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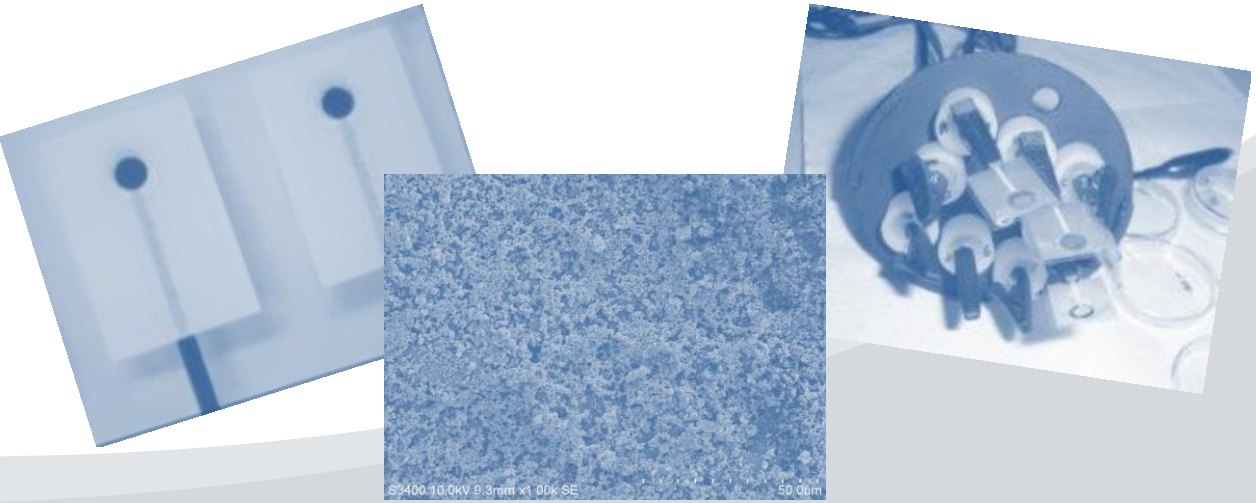
Recent Progress in Disposable Ion-selective Sensors for Environmental Applications

Giusy Matzeu, Claudio Zuliani and Dermot Diamond



CIMTEC 2012,
Montecatini Terme

sfi Fondúireacht Eolaíochta Éireann
Science Foundation Ireland

Summary

- Introduction

  Ion Selective Electrodes (ISEs)

- Pb-ISEs: Conductive polymers (CP) as solid-contact (SC). An optimization study.

  POT

  PEDOT

- Pb-ISEs: New materials for the solid contact

  Gold Nanoparticles (GNPs)

Introduction

- Analyte
- Chemo/Bio Sensing
- Wireless Data Transmission

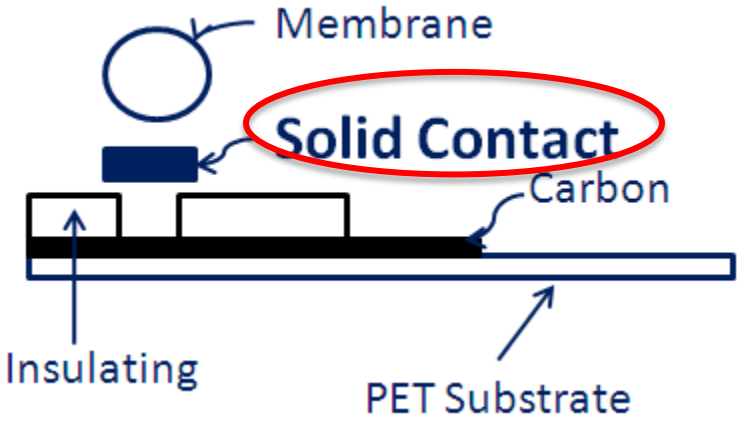
Ion Selective Electrode (ISE) able to detect the analyte of interest

ISE integrated into a wireless device for in situ monitoring

How to make an SC-ISE

Screen Printing Technology

- Cost
- Reproducibility

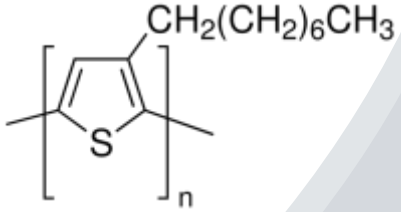


Solid Contact layer in SC-ISEs: material properties is a key factor in ensuring sensor reproducibility

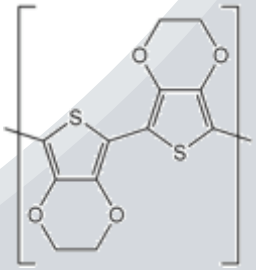
Solid Contact materials

The materials employed in this study:

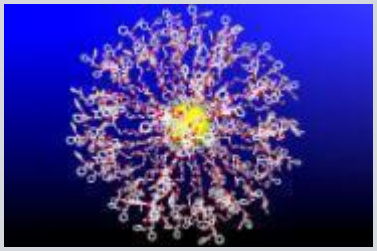
- Poly(3-octylthiophene-2,5-diyl) (**POT**)



- Poly(3,4-ethylenedioxythiophene) (**PEDOT**)

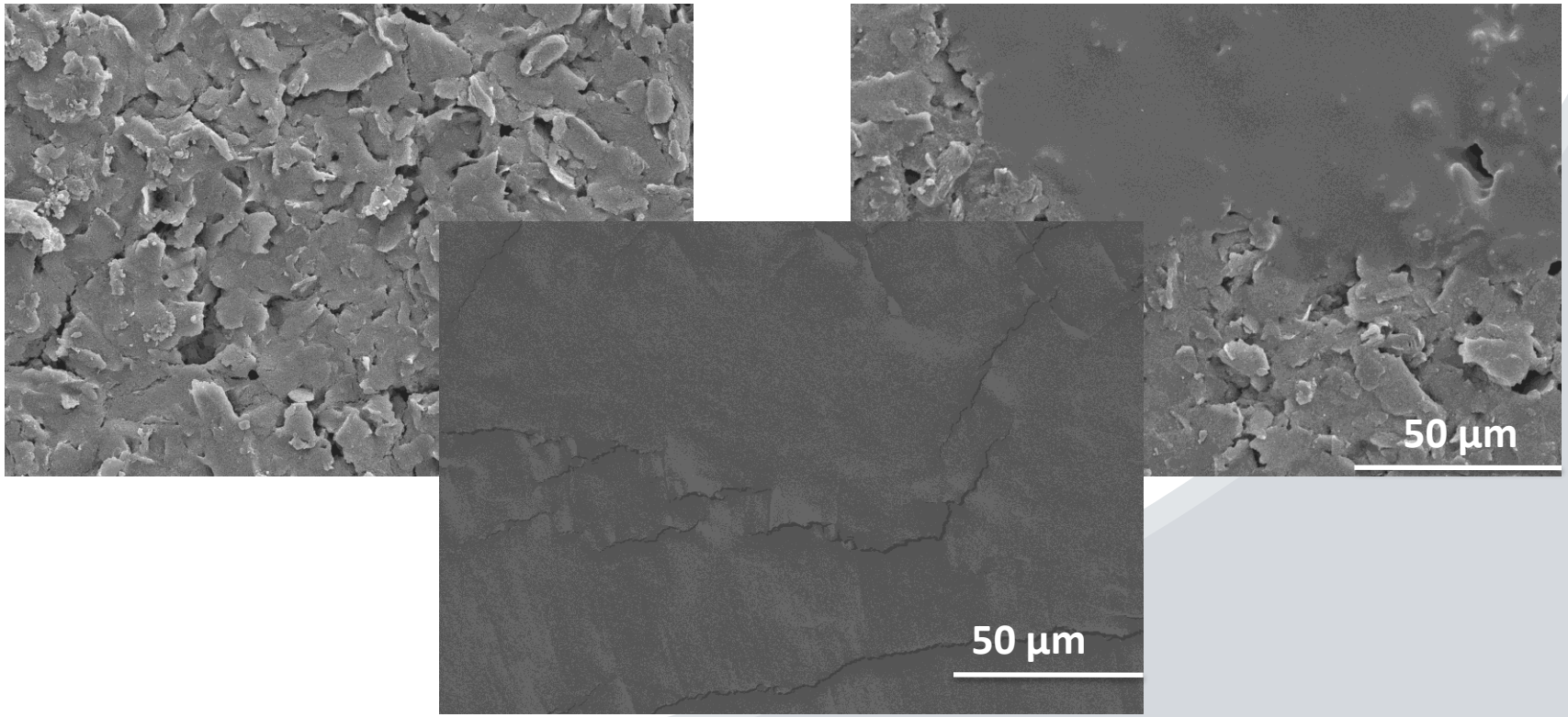


- Thioctic acid and thioctic amide gold nanoparticles



POT

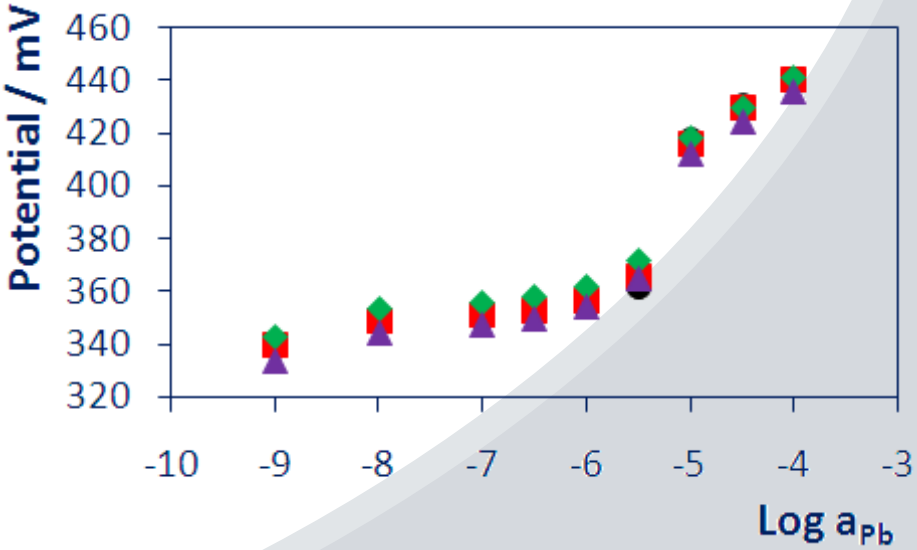
Drop-casting different amounts of POT ⟶ **Coverage** changes



POT

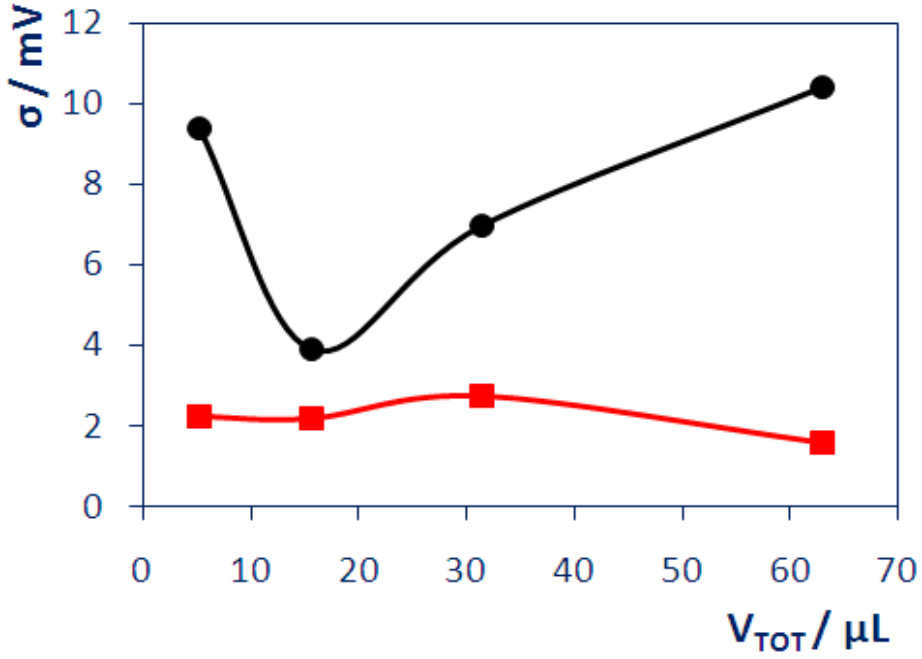
Typical calibration curve realized using POT as solid contact layer

SPE	Sensitivity (mV)	Baseline (mV)
1	48.15	339.3
2	46.36	339.7
3	43.16	343.9
4	44.43	333.7



POT

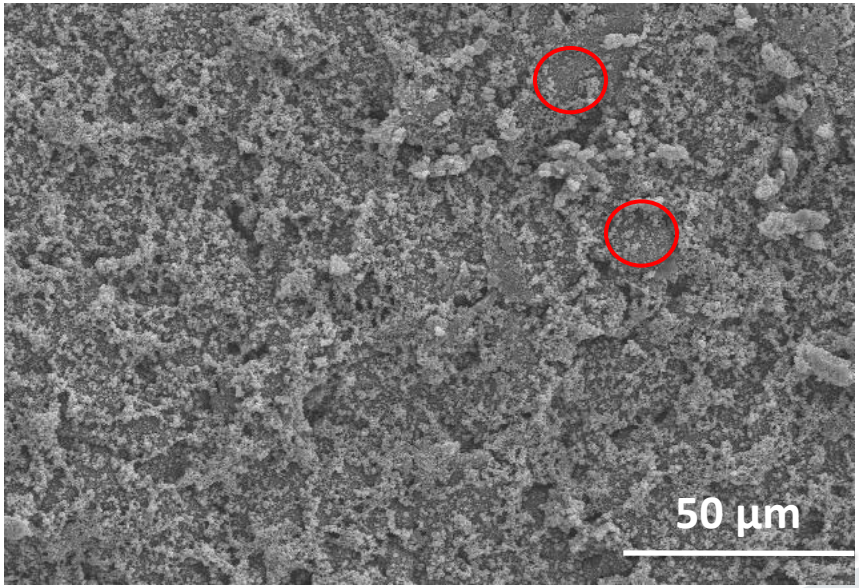
How the performances of the Lead ISEs were affected in changing the amount of POT drop cast

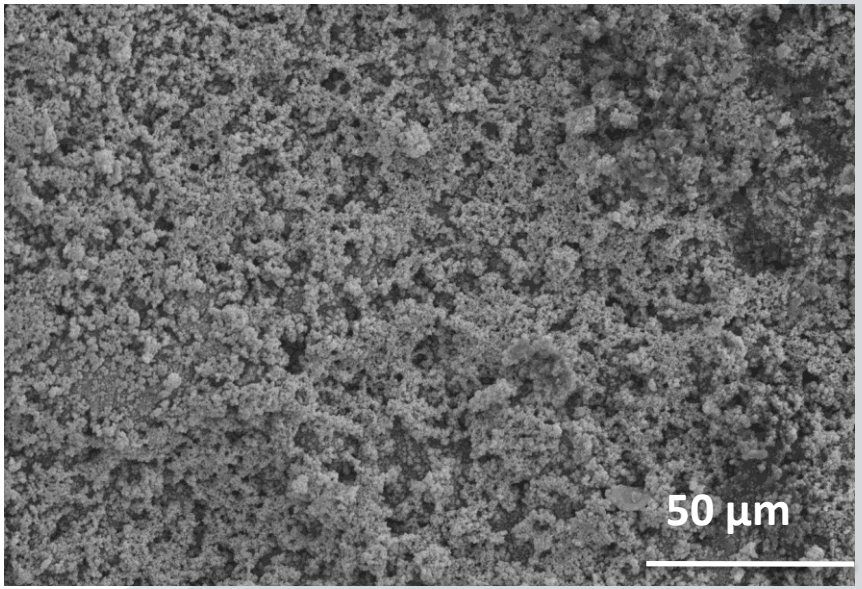


- Standard deviation for the offset of the ISEs calibration curves

- Standard deviation for the slope of the ISEs calibration curves

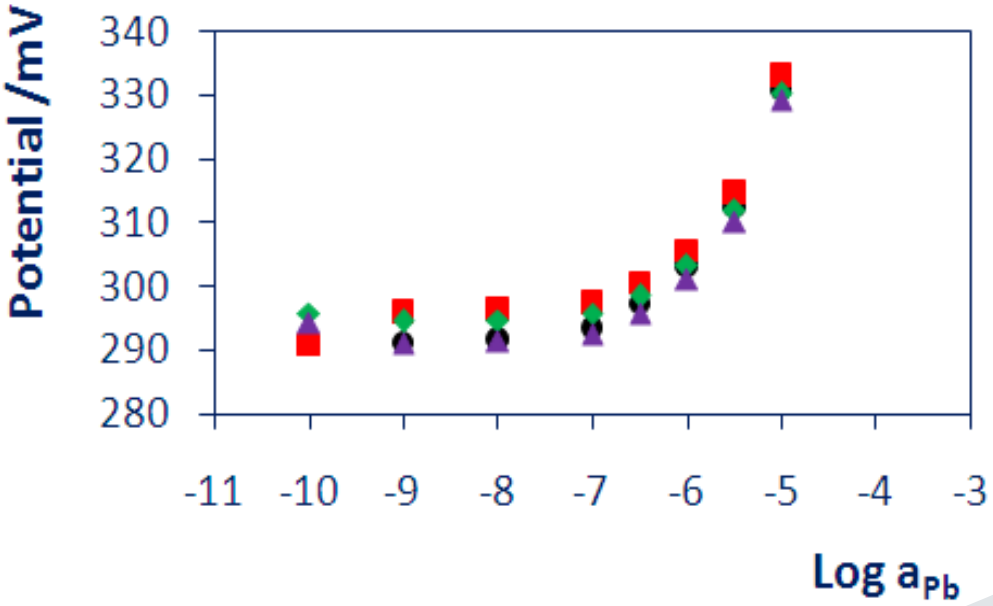
PEDOT





PEDOT

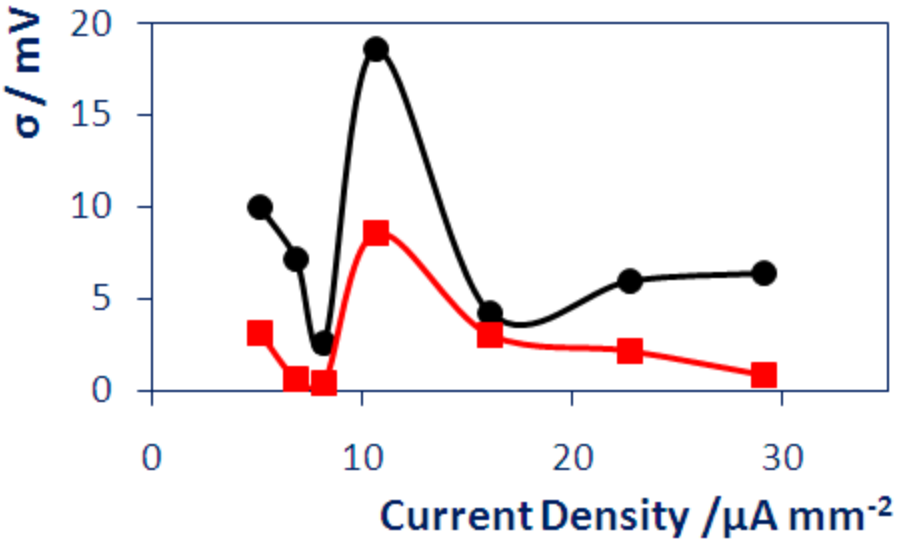
Typical calibration curve realized using PEDOT as solid contact layer



SPE	Sensitivity (mV)	Baseline (mV)
1	27.57	289.1
2	27.45	294
3	27.06	292.7
4	28.02	288.8

PEDOT

For PEDOT the performances are affected by the thickness and the redox state of the conducting polymer



- Standard deviation for the offset of the ISEs calibration curves

- Standard deviation for the slope of the ISEs calibration curves

GNPs

Reasons for using GNPs as solid contact :

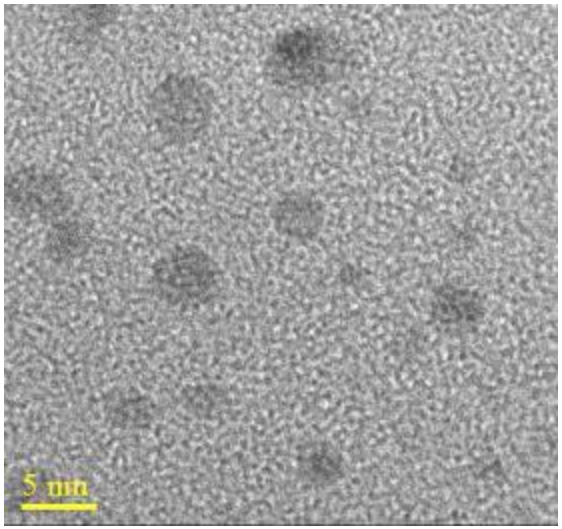
- Possibility of tuning the ligands and achieve control over hydrophobicity/hydrophilicity of the SC layer

- Ligands may be selected to bind the metal ion of interest, *i.e.*, control ionic fluxes at the membrane/SC layer interface

- Increase in the surface area of the solid contact layer, *i.e.*, increased stability of the ISEs response as demonstrated by the use of CNTs and other carbon nanomaterials

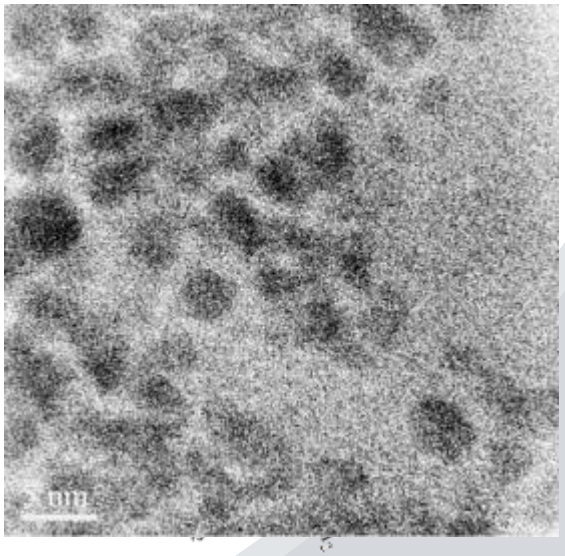
GNPs

TEM of Thioctic Acid GNPs



- soluble in water
- d_{mean} = 3.6 ± 0.6 nm
- $Au_{1565}(TA)_{161}$
  $(C/H)_{exp}$=1.72; $(C/H)_{the}$=1.75

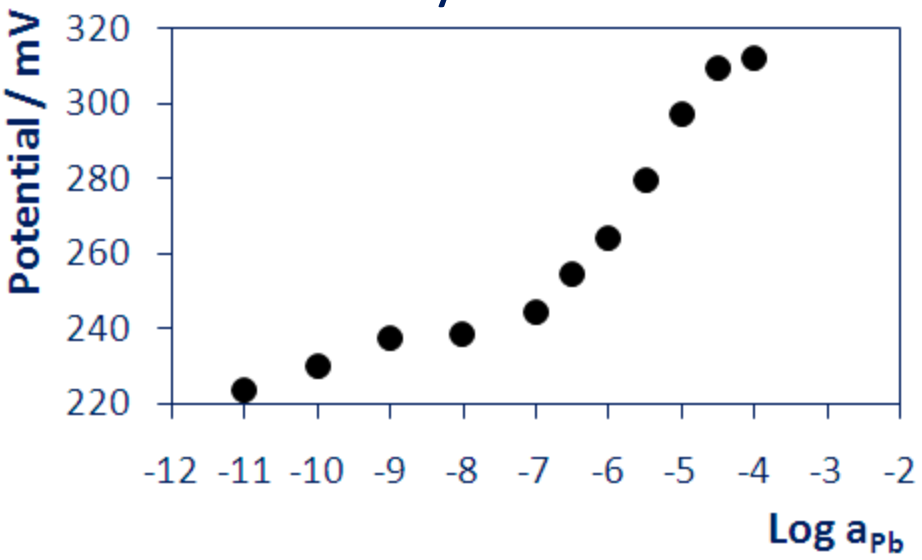
TEM of Thioctic Amide GNPs



- soluble in DMSO
- d_{mean} = 3.5 ± 0.7 nm
- $Au_{1314}(TA)_{311}$
  $(H/C)_{exp}$=1.88; $(H/C)_{the}$=1.88

Thioctic Acid GNPs

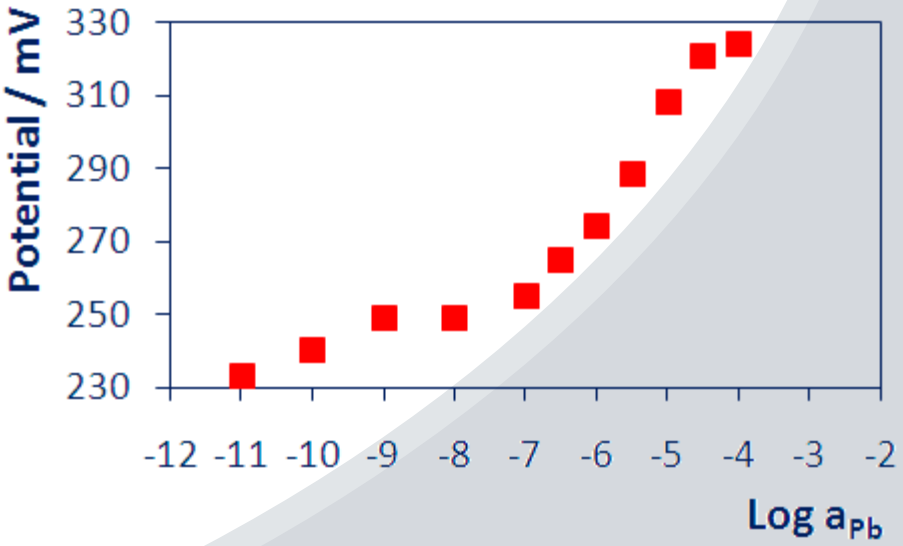
10 monolayers of GNPs as SC



SENSITIVITY: 26.68 mV

LOD: 6.87

50 monolayers of GNPs as SC

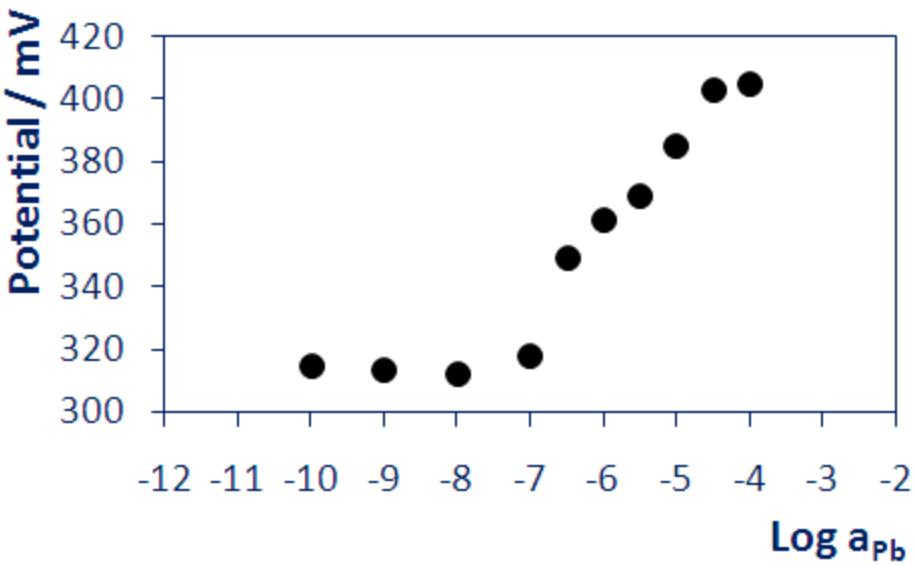


SENSITIVITY: 31.91 mV

LOD: 6.53

Thioctic Amide GNPs

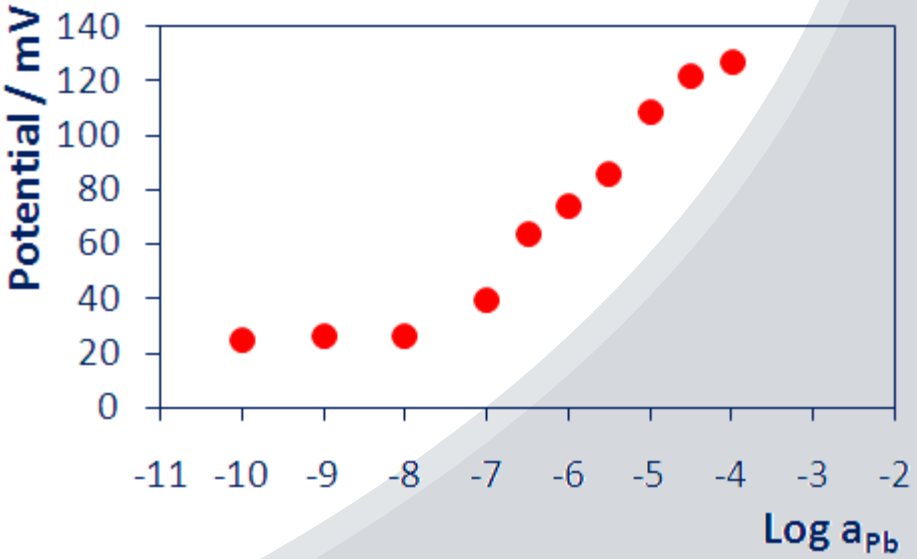
10 monolayers of GNPs as SC



SENSITIVITY: 33.93 mV

LOD: 7.2

50 monolayers of GNPs as SC



SENSITIVITY: 26.36 mV

LOD: 7.9

Conclusions

- POT: depend on the thickness of the conducting polymer
- PEDOT: depend on the thickness and the redox state of the conducting polymer
- GNPs: indicate the possibility of decreasing significantly the LOD replacing the CP with the GNPs in the solid contact layer

Future Work

- Other optimizations needed for improving ISEs performances: **Ion-selective MEMBRANE**

- Exploration of the GNPs as solid contact, *e.g.*, ligand, to fully exploit their potentials

- Preparation of calibrationless sensors directly integrated into wireless platforms for environmental applications

Acknowledgements

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