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Fully graphene-based electrode platforms for biosensing applications

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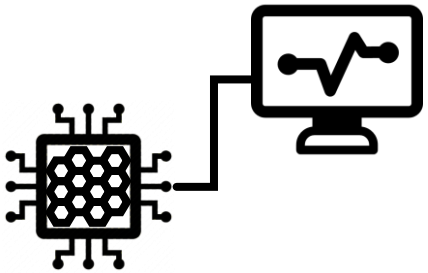

Electrochemistry as detection strategy

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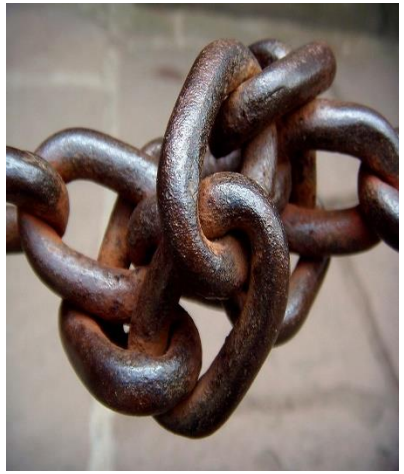
Rapid

Fast measurements
“Trial-and-error”

Reliable



Sensitive
Accurate

Low cost

Cheap chemicals
Low volumes

Easy preparative

Measures in-site
or on-site

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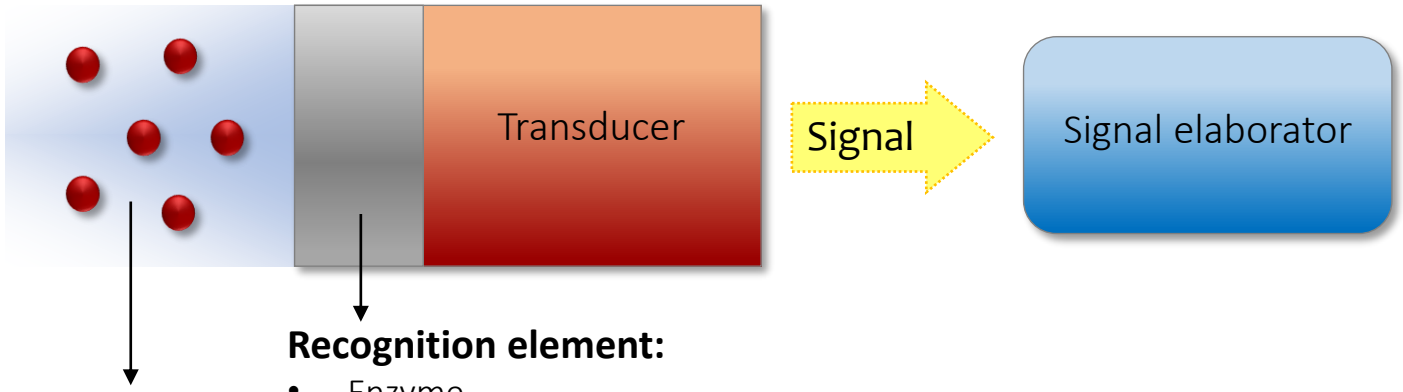
Electrochemistry as detection strategy in wearable biosensing



Recognition element:

- Enzyme
- DNA fragment
- Antibody
- Cell

Biomarkers in sweat

- Na^+
- K^+
- Glucose
- Lactate
- Cortisol
- Uric acid

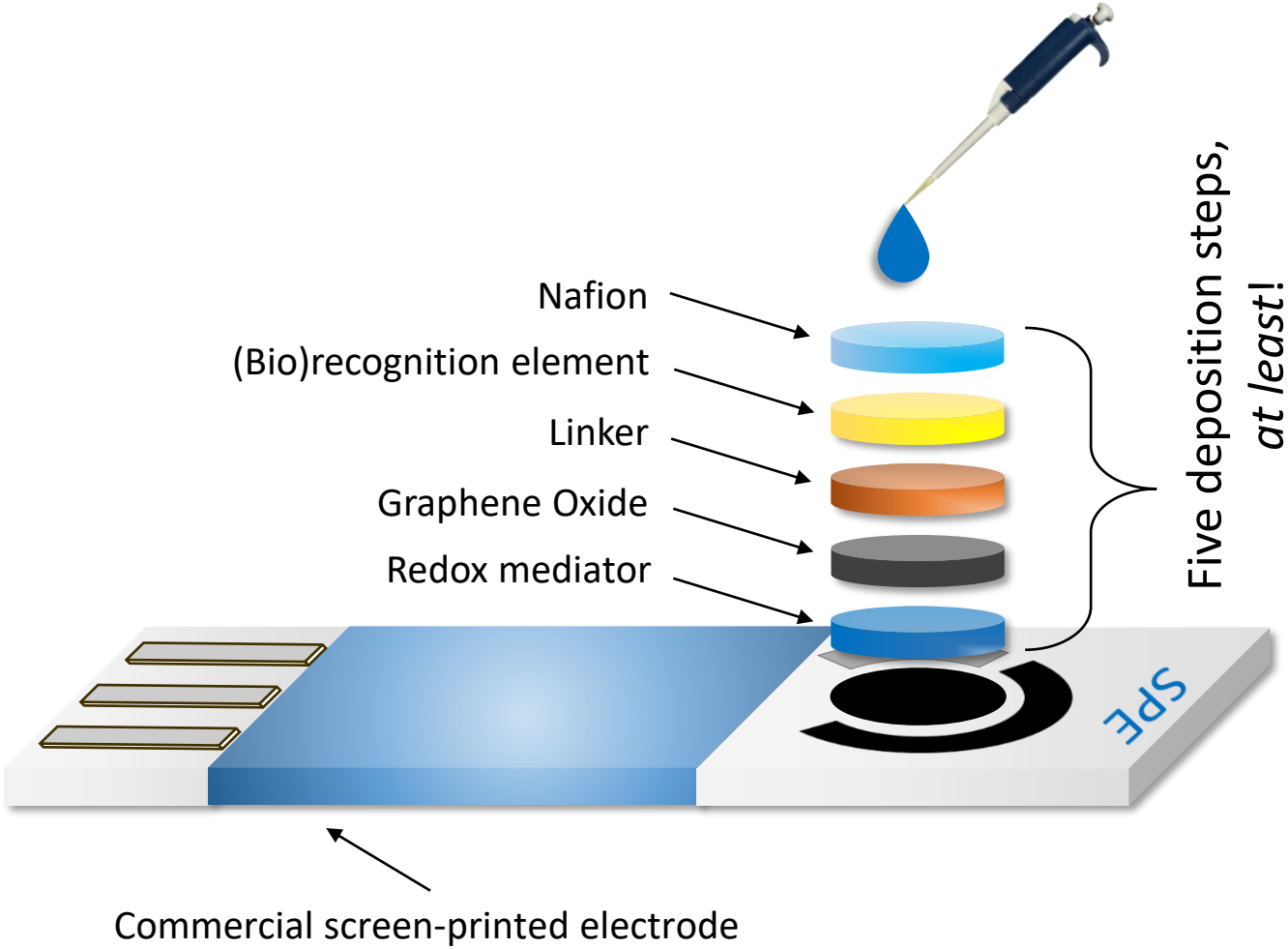
State-of-the-art wearable devices:

"Tattoo " biosensor

Flexible wristband

a) J. Kim et al., *Talanta* 177 (2018) 163-170
b) L. Geddes et al., *Nature* (2016)

Electrochemistry as detection strategy in wearable biosensing



Drop-casting

- most common method on lab-scale
- hand-made process
- several layers required

Drawbacks

- low reproducibility
- coating stability
- Not scalable to industrial size

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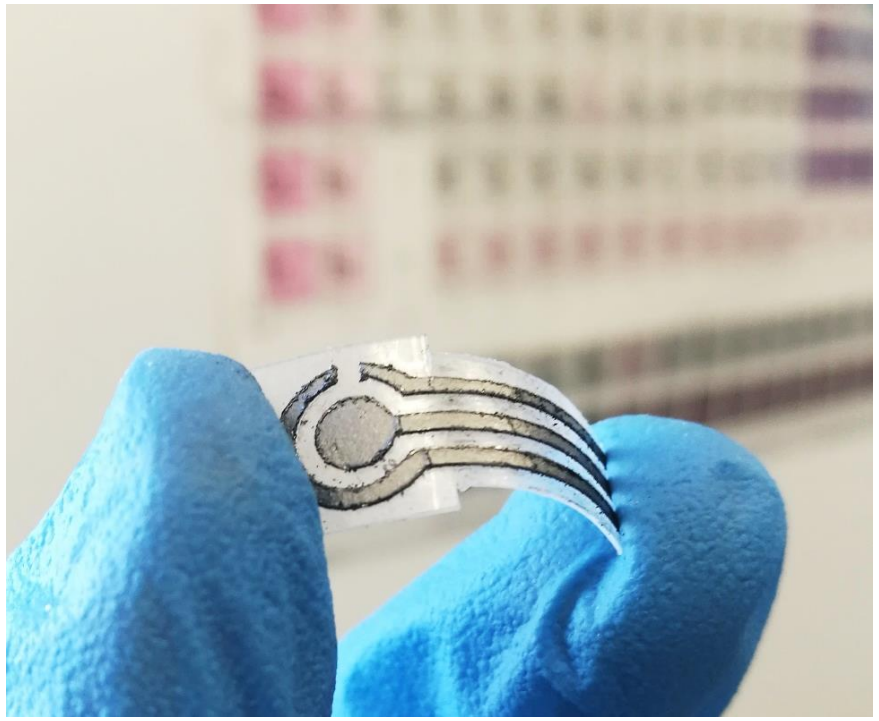
F. Poletti et al., J. Phys. Mater. 3 (2020) 014011

G-Paper Electrodes (GPE)



Printed on PET, a flexible transparent substrate

Advantages

- sensor fabricated with the active element
- no coating required: GPEs can be employed *bare*
- scalable to industrial size

G-Paper Electrodes (GPE)

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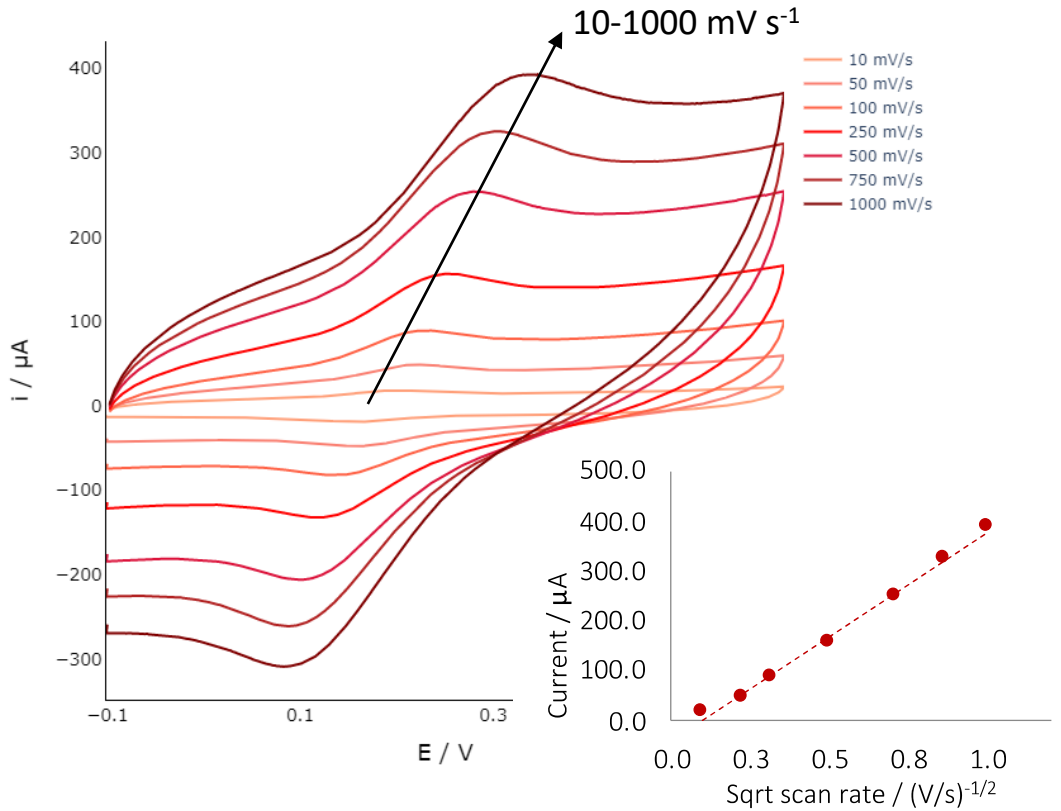
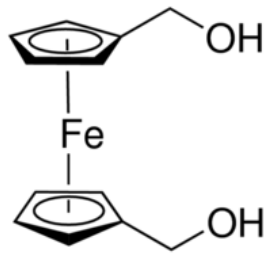
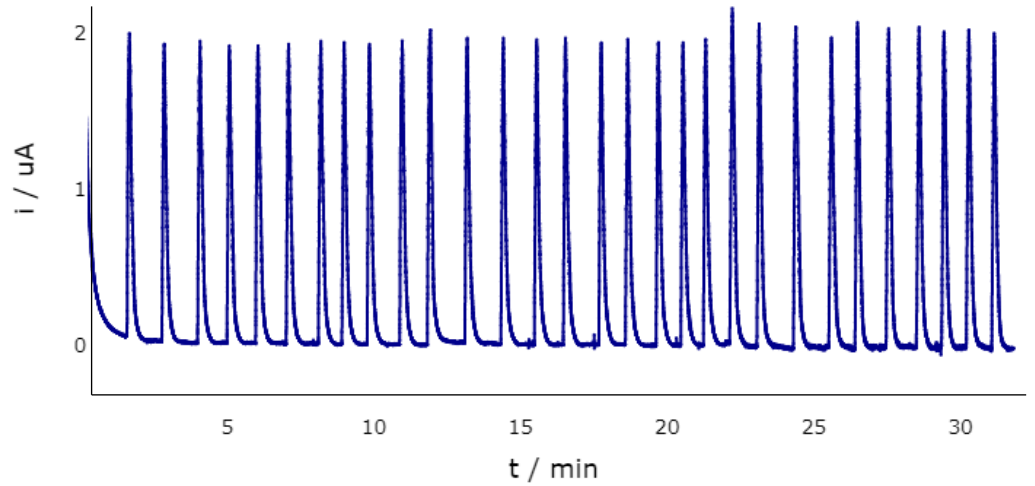
Check of the electrode conductivity



CV responses on Fc. In the inset is reported the linear correlation (R^2= 0.995) according to the equation of Randles-Sevcik.



Benchmark redox species:
1,1'-ferrocene dimethanol (Fc)



Response for thirty subsequent injections of 0.1 mM Fc on a GPE at +0.35 V obtained using flow injection analysis; pump speed: 1 mL min^{-1}

RSD% = 3.1 %

Good conductivity and repeatability

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G-Paper Electrodes (GPE)

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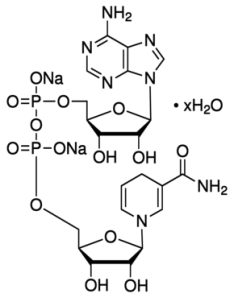
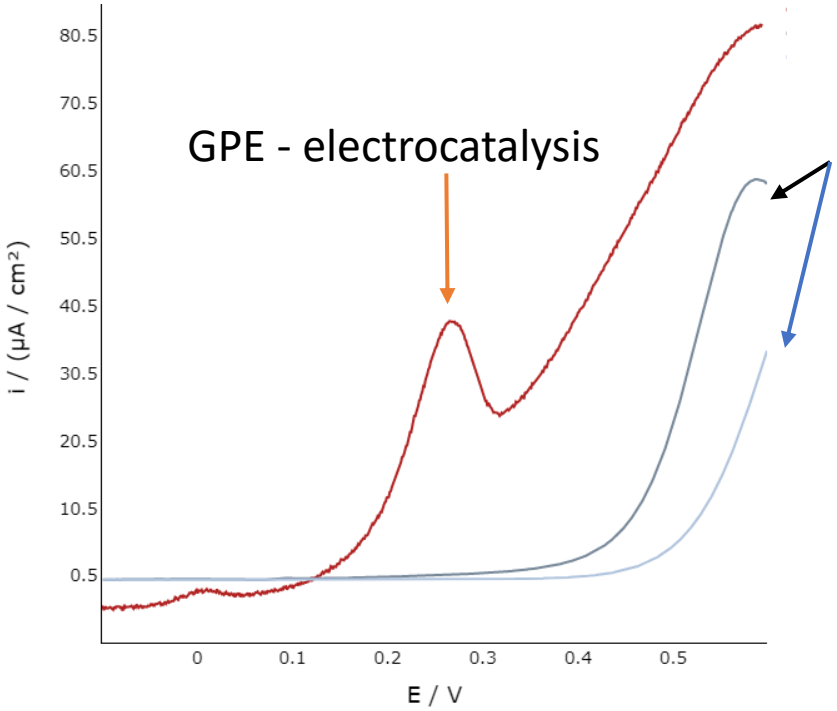
NADH detection





	GPE
Sensitivity (µA mM^{-1} cm^{-2})	**107.2**
RSD_{slope} %	3.4
Potential (V)	+0.35

Forward voltammetric scan for 1 mM NADH in 0.1 M PBS and 0.1 M KCl

Bare GPEs allow NADH detection at electrocatalytic potential of +0.35 V:

- Higher sensitivity with respect to bare carbon electrodes
- Higher selectivity, as less chemical species can oxidize at low potentials
- No coating is required on the GPE

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G-Paper Electrodes (GPE)

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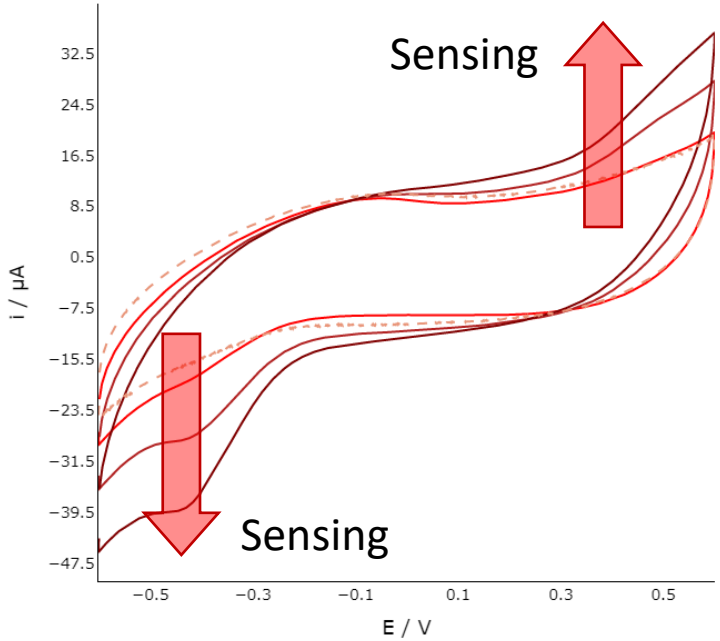
H_2O_2 detection



CVs obtained in absence (dashed line) and in presence (solid lines) of 1, 5 and 10 mM H_2O_2 in 0.1 M PBS

	GPE	Commercial SPE
Sensitivity (µA mM^{-1} cm^{-2})	**4.45**	**3.34**
Potential (V)	**-0.40**	**-0.40**

Bare GPEs allow H_2O_2 detection at both oxidation and reduction potentials:

- Higher sensitivity at reduction potentials
- No electrocatalysis. Analytical performance similar to commercial SPEs
- No coating is required on the GPE

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GPEs in biosensing applications

Possibility to employ GPEs on

dehydrogenase- and **oxidase-**based enzymes

$$\text{L-lactate} + NAD^+ \xrightarrow{\textbf{LDH}} \text{piruvate} + NADH$$

$$\text{L-lactate} + O_2 \xrightarrow{\textbf{LOx}} \text{piruvate} + H_2O_2$$

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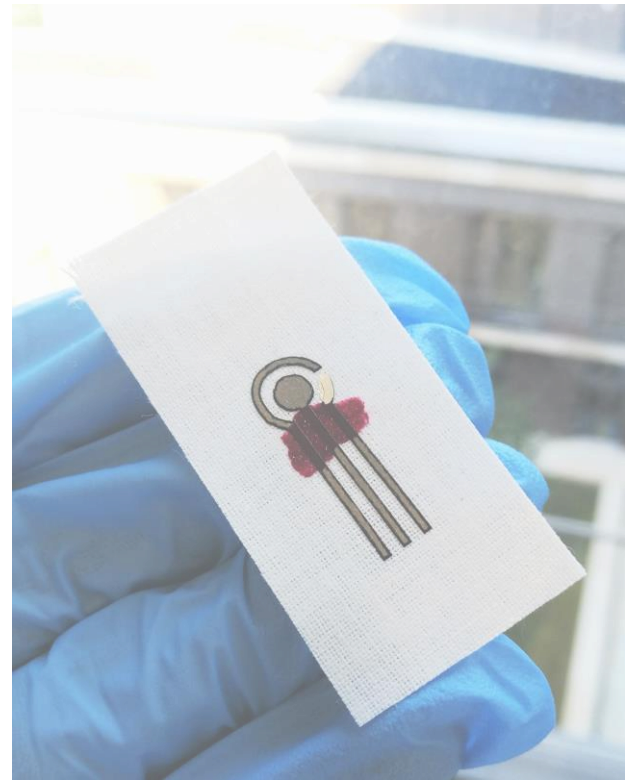
To conclude

- GPEs have a stable, repeatable electrochemical response;
- tests on Fc showed good conductivity;
- great electrocatalysis on NADH oxidation;
- no need for further functionalization.



Perspectives:

- detection of other analytes;
- functionalization with biological elements;
- continuous monitoring in a complex matrix.

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Thanks!

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