

Development of an Autonomous Sensing Device - detector based on miniature, solid-state ion-selective sensors

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DCU, Ireland

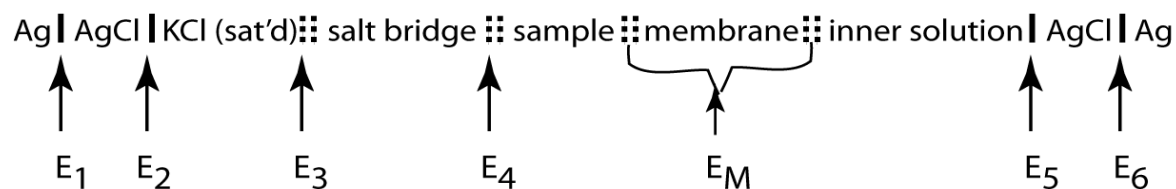
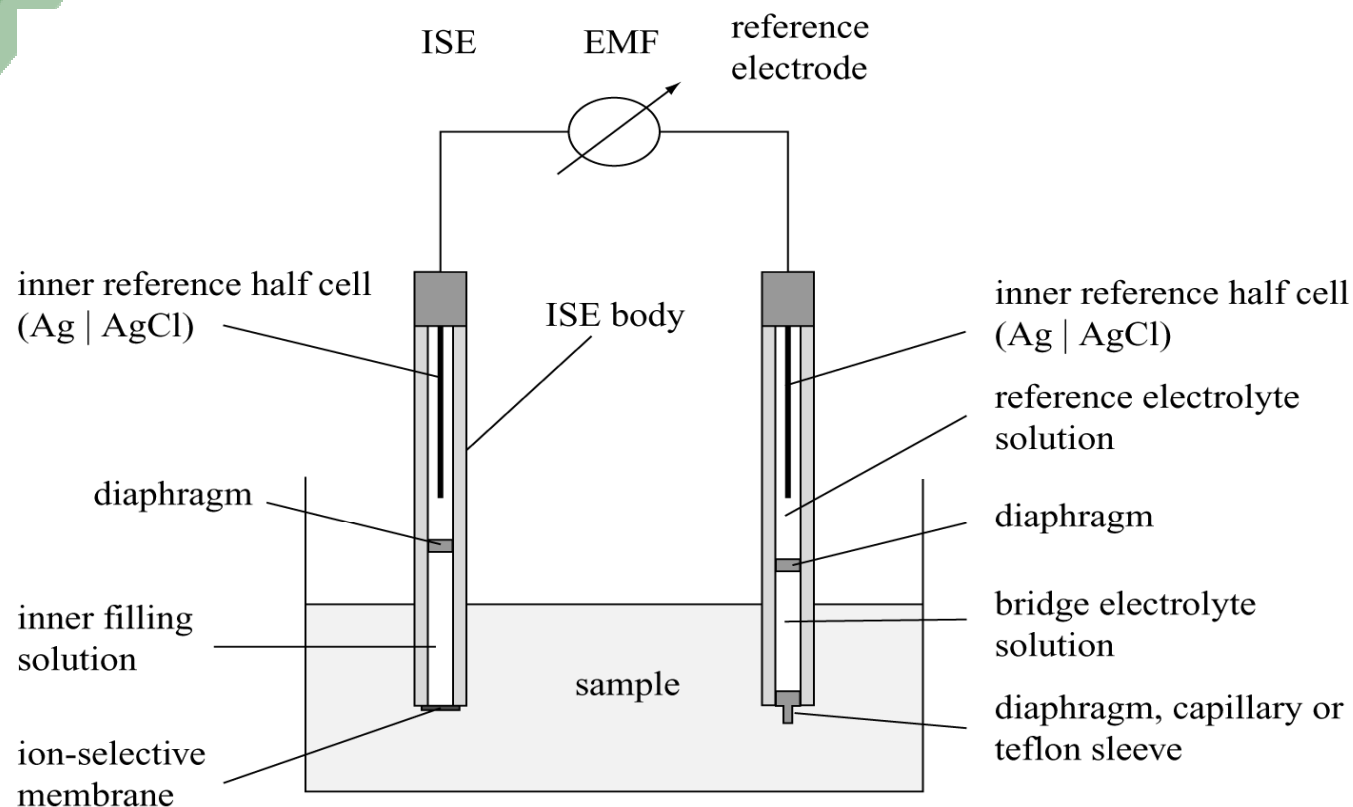
Abo Academi, Finland

San Francisco 215th ECS Meeting 2009

OUTLINE

- Background
- Development of solid-state ion-selective electrodes
- Development of solid-state reference electrodes
- Electronic circuitry for data acquisition and wireless transmission
- Field experiments

Chemical sensors with potentiometric detection - Ion Selective Electrodes (ISE)



$$E_{\text{cell}} = E_1 + E_2 + E_3 + E_4 + E_5 + E_M + E_J = E_{\text{const}} + E_J + E_{\text{PB1}} + E_{\text{PB2}}$$

one of the most
important
chemical sensors

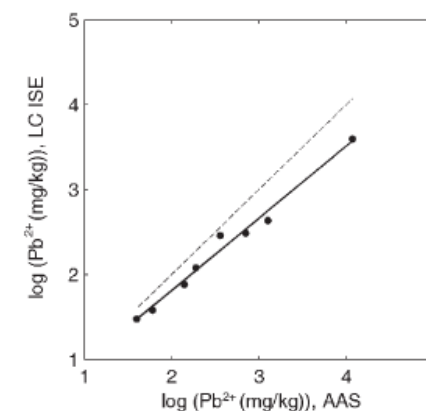
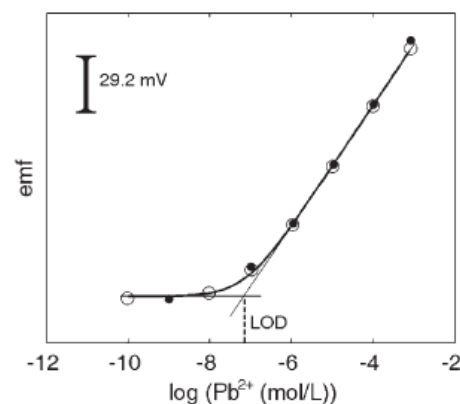
Process
Control

ISEs'
Applications

Clinical
Analysis

Environmental
monitoring

quality of drinking water
pollution by toxic heavy metal (lead)

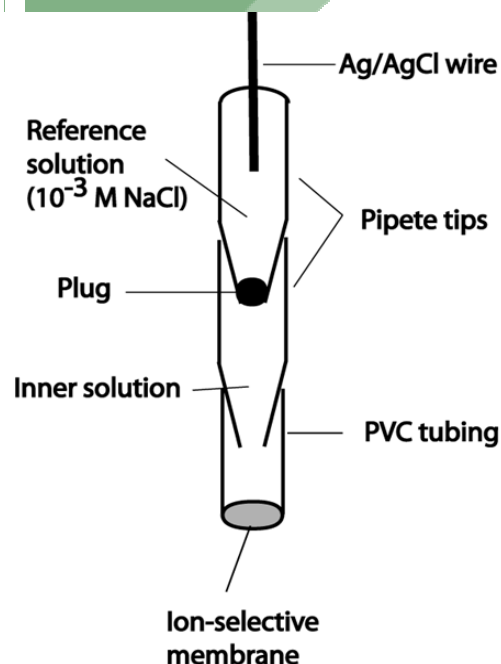


Evaluation of Liquid- and Solid-Contact, Pb²⁺-Selective Polymer-Membrane Electrodes for Soil Analysis

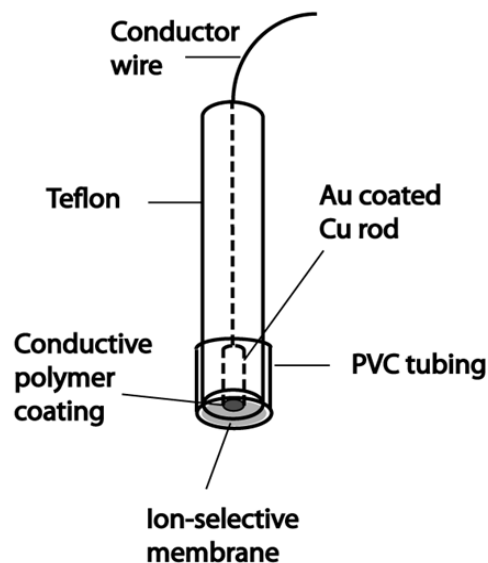
Christina M. McGraw,^a Tanja Radu,^b Aleksandar Radu,^{b*} Dermot Diamond^b

Electroanalysis 20, 2008, No. 3, 340–346

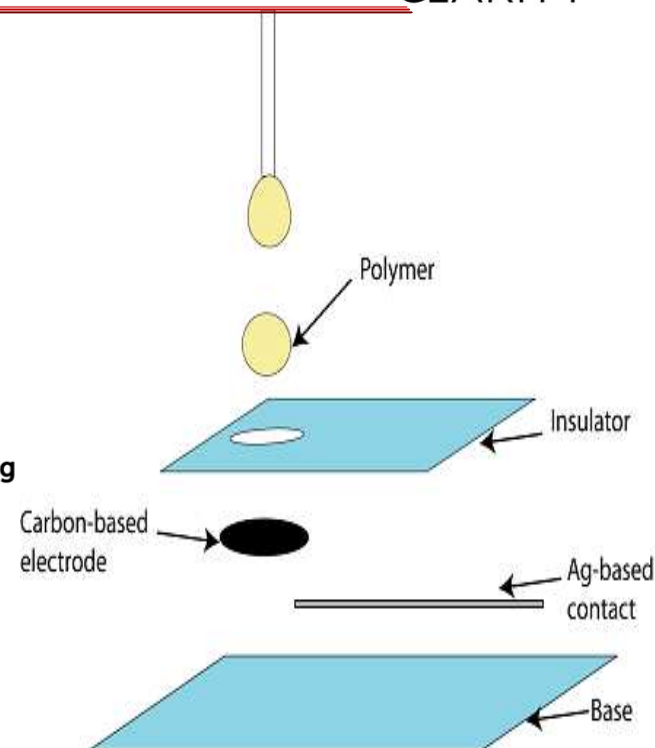
Development of “solid contact” ISEs



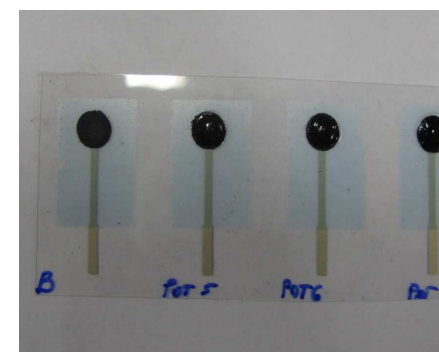
Liquid-contact electrode



Solid-contact electrode



- Lipophilic (does not allow for formation of water layer)
- Known to poses ionic and electronic conductivity



Drop-cast ISE membrane
on top of a POT layer
(~0.60 mm) thick

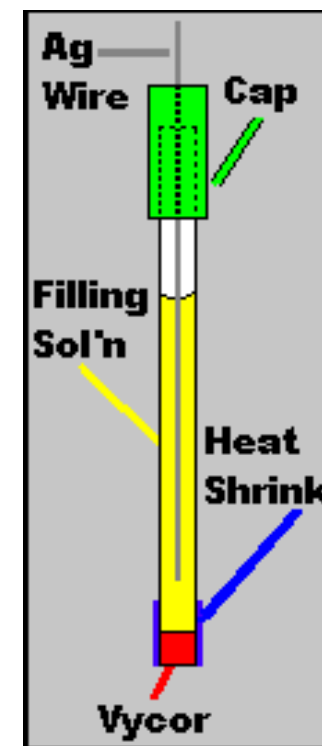
Development of “solid contact” ISEs

- simple construction
- good detection limit
- very low power demand
- simple experimental setup
- miniaturization opportunities arising from solid-state format
- ISEs an excellent prospect for integration in autonomous sensing devices
- integration in large wireless chemo-sensing networks (new application fields, collaboration with scientist and engineers of different expertise)

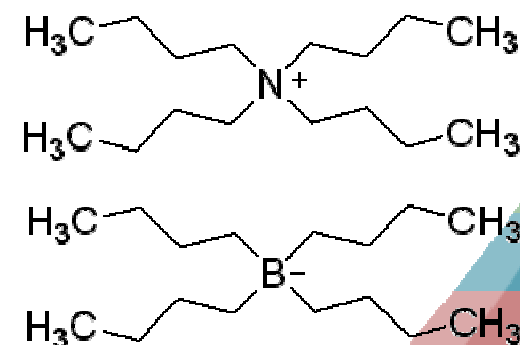
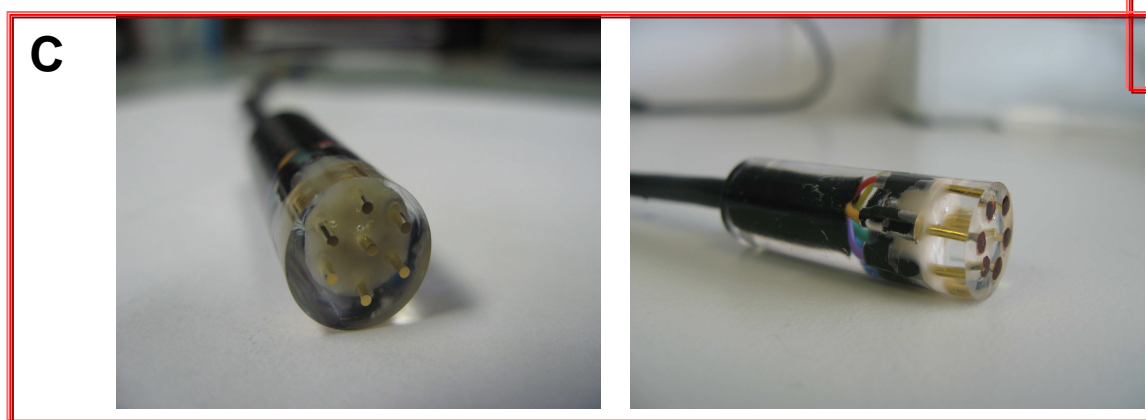
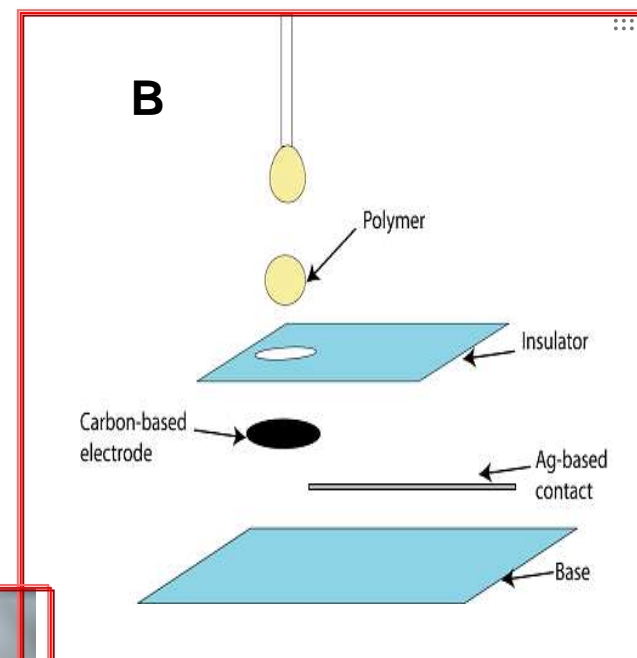
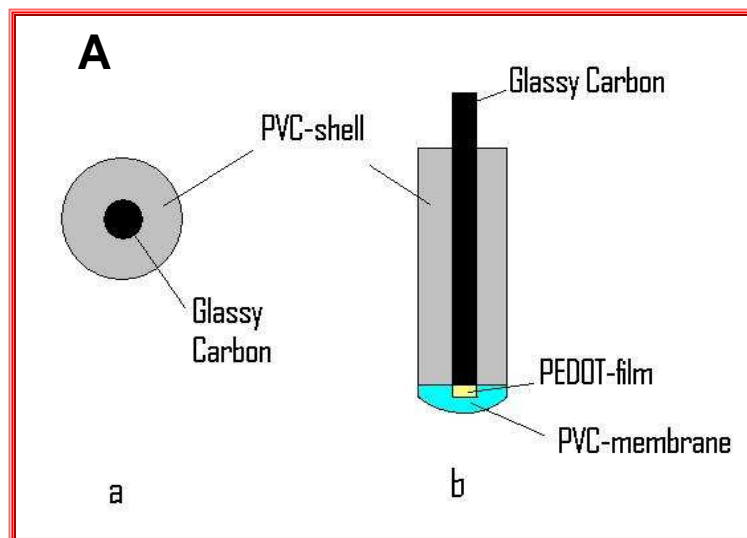
Reference electrode

Conventional reference electrode

- Internal solution
- Require maintenance
- Vertical working position
- Cannot be miniaturized
- Causes a risk of contaminating the sample through leakage of the filling solution

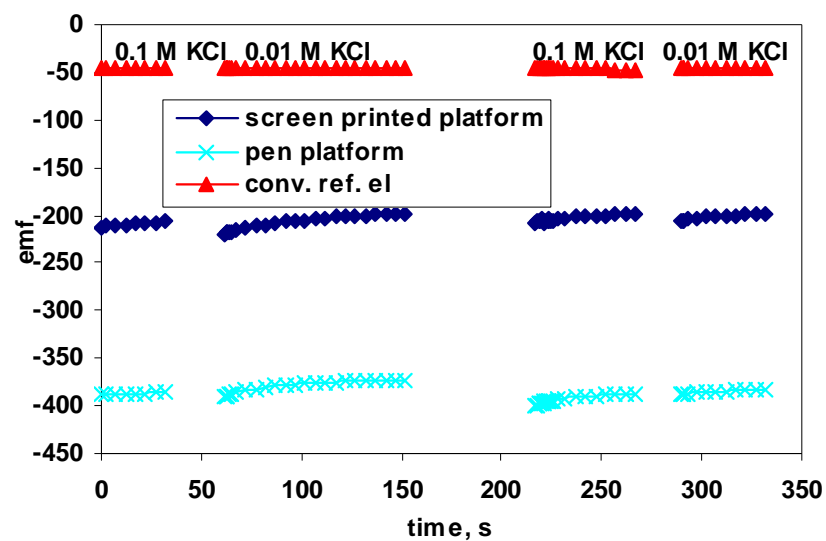
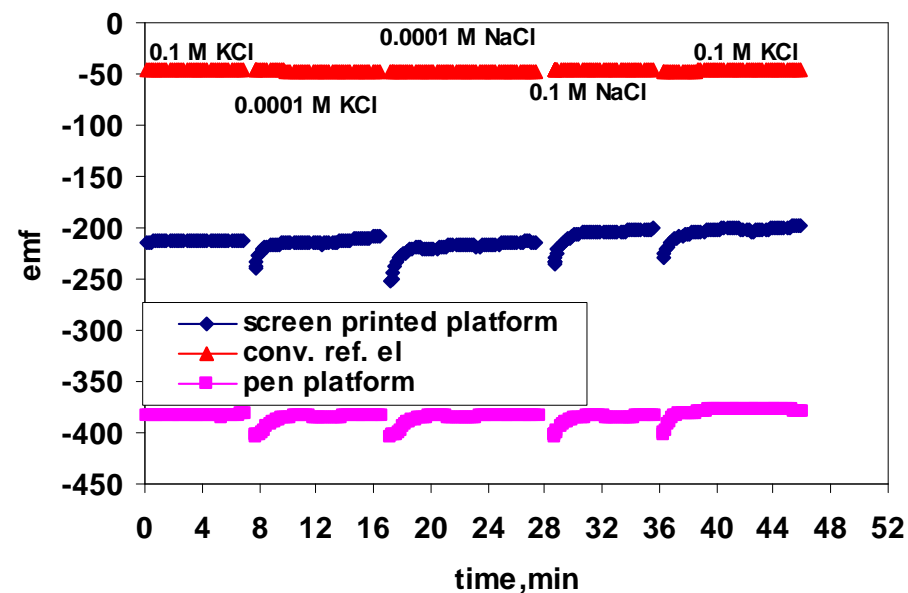
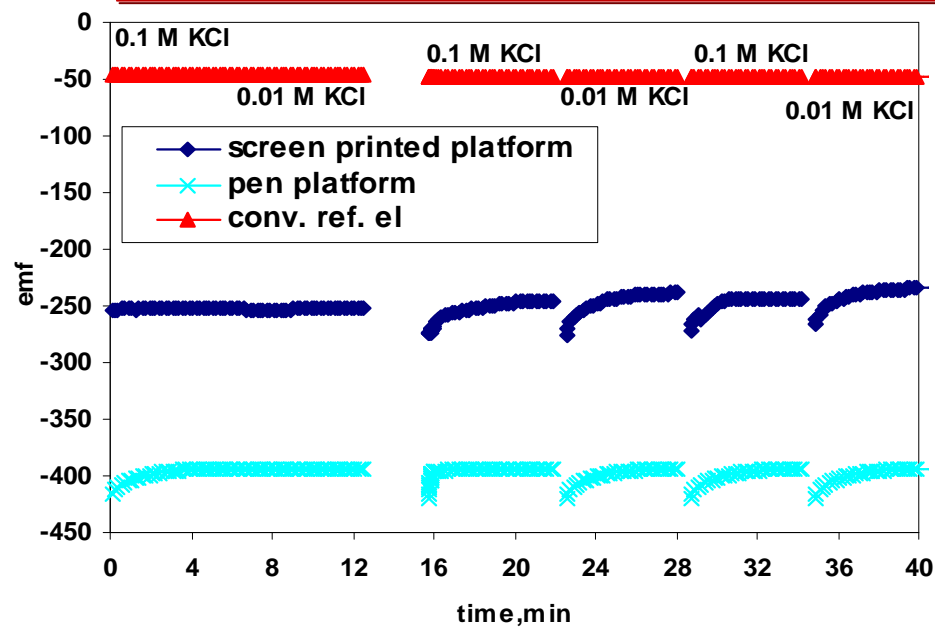


Reference electrodes

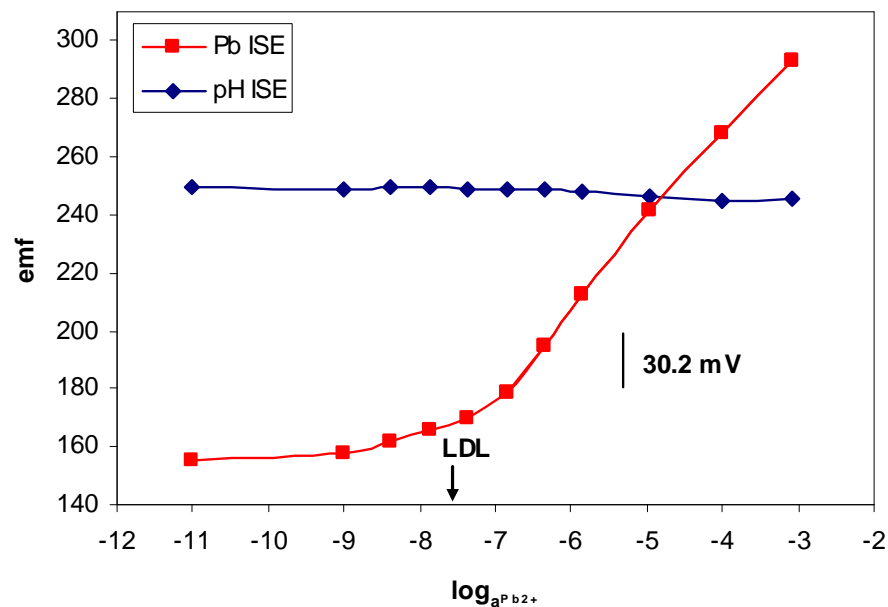


U. Mattinen, J. Bobacka and A. Lewenstam, "Solid-Contact Reference Electrodes Based on Lipophilic Salts", *Electroanalysis* 2009 (accepted)

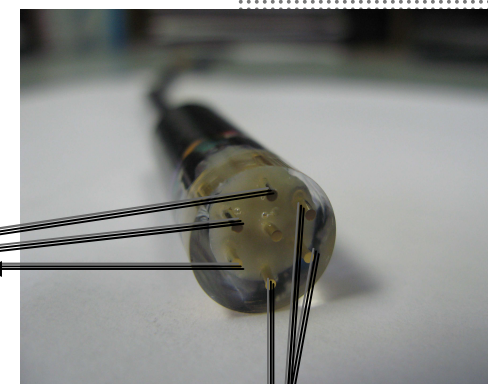
Experiments



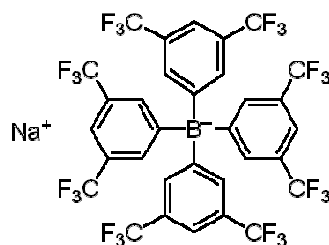
Experiments



WE – pH ISE



WE – Pb^{2+} selective

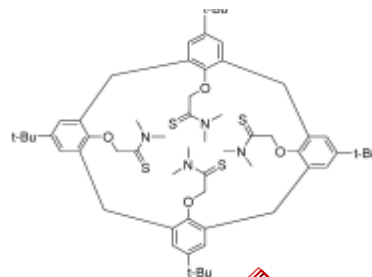


5 mmol/kg NaTFPB

Sodium tetrakis [3,5-bis(trifluoromethyl)] phenylborate

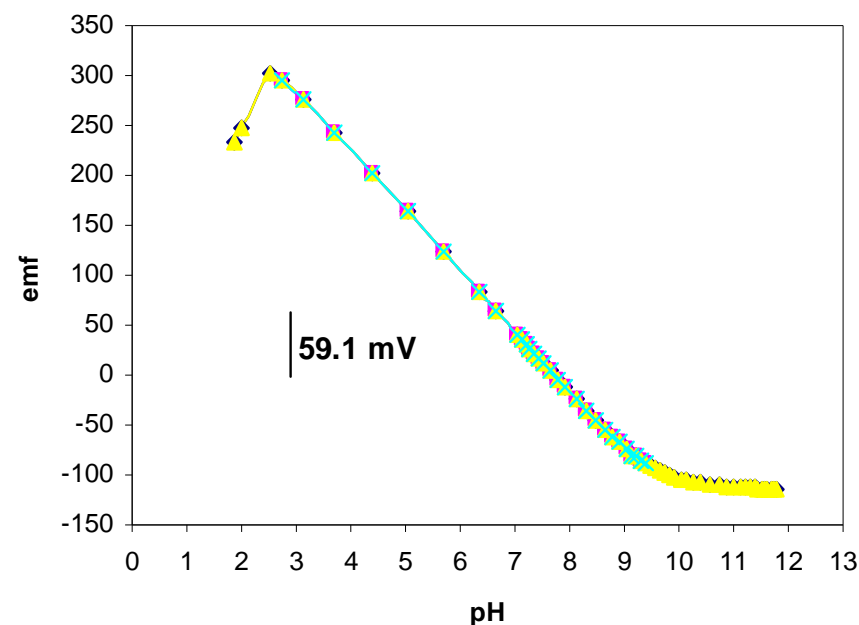
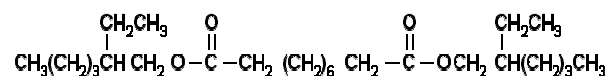
15 mmol/kg Pb IV

tert-Butylcalix[4] arene-tetrakis(N,N dimethylthioacetamide)

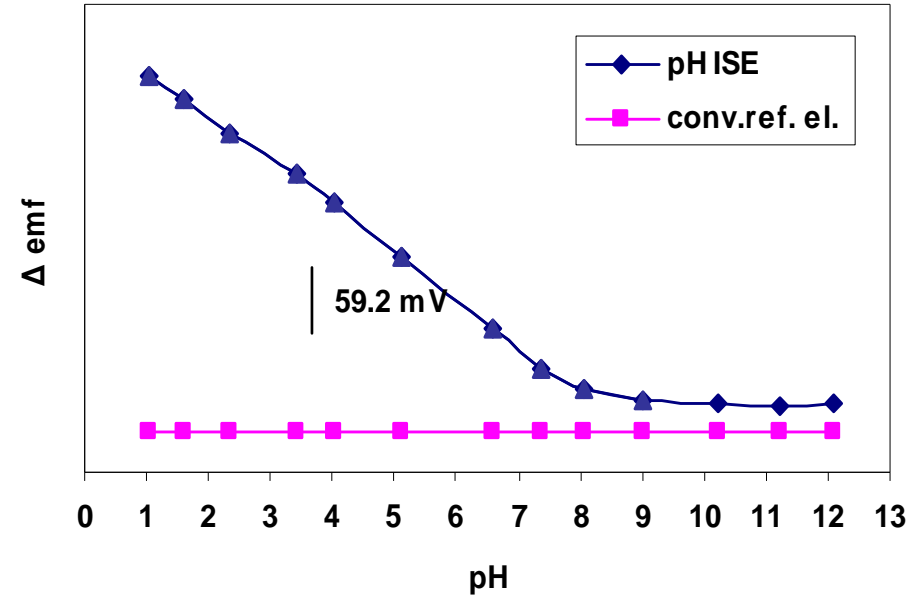
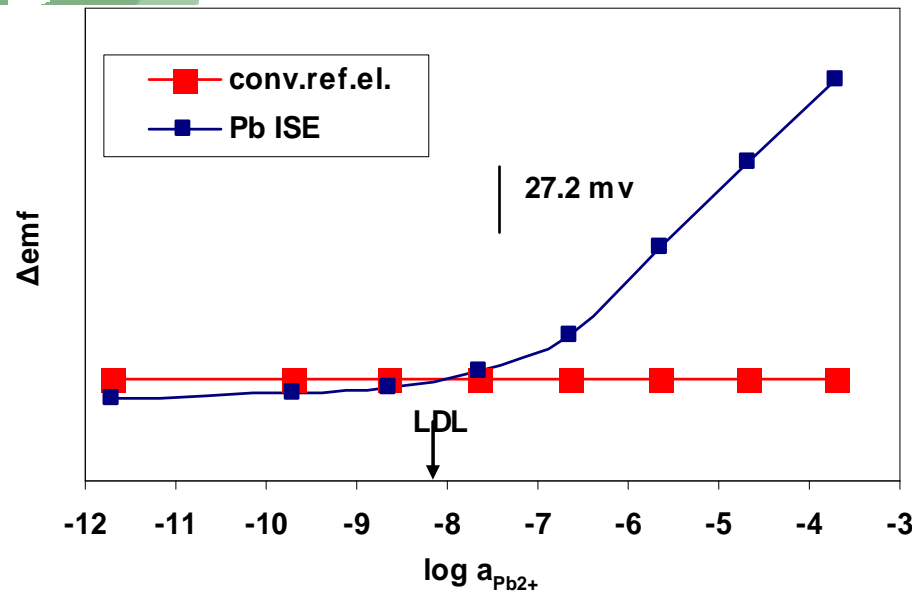


PVC:DOS 1:2

Bis(2-ethylhexyl) sebacate

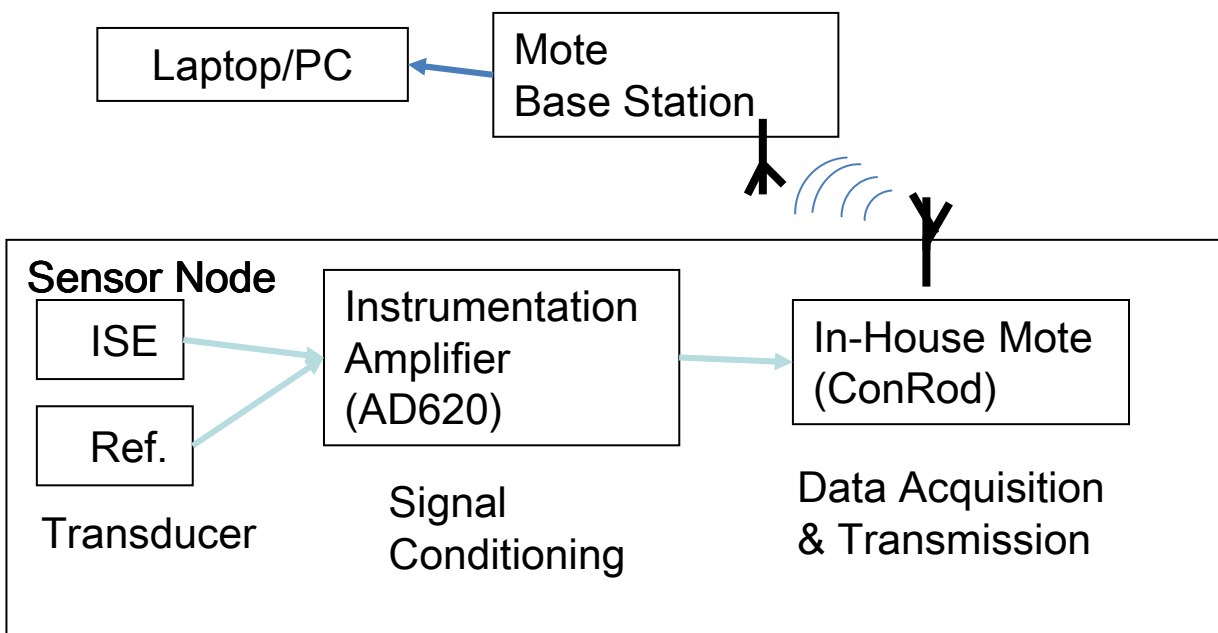
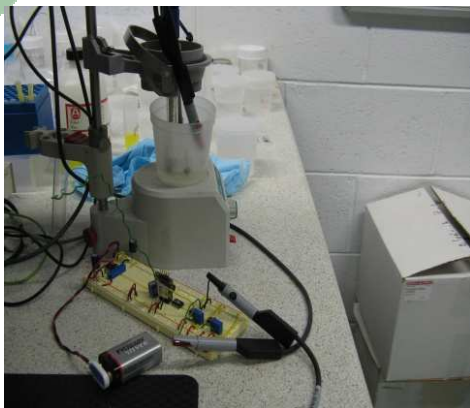


Experiments

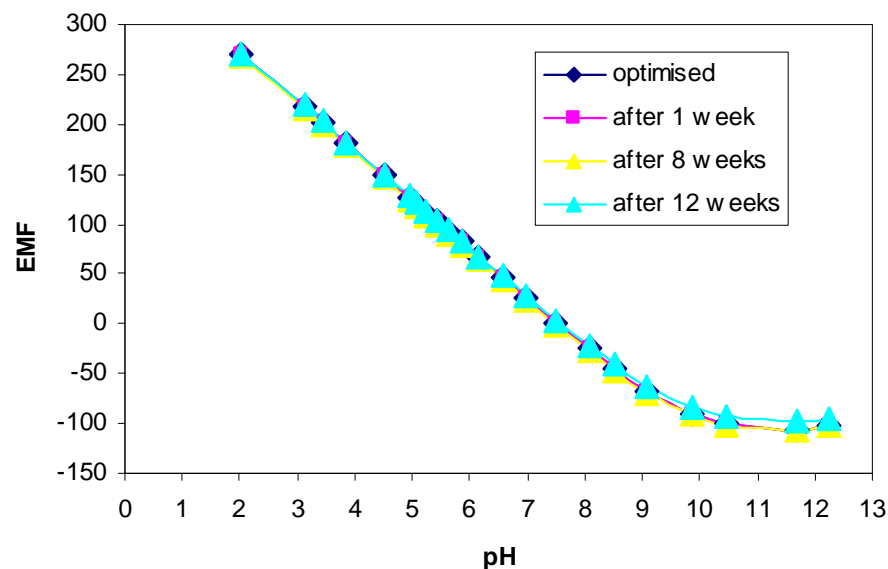


- Results are repeatable and reproducible
- The absolute value of potential difference is the same when we use conventional reference electrode or our home made reference electrode (using screen printed platforms or pen platforms)

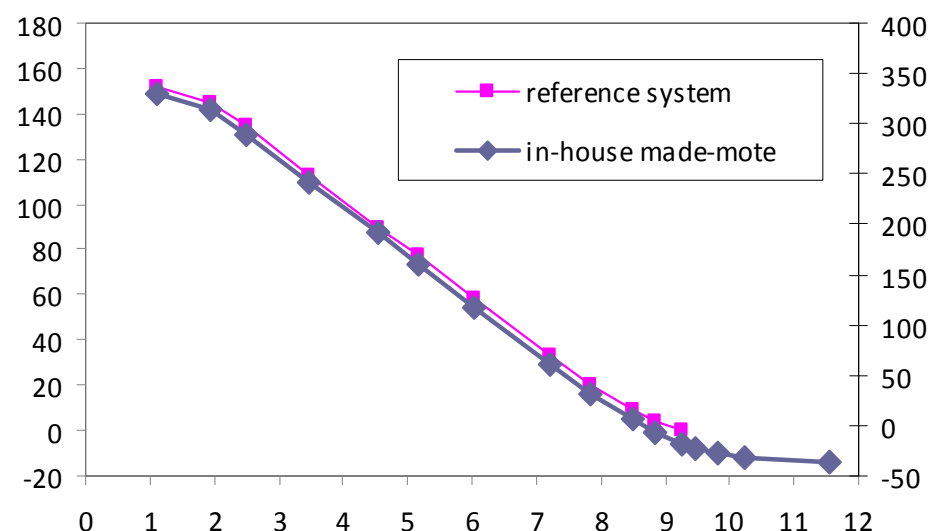
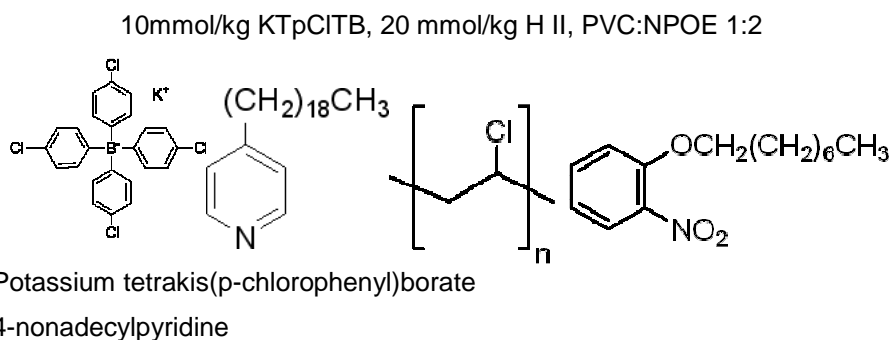
Circuitry for wireless data transmission



Mote (electronic circuitry for data acquisition and wireless transmission)



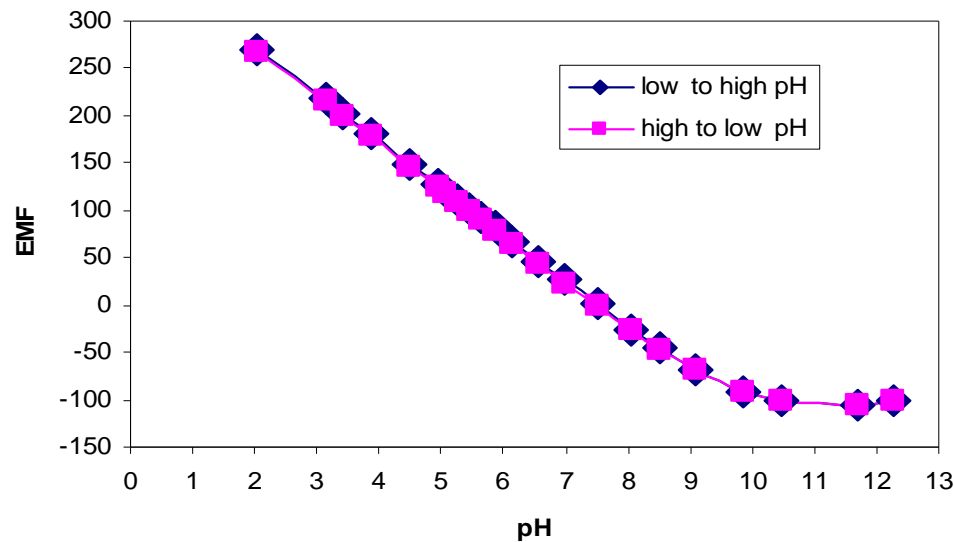
Investigation of long-term stability of sensors



validation of wireless circuitry

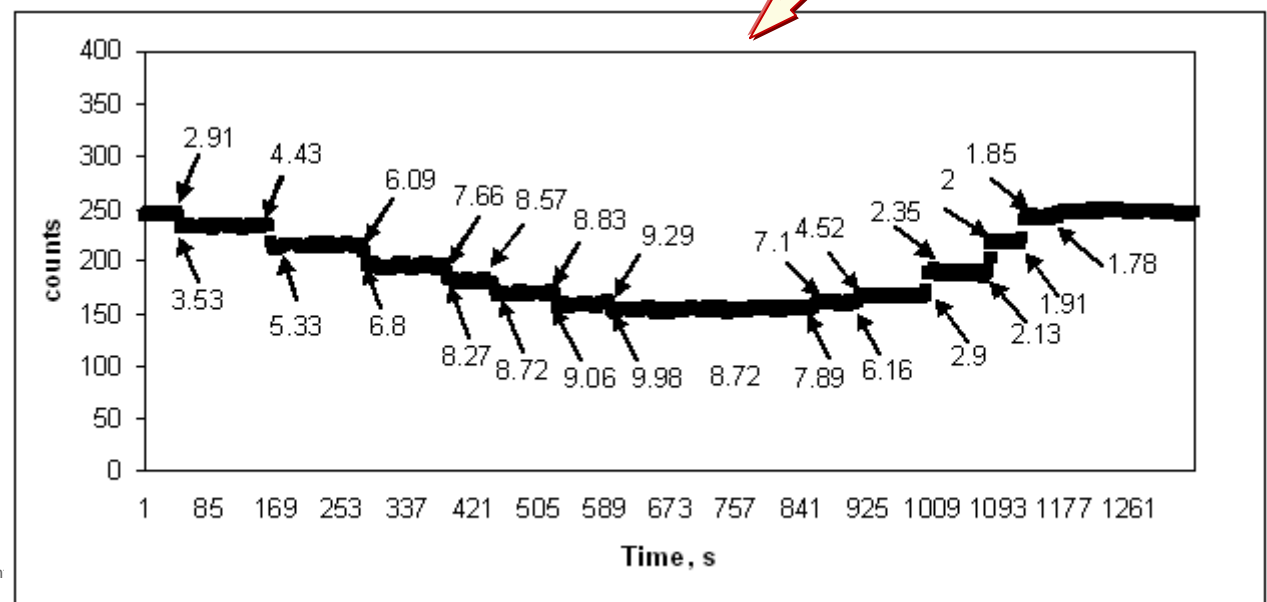
E. Bakker Anal. Chim. Acta 1994

Mote (electronic circuitry for data acquisition and wireless transmission)



experiments performed with wireless mote

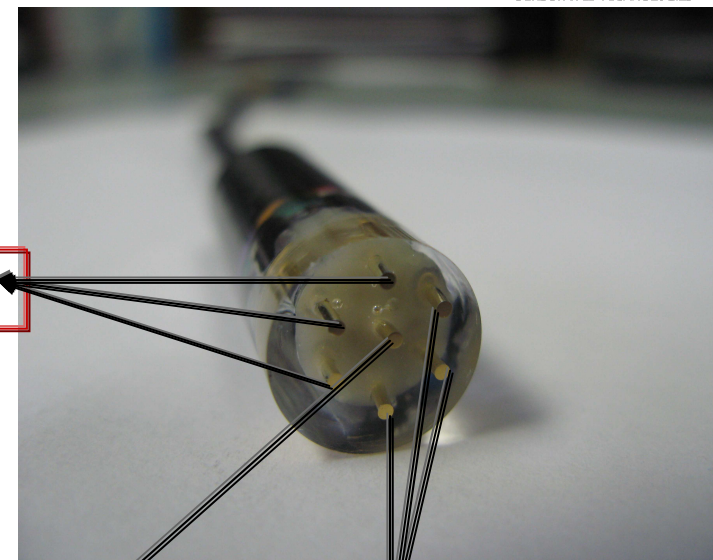
reversibility of response to pH



Experiments

•Field trials

- with conventional reference electrode
- with solid contact reference electrode



WE - pH ISE

RE

WE - Pb²⁺ ISE



Field trials

	pH measured for pen platform	pH measured for screen printed platform	pH calculated	D, %
Distil water	4.3	4.3	4.38	1.83
Rain water	5.85	5.85	5.96	1.88
Tap water	7.94	7.93	8.07	1.64
Tolka river	7.5	7.51	7.33	1.93
Royal channel (Public library)	7.52	7.52	7.33	1.90
Botanic garden	7.95	7.95	7.76	1.84
Royal channel (Shandon gardens)	7.53	7.52	7.43	1.77
Tolka park	7.95	7.94	7.85	1.62

Conclusions

- Advances in both solid-contact ISEs and solid-contact reference electrodes gave us the opportunity to develop common platform for both SC-ISE and SC-RE
- Screen-printed ISEs perform similarly to classically prepared ones
- *In-house* prepared motes allow wireless data transmission and are compatible with screen-printed and pen ISEs
- ISEs are suitable for use as a chemo-sensing component in a wireless sensor network (WSN)
 - for monitoring the quality of a fresh water system

Acknowledgments

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➤ Prof. Dermot Diamond



- Prof. Johan Bobacka (Abo Academi, Turku, Finland)
- Ulriika Mattinen
- Prof. Andrzej Lewenstam (Abo Academi, Turku, Finland)