CUSTOMIZED SCREEN-PRINTED ELECTRODES BASED ON Ag-NANOSEEDS FOR ENHANCED ELECTROANALYTICAL RESPONSE TOWARDS Cd(II), Pb(II) AND As(V) IN AQUEOUS SAMPLES

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chemosensors MDPI
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AGENDA

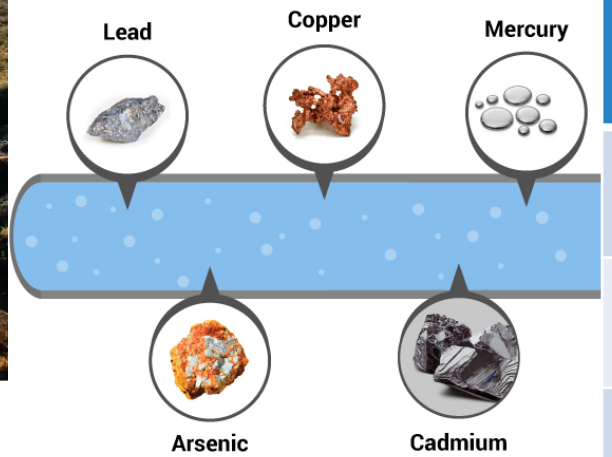
- Heavy Metals contamination problematic
- Objectives
- Methodology
- Results
- Conclusions

HEAVY METAL WATER CONTAMINATION

Waste water from a gold mine flows into the forest. Guyana, South America. kakteen / shutterstock

Heavy metal ions

- ✓ High toxicity
- ✓ Non-biodegradability
- ✓ Bioaccumulation
- ✓ Adverse health effects in humans



	WHO	EU Directive 2020/2184
Pb(II)	10 µg/L	10 µg/L
Cd(II)	3 µg/L	5 µg/L
As(V)	10 µg/L	10 µg/L

Source: https://theconversation.com/acid-drainage-the-global-environmental-crisis-youve-never-heard-of-83515

Source: http://water-purifiers.com/heavy-metal-contamination-in-drinking-water/

HEAVY METAL WATER CONTAMINATION

Heavy Metal Detection Methods

- ✓ Flameless atomic adsorption spectrometry (FAAS)
- ✓ Inductively coupled plasma mass spectrometry (ICP-MS)
- ✓ Hydride generation atomic fluorescence spectrometry (HG-AFS)
- ✓ **ELECTROCHEMICAL TECHNIQUES: ANODIC STRIPPING VOLTAMMETRY (ASV)**

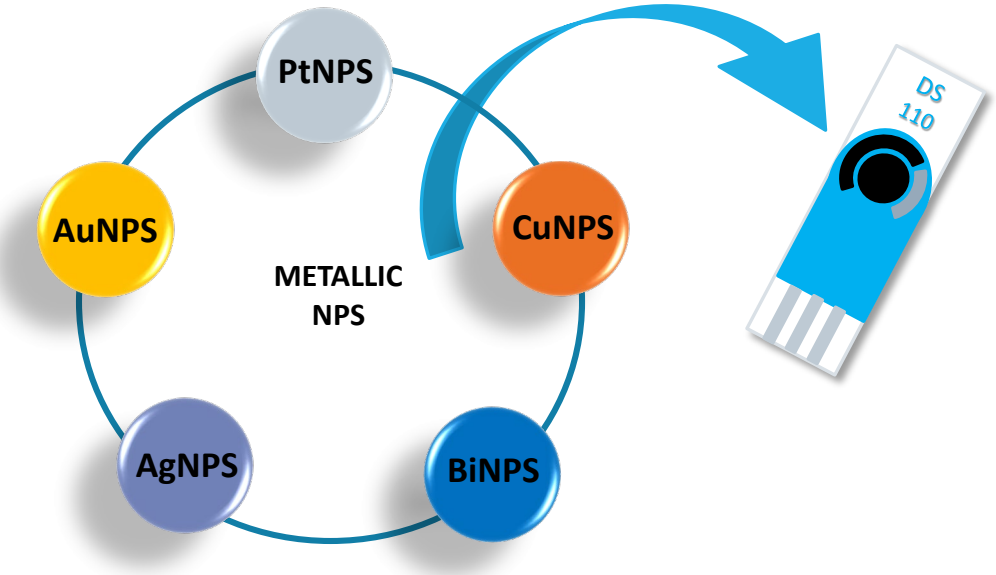
LOWER DETECTIO LIMITS

LOW COST

NG

FAST ANALYSIS

Nanoparticles/Screen-printed electrodes[1]



- ✓ Electrochemical response improvement
- ✓ ↓ Electron Transfer Resistance
- ✓ Catalyzing the electrode's response at low analyte concentrations

[1]Torres-Rivero, K.; Florido, A.; Bastos-Arrieta, J. Recent Trends in the Improvement of the Electrochemical Response of Screen-Printed Electrodes by Their Modification with Shaped Metal Nanoparticles. *Sensors* **2021**, *21*, 2596.

OBJECTIVES

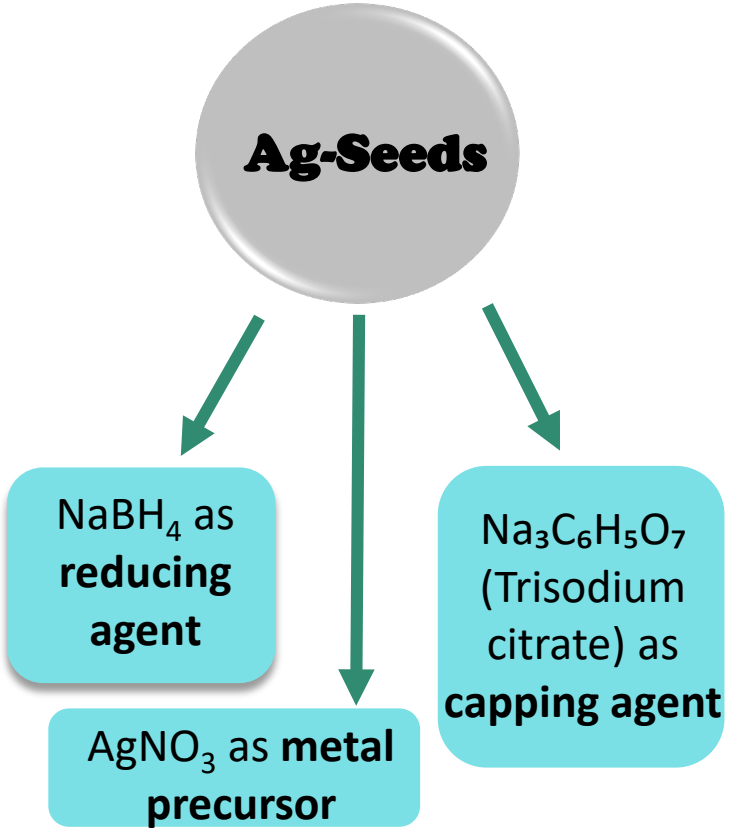
Voltammetric determination of HMIs based on the use of carbon-nanofiber-based screen-printed electrodes (SPCNFEs) modified with silver nanoparticles (Ag-NPs)

Ag-NS → **Screen-printed electrodes** → **AgNS modified Screen-printed electrodes**

- ❑ Synthesize Ag-NS
- ❑ Modify SPCNFE with the dropcasting technique
- ❑ Characterize the modified electrode surface.
- ❑ Characterize the modified electrode electrochemically using DPASV
- ❑ Study the applicability of the modified electrode in As(V) spiked tap water samples

METHODOLOGY

1. Ag-Seeds Synthesis[2]



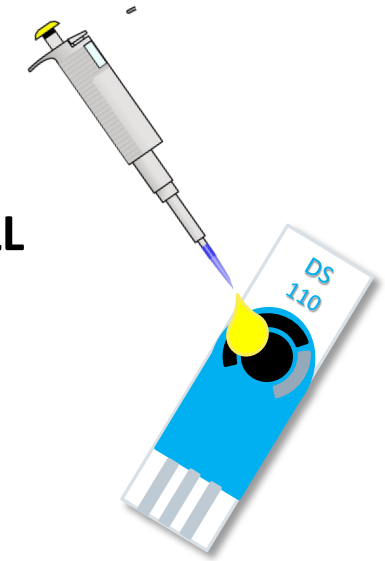
2. Ag-Nanoseeds characterization

- ✓ Scanning electron microscopy (**SEM**)
- ✓ Transmission electron microscopy (**TEM**)

3. SPCNFE Modification

Dropcasting

1 drop of **40 µL**

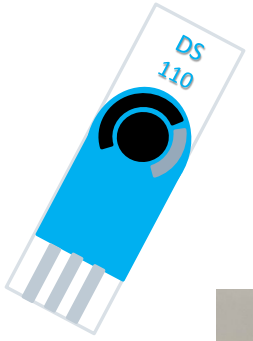


✓ Heat at **50 ºC** for **30 minutes**

[2]D. Aherne, D. M. Ledwith, M. Gara, and J. M. Kelly, *Adv. Funct. Mater.*, vol. 18, no. 14, pp. 2005–2016, 2008

METHODOLOGY

4. Modified SPCNFE Surface characterization



Scanning Electron Microscopy (SEM)

5. SPEs El cterization

	Pb(II)	Cd(II)	As(V)
Buffer	0.1 mol/L Acetate buffer pH 4.5	0.1 mol/L Acetate buffer pH 4.5	0.01 mol/L HCl pH 2.0
Standard	1 mg/L	1 mg/L	1 mg/L

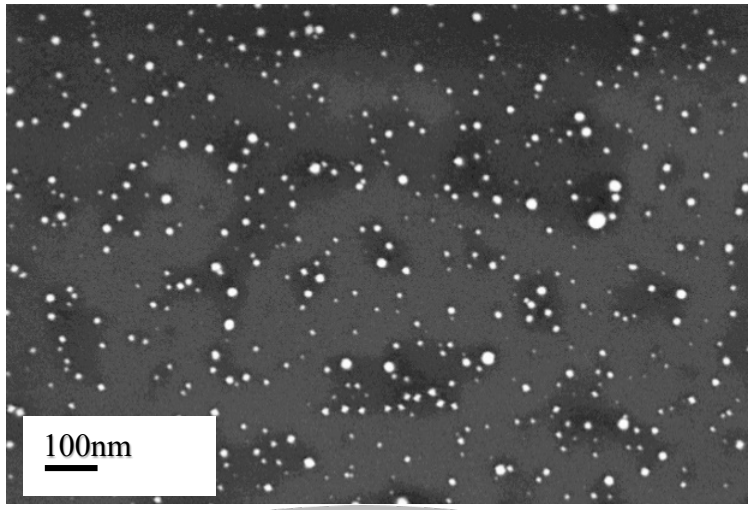
DPASV Parameters

	Pb(II)	Cd(II)	As(V)
E_d	-1.4 V	-1.4 V	-1.3 V
T_d	180 s	180 s	120 s
Scanning Potential	-1.4 V - 0.0 V	-1.4 V – 0.0 V	-1.3 V – 0.65 V

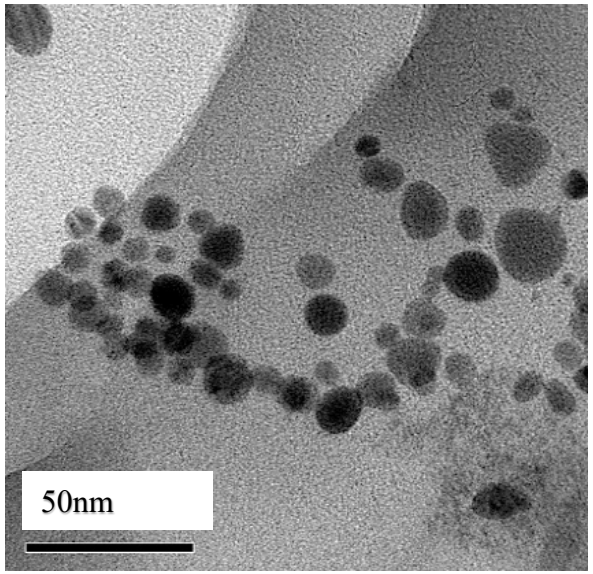
RESULTS

1. Ag-Nanoseeds characterization[3]

SEM micrograph



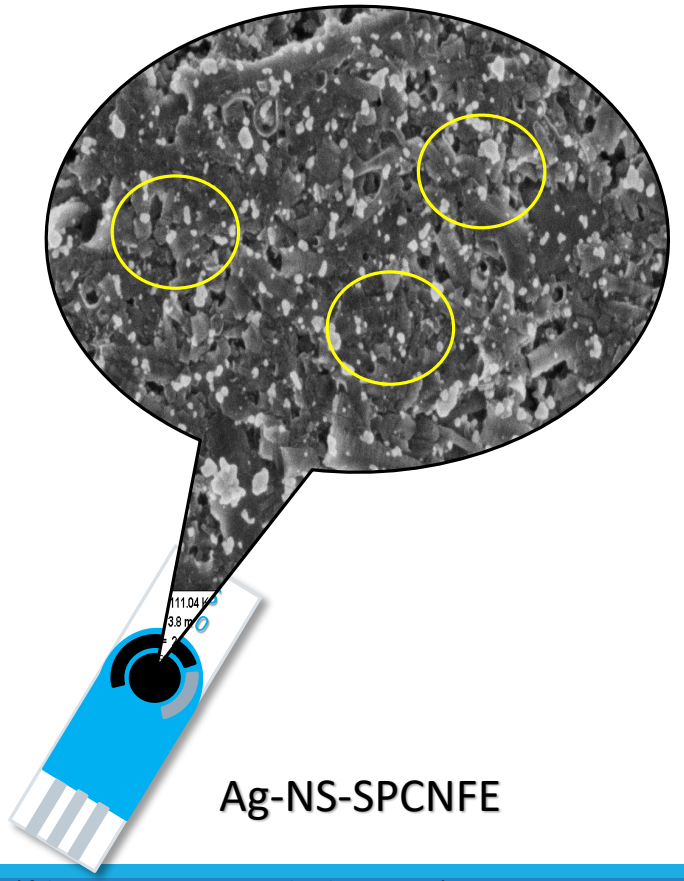
TEM micrograph



Ag-Nanoseeds

- Spherical shape
- 12.2 ± 0.4 nm

2. Ag-NS-SPCNFE Surface characterization[4]



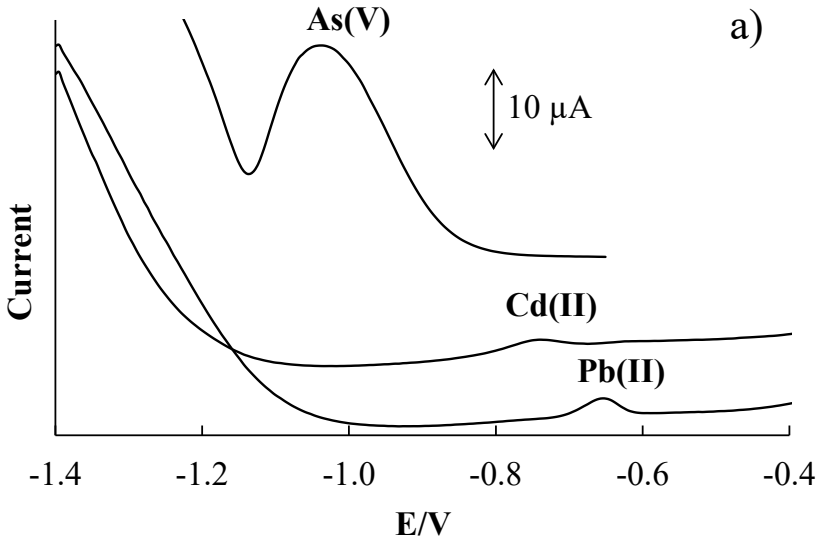
Ag-NS-SPCNFE

[3]Torres-Rivero, K.; Torralba-Cadena, L.; Espriu-Gascon, A.; Casas, I.; Bastos-Arrieta, J.; Florido, A. Strategies for Surface Modification with Ag-Shaped Nanoparticles: Electrocatalytic Enhancement of Screen-Printed Electrodes for the Detection of Heavy Metals. *Sensors* **2019**, *19*, 1–14

[4]Torres-Rivero, K.; Pérez-Ràfols, C.; Bastos-Arrieta, J.; Florido, A.; Martí, V.; Serrano, N. Direct As(V) determination using screen-printed electrodes modified with silver nanoparticles. *Nanomaterials* **2020**, *10*, 1–10

RESULTS

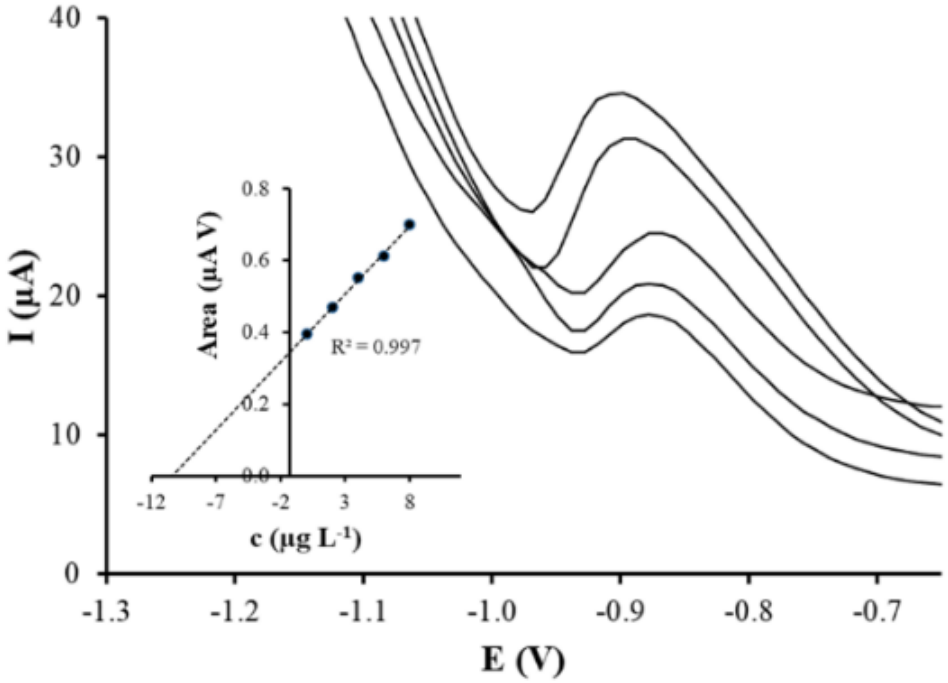
Ag-NS-SPCNFE Electrochemical Characterization



Analyte	LOD (µg.L^{-1})	Linear Range (µg.L^{-1})	R^2	Sensitivity (nA µg^{-1} L) (SD)
Pb(II)	3.3	10.9-99.6	0.999	103 (3)
Cd(II)	3.7	12.2-73.4	0.992	22 (1)
As(V)	2.6	8.9 - 40.0	0.991	260 (10)

RESULTS

Ag-NS-SPCNFE-Application in real sample



	As(V)	
	CAs(V) (µg.L^{-1})	SD (µg.L^{-1})
DPASV	10.04	0.37
ICP-MS	10.70	0.20

Tap water samples were collected from the local water distribution network managed by Aigües de Barcelona Company
https://www.aiguesdebarcelona.cat/

CONCLUSIONS

✓Ag-Nanoseeds were **synthesized**, microscopically **characterized**, and **used for the modification of SPCNFE**.

✓Ag-NS-SPCNFE **was suitable for determining Pb(II), Cd(II), and As(V)** at low µg.L^{-1} levels.

✓Electrochemical characterization showed **wider linear ranges for Pb(II) and Cd(II)** determination but **lower sensitivities as compared to As(V).**

✓**LODs** achieved in this investigation **are equal or lower** than other **LODs previously reported**.

✓The suitability of Ag-NS-SPCNFE for the **determination of As(V) in spiked water samples**, achieving **comparable results with ICP-MS** with **good reproducibility**.

Acknowledgments

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Thank you for your attention!

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