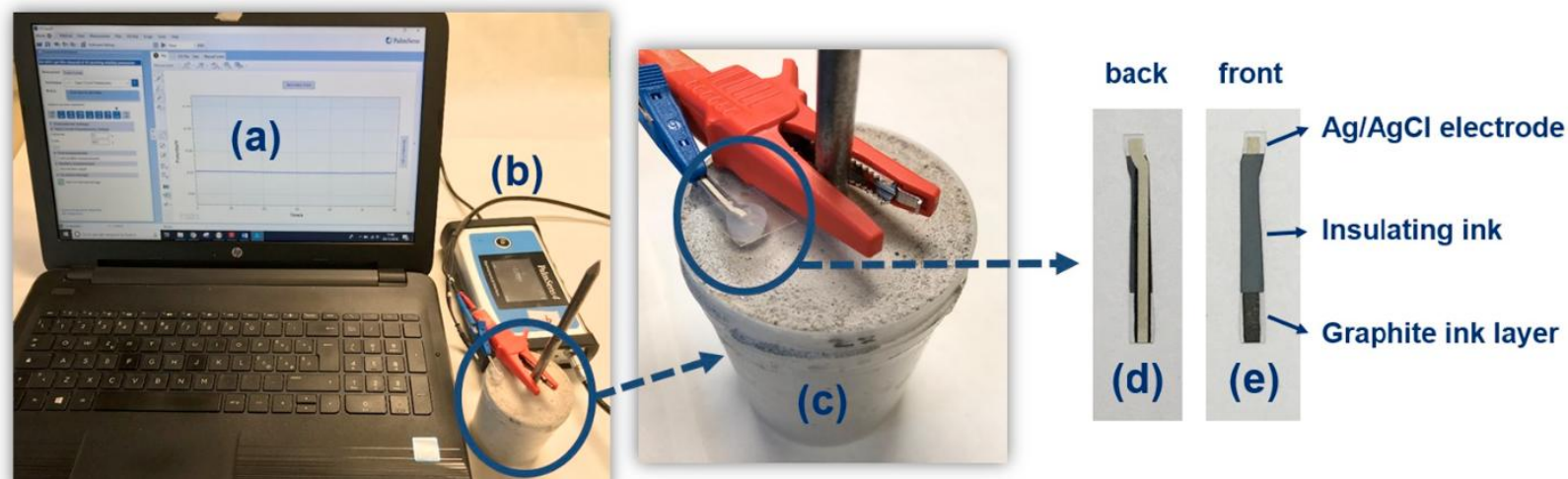


Paper-based devices for aerosol samples



Paper-based devices for solid samples

Paper in hybrid systems



Short communication

Screen-printed electrode as a cost-effective and miniaturized analytical tool for corrosion monitoring of reinforced concrete

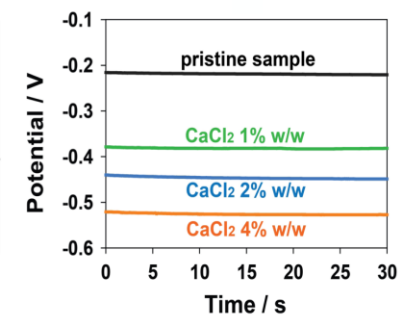
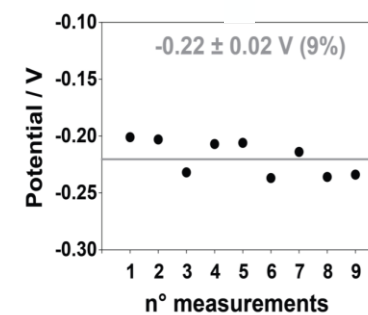
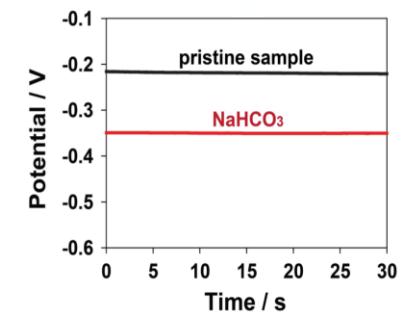
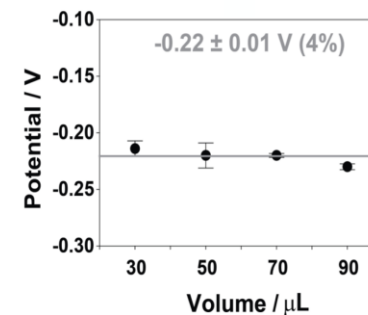
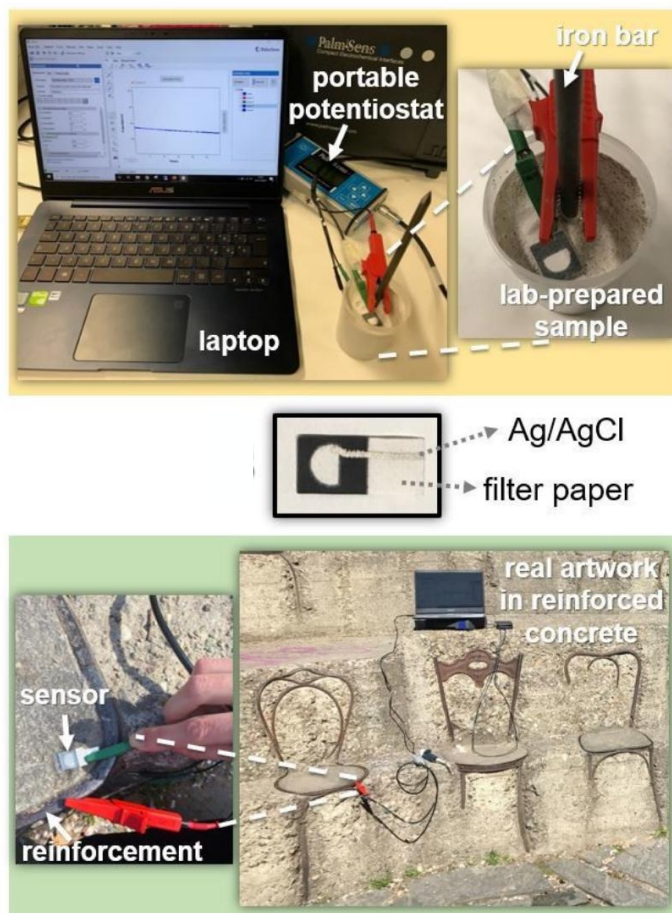
Alessandro Sassolini<sup>a,1</sup>, Noemi Colozza<sup>b,1</sup>, Elena Papa<sup>b</sup>, Kersti Hermansson<sup>c</sup>, Iliaria Cacciotti<sup>d</sup>, Fabiana Arduini<sup>b,\*</sup>

<sup>a</sup> ARPA Lazio, Via Salaria per L'Aquila 6-8, 02100 Rieti, Italy

<sup>b</sup> Department of Chemical Science and Technologies, University of Rome Tor Vergata, Via della Ricerca Scientifica, 00133 Rome, Italy

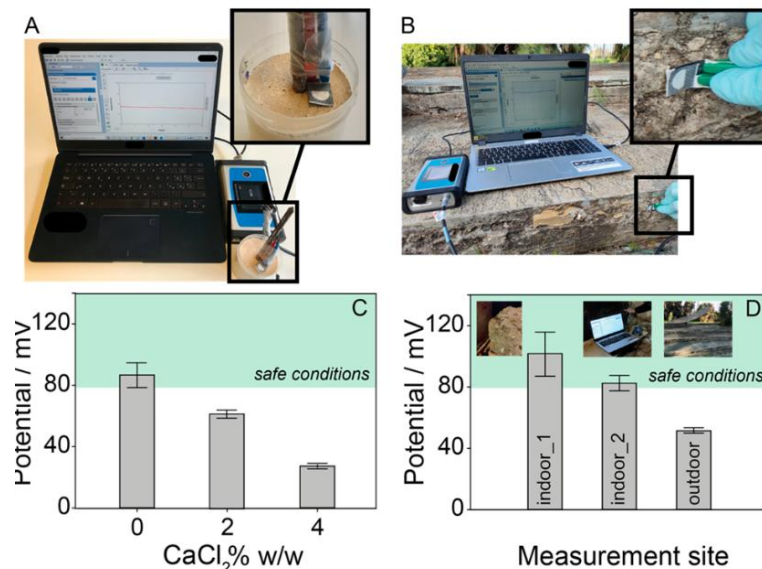
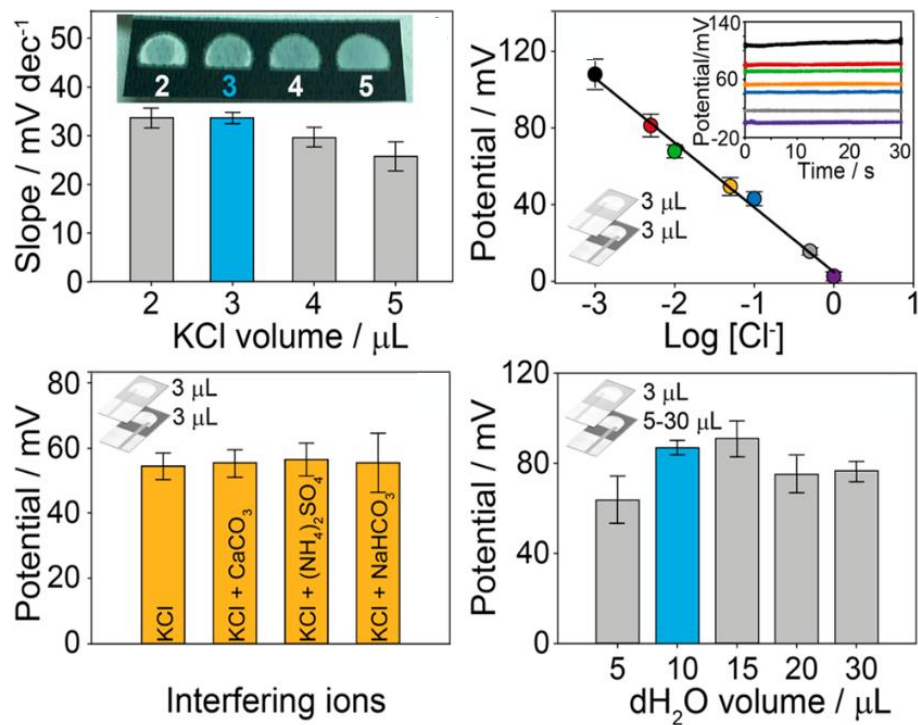
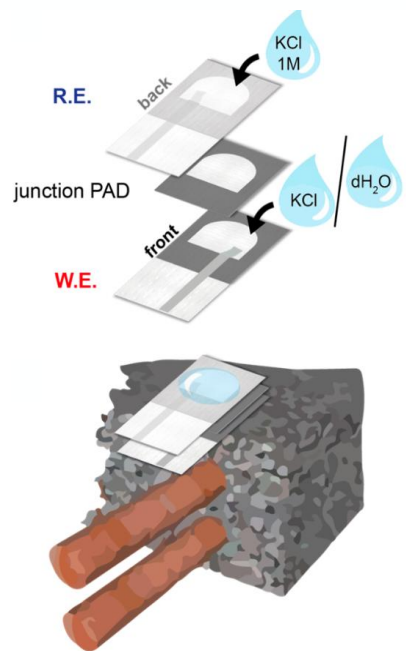
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<sup>d</sup> Department of Engineering, University of Rome Niccolò Cusano, Via Don Carlo Gnocchi 3, 00166 Rome, Italy



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

Noemi Colozza,<sup>[a]</sup> Alessandro Sassolini,<sup>[b]</sup> Lorenzo Agosta,<sup>[c]</sup> Alfredo Bonfanti,<sup>[d]</sup> Kersti Hermansson,<sup>[c]</sup> and Fabiana Arduini<sup>[a, e]</sup>



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Technical Note

### Vertical-Flow Paper Sensor for On-Site and Prompt Evaluation of Chloride Contamination in Concrete Structures

Noemi Colozza,\* Sara Tazzioli, Alessandro Sassolini, Lorenzo Agosta, Maria Giuseppina di Monte, Kersti Hermansson, and Fabiana Arduini\*

Cite This: *Anal. Chem.* 2021, 93, 14369–14374

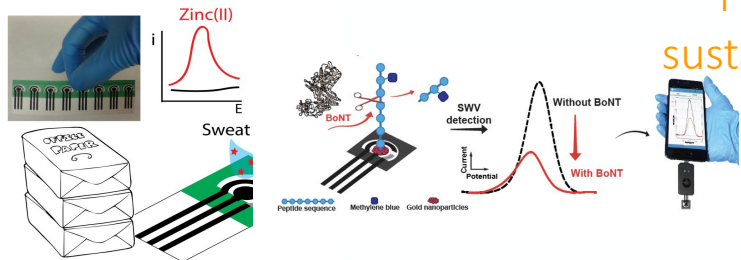
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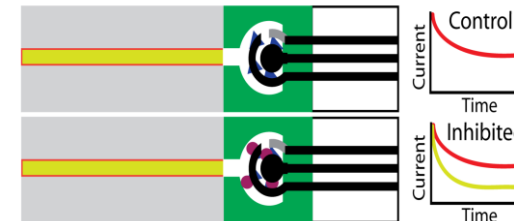
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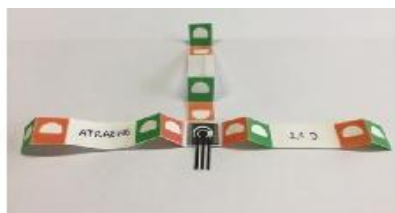
Paper-based as sustainable substrate



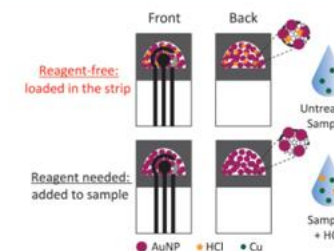
Paper-based reagent free device



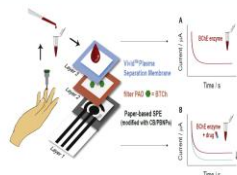
Paper-based origami device for multiple analysis



Paper as reactor



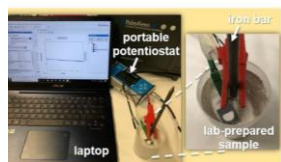
Paper-based lab on a chip



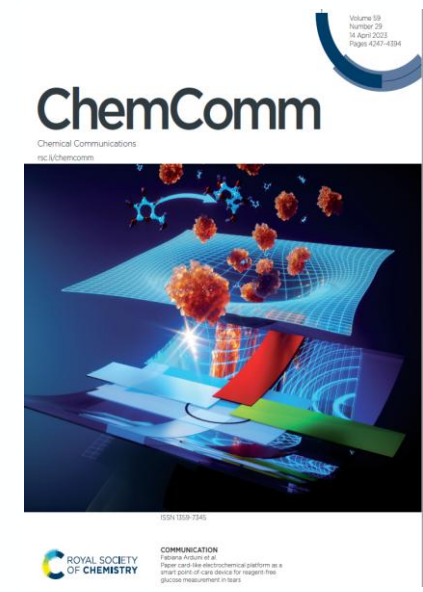
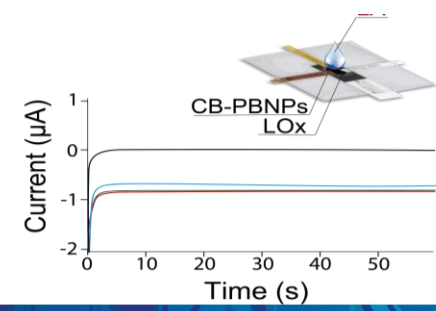
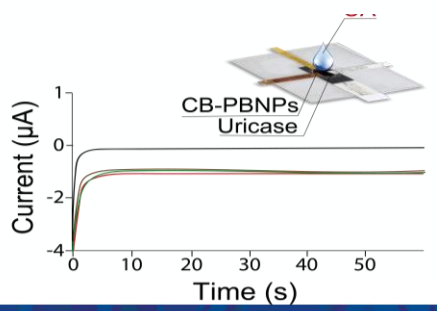
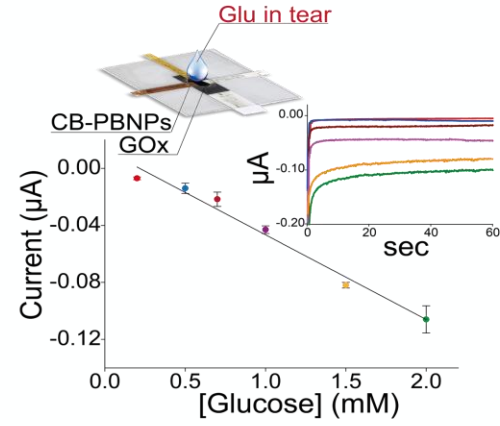
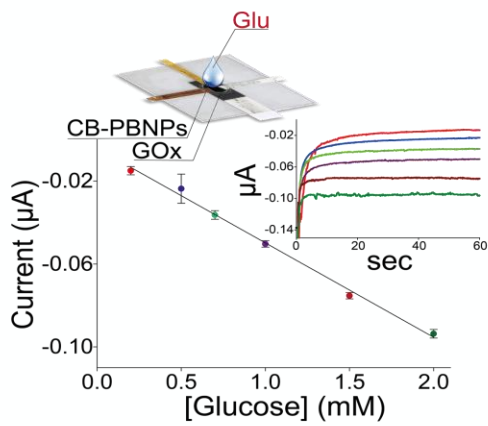
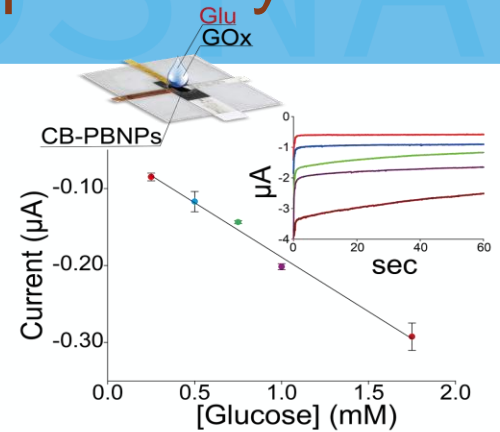
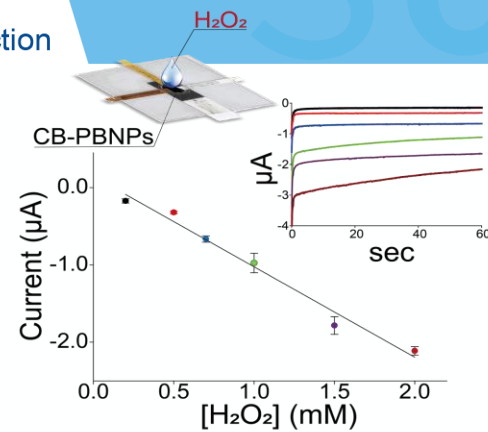
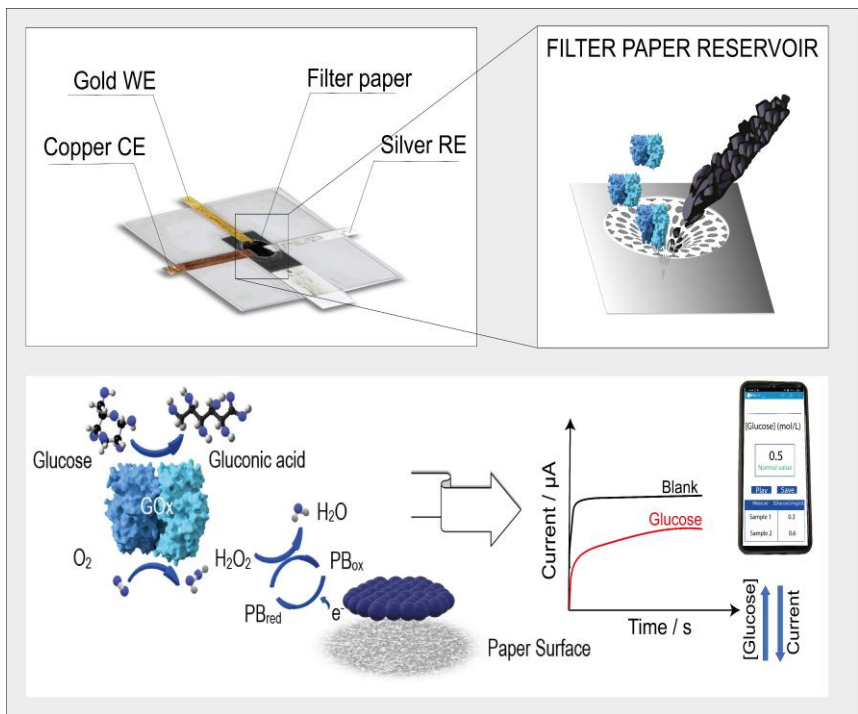
Paper-based devices for aerosol samples

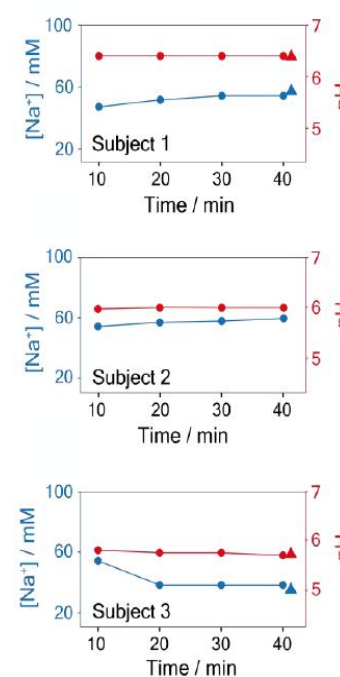
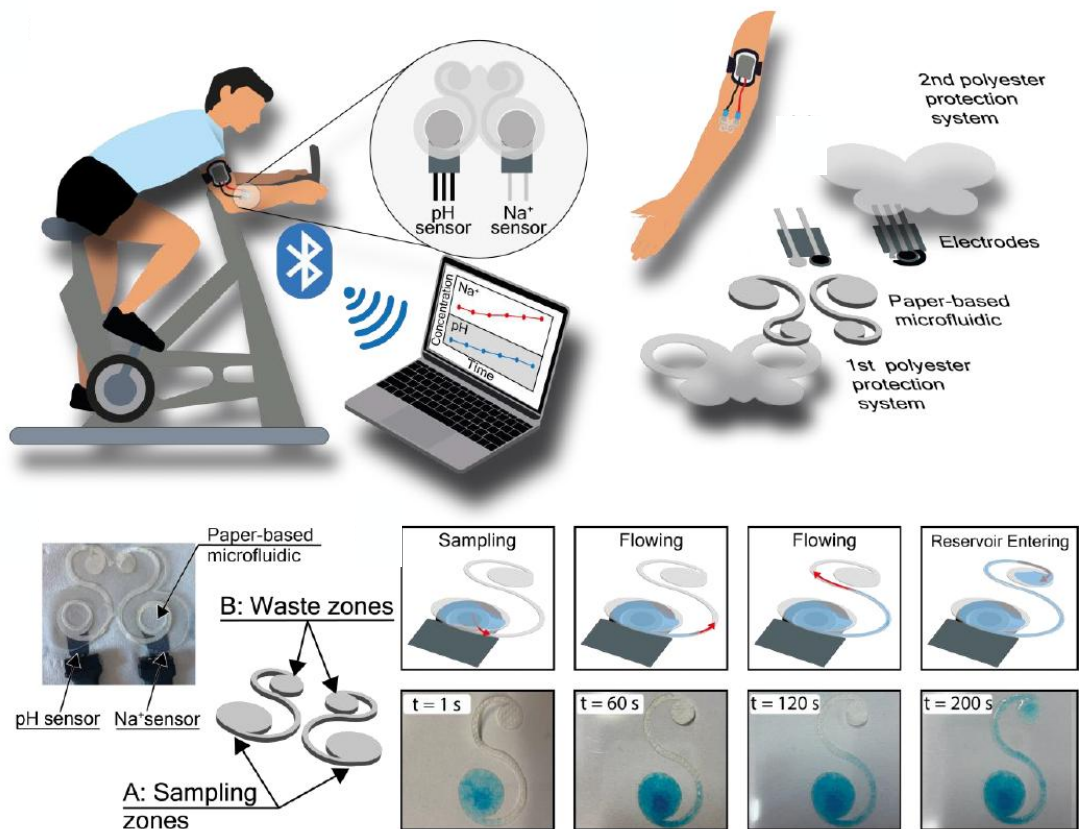


Paper-based devices for solid samples



Paper in hybrid systems



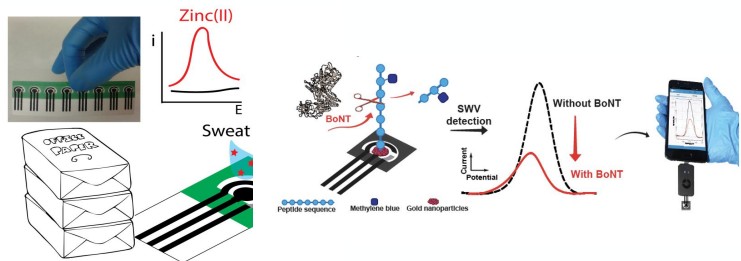


Microchimica Acta (2024) 191:580  
<https://doi.org/10.1007/s00604-024-06564-1>

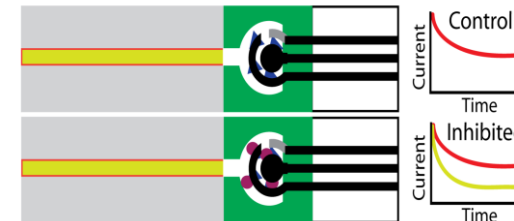
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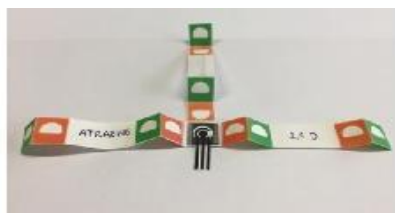
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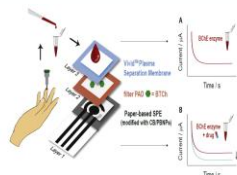
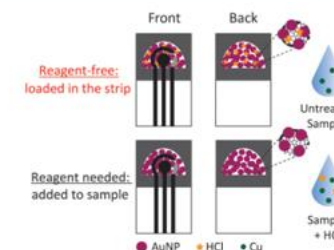
Paper-based reagent free device



Paper-based origami device for multiple analysis

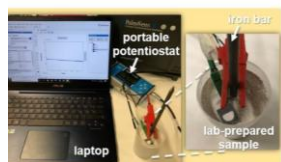
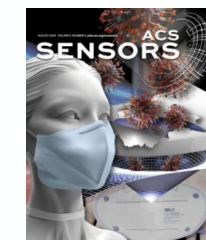


Paper as reactor



Paper-based lab on a chip

Paper-based devices for aerosol samples



Paper-based devices for solid samples

Paper in hybrid systems



International Journal of Biological Macromolecules  
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## Paper as smart support for bioreceptors immobilization in electrochemical paper-based devices

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Electrochemical paper-based devices: when the simple replacement of the support to print ecodedigned electrodes radically improves the features of the electrochemical devices

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Paper as a Sustainable Material for Smart Electrochemical (Bio)sensors with Unprecedented Features: A Perspective  
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ABSTRACT: This perspective has the overriding goal of reporting the tipping points in the roadmap of electrochemical paper-based devices by harnessing the multiple paper characteristics such as cost-effectiveness, widespread accessibility, mechanical strength, porosity, and capability to be easily cut, folded, modified, and assembled. The use of paper in electrochemical devices not only provides additional features to the electrochemical devices such as the environmentally friendliness, ease multiplexed analysis, and three-dimensional structures by folding and unfolding operations but has broken down barriers for delivering measurement without (i) addition of reagents, (ii) sample treatment (for liquid, solid, and solid samples), and (iii) any additional pump for microfluidics. I lay out the advantages of using paper for the design of miniaturized electrochemical devices, underlying the next steps in the paper-based electrochemical device roadmap.



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