Electrochemical impedance spectroscopy as a tool for probing the functionality of ion-selective membranes

215th ECS Meeting, San Francisco

24-29/05/09

This work is supported by Science Foundation Ireland under grant 07/CE/I1147

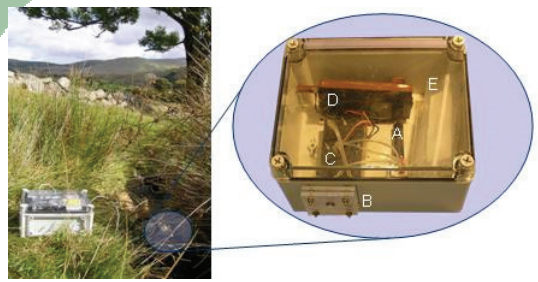
Outline

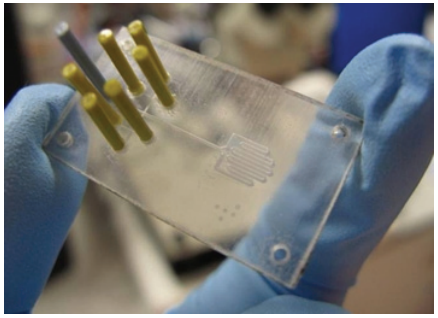
- Can we use electric signal instead of calibration solutions?
  - Evaluate the functionality – exclude under-performing ISEs from calibration
    - Physical damage
    - Biofouling
    - Leaching of the components
  - Give recommendations for designing a simple circuitry to be integrated with ISEs

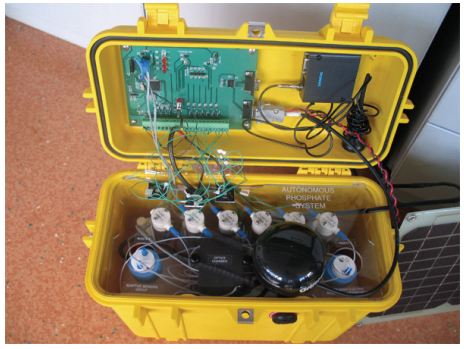
This work is supported by Science Foundation Ireland under grant 07/CE/I1147

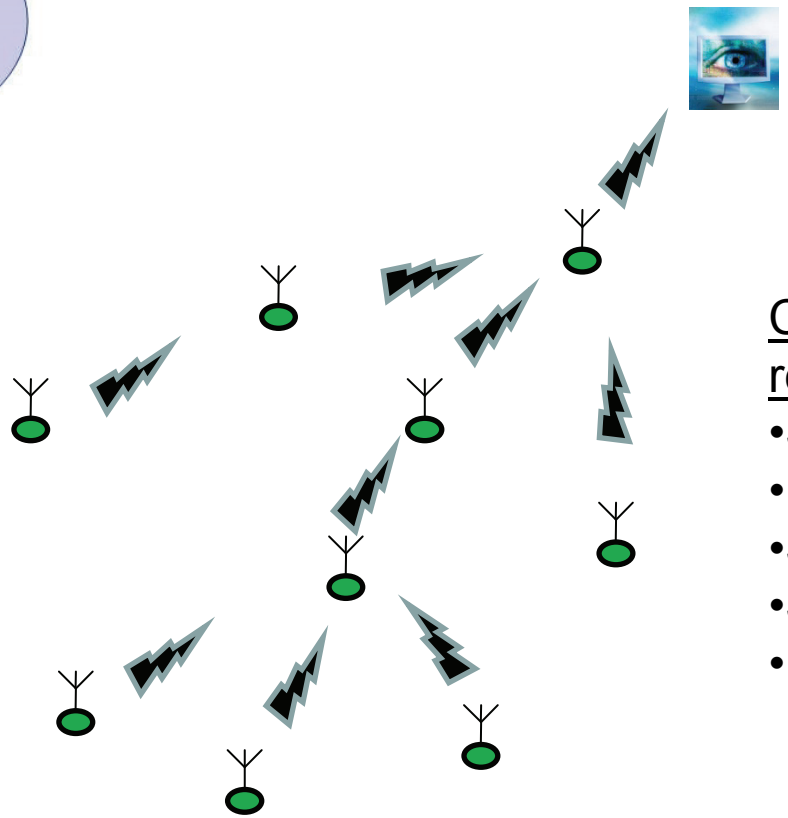
CLARITY
CENTRE FOR SENSOR WEB TECHNOLOGIES
UNIVERSITY COLLEGE DUBLIN
DUBLIN CITY UNIVERSITY
TYNDALL NATIONAL INSTITUTE

Why replacing calibration solutions?









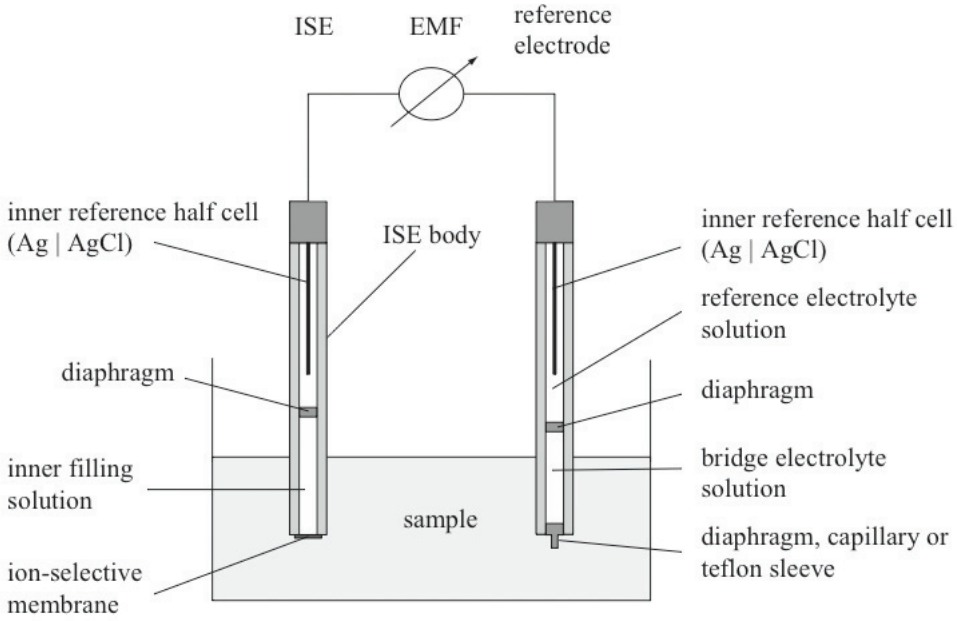
Chemical sensor requirements:

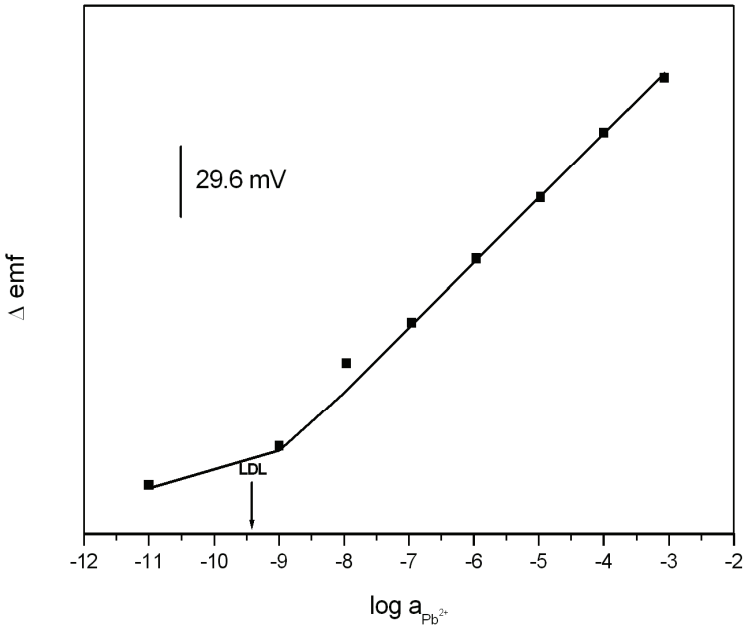
- Simple
- Low power
- Small
- Sensitive
- Inexpensive

This work is supported by Science Foundation Ireland under grant 07/CE/I1147

CLARITY
CENTRE FOR SENSOR WEB TECHNOLOGIES
UNIVERSITY COLLEGE DUBLIN
DUBLIN CITY UNIVERSITY
TYNDALL NATIONAL INSTITUTE

Ion-Selective Electrodes (ISEs)

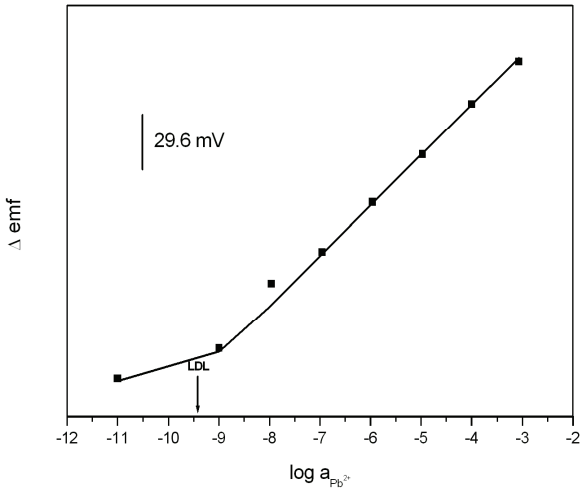


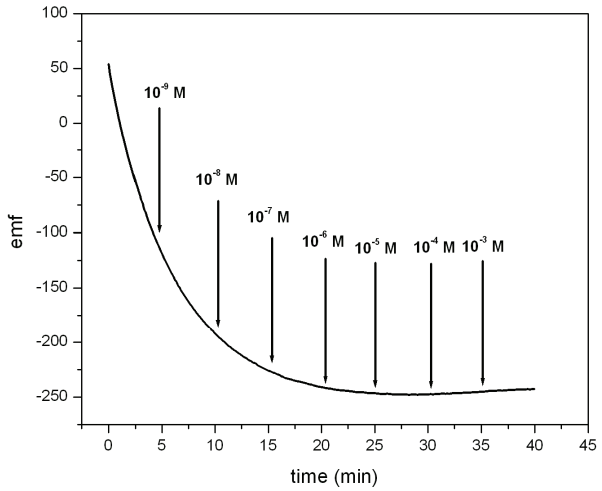


This work is supported by Science Foundation Ireland under grant 07/CE/I1147

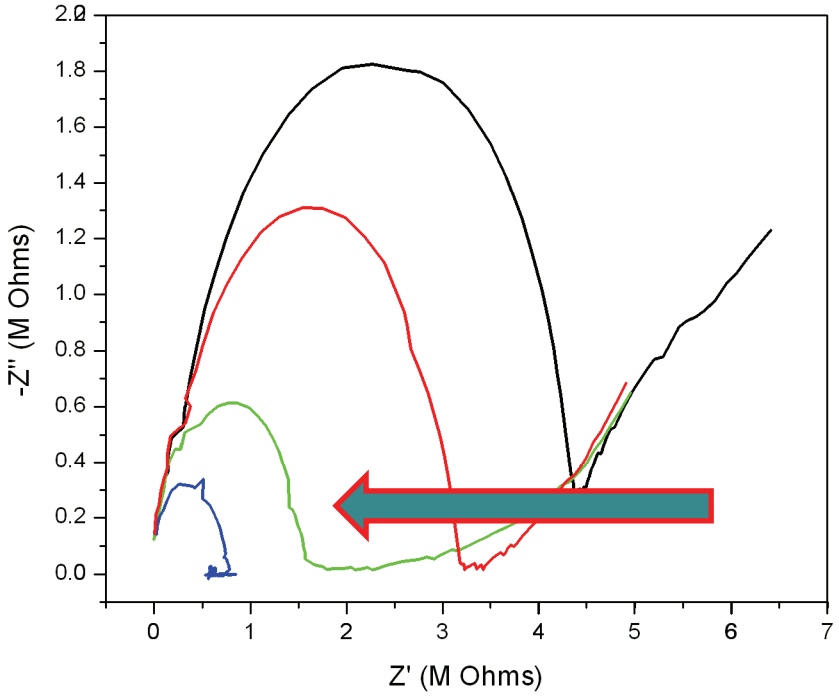
UNIVERSITY COLLEGE DUBLIN
DUBLIN CITY UNIVERSITY
TYNDALL NATIONAL INSTITUTE

Physical damage (LC ISEs)



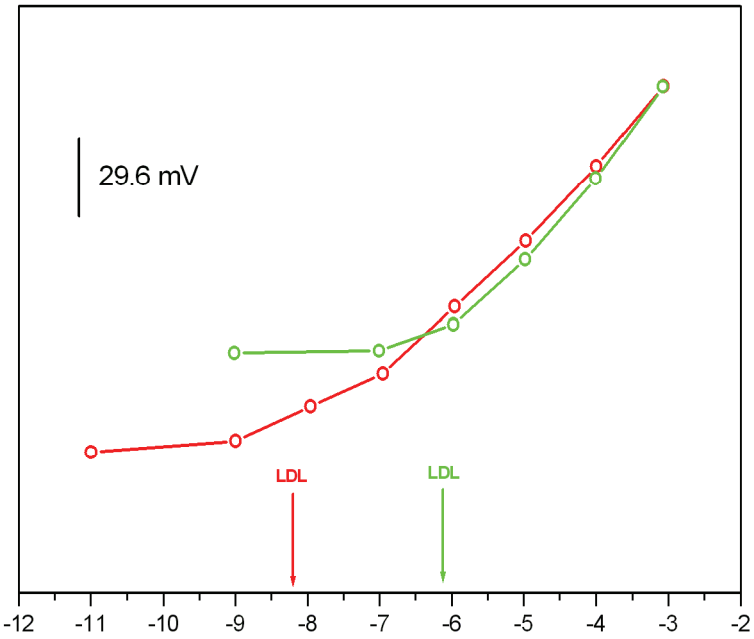


- Excitation potential: 100 mV
- ω range 100 kHz to 0.01 Hz
- 3 electrode setup
- 10^{-3} M $Pb(NO_3)_2$



This work is supported by Science Foundation Ireland under grant 07/CE/I1147

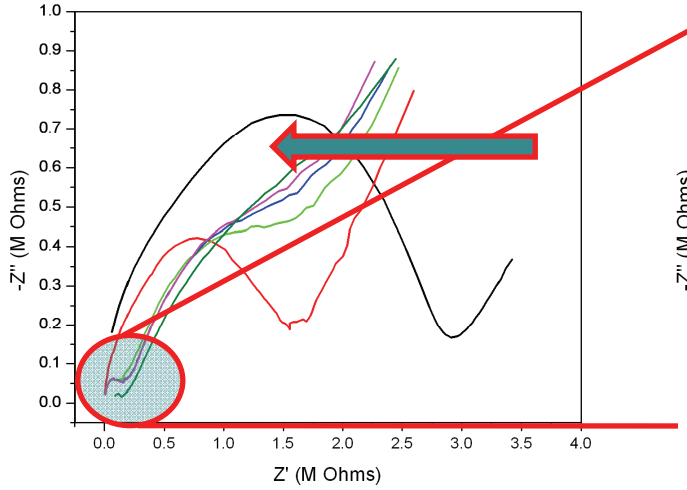
Physical damage (SC ISEs)

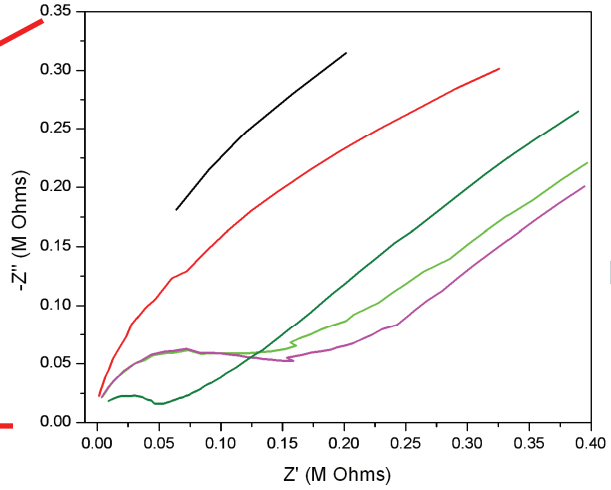


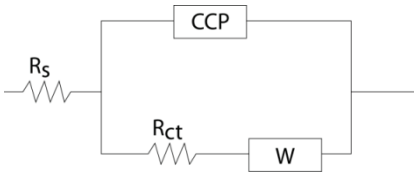
R 14:20 (section J3) Dr. Salzitsa Anastasova; “Development of an Autonomous Sensing Device - Detector based on Miniature, Solid-state Ion-selective Sensors “

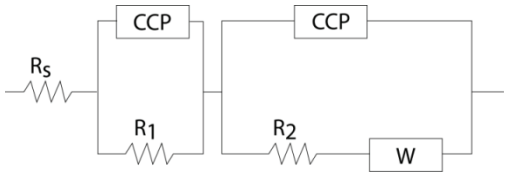
This work is supported by Science Foundation Ireland under grant 07/CE/I1147

Physical damage (SC ISEs)









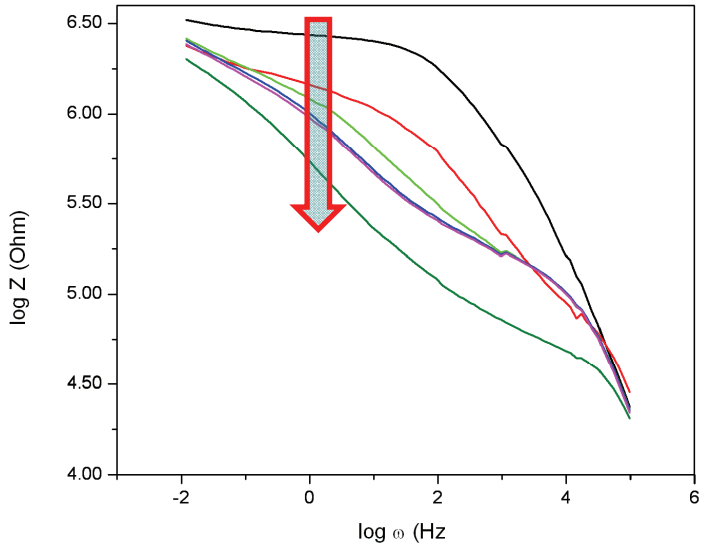
	optimized	case 1
Rs	500	500
R1	2.9E+06	1.8E+06
Q	2.0E-08	6.0E-09
n	0.6	0.6
W	5.0E-06	5.0E-06

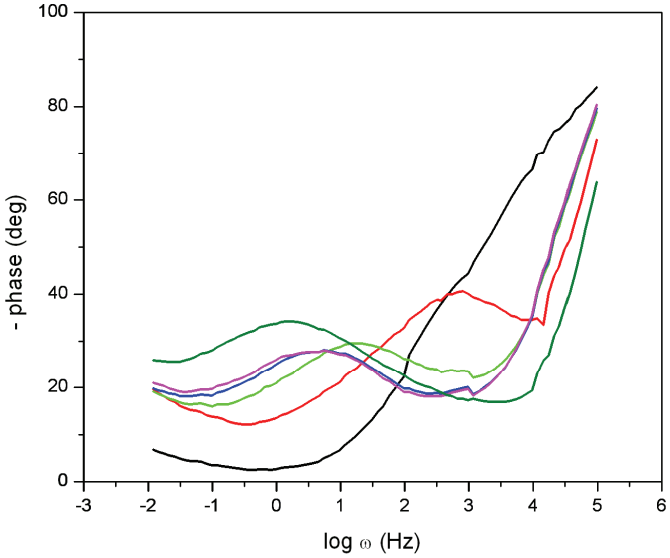
	case 2	case 3	case 4	case 5
Rs	500	500	500	500
R1	2.0E+06	2.0E+06	2.0E+06	2.0E+06
Q1	8.0E-07	9.0E-07	1.0E-06	2.0E-06
n1	0.5	0.5	0.5	0.5
R2	2.2E+05	2.2E+05	2.2E+05	5.0E+04
Q2	1.0E-07	1.0E-07	1.0E-07	1.0E-07
n2	0.5	0.5	0.5	0.5
W	1.0E-05	1.0E-05	1.0E-05	1.0E-05

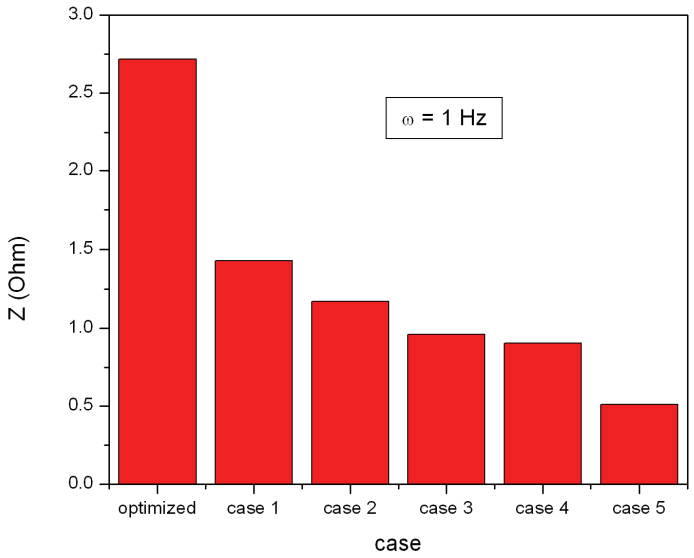
This work is supported by Science Foundation Ireland under grant 07/CE/I1147

UNIVERSITY COLLEGE DUBLIN
DUBLIN CITY UNIVERSITY
TYNDALL NATIONAL INSTITUTE

Physical damage (SC ISEs)





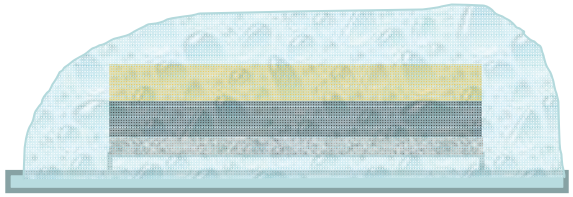


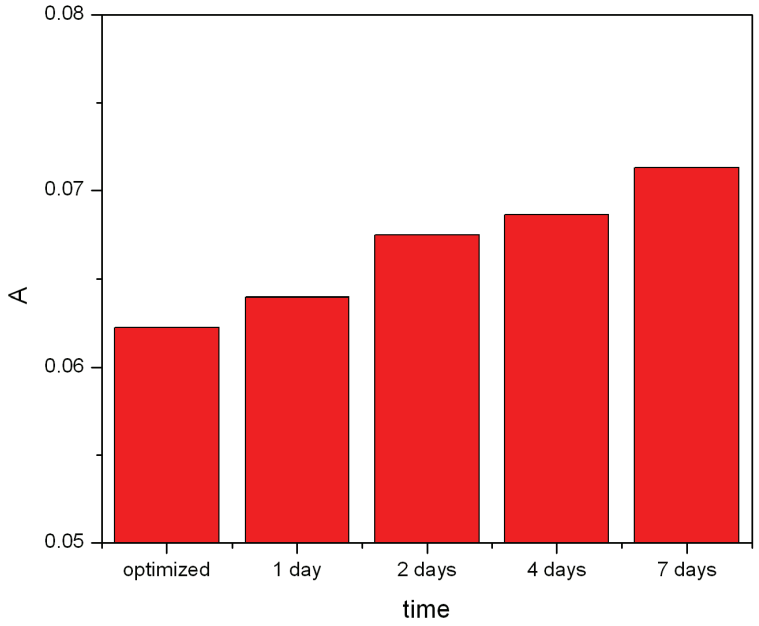
This work is supported by Science Founda

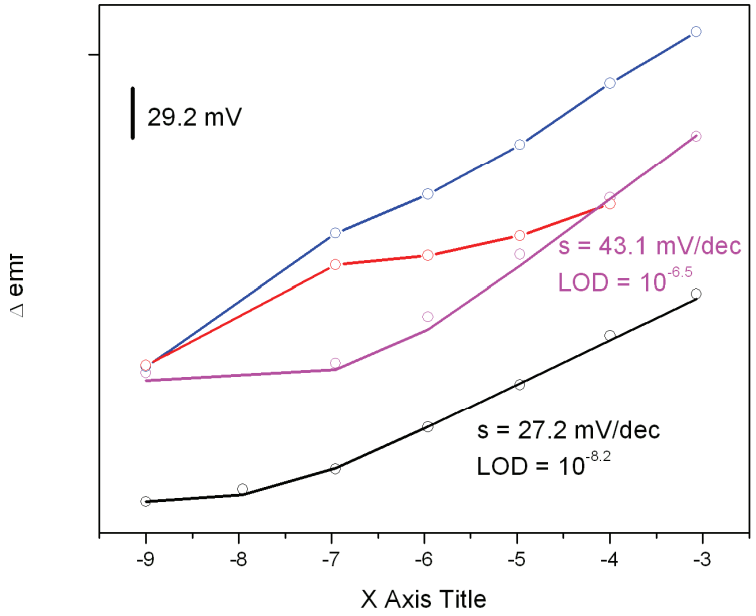
CLARITY
CENTRE FOR SENSOR WEB TECHNOLOGIES

UNIVERSITY COLLEGE DUBLIN
DUBLIN CITY UNIVERSITY
TYNDALL NATIONAL INSTITUTE

Biofouling

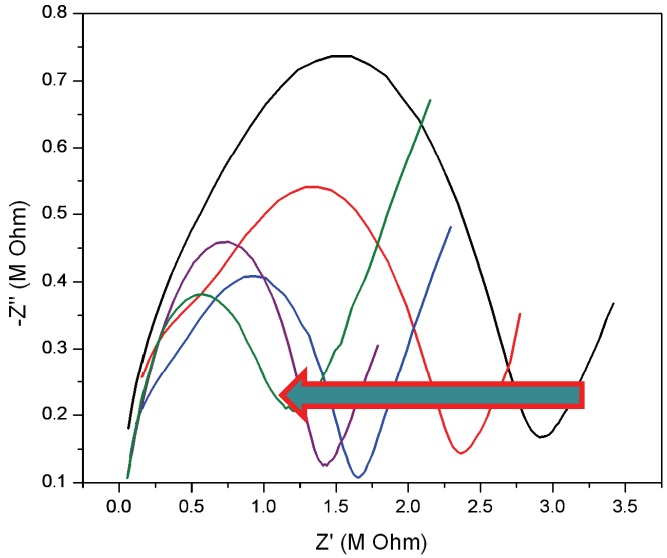


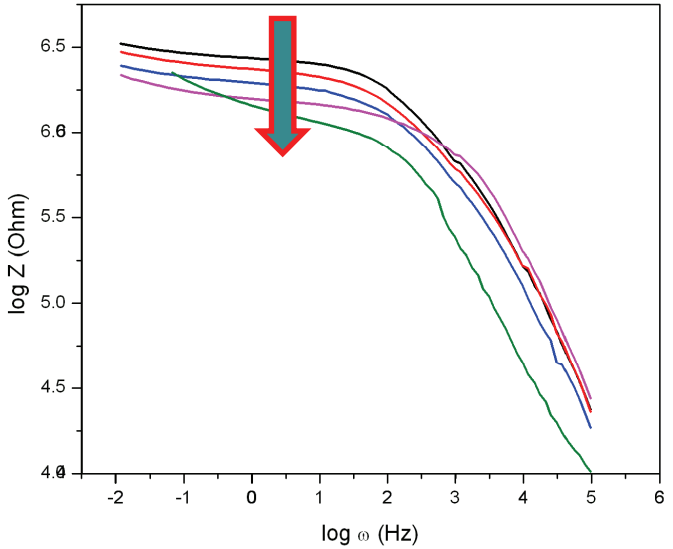


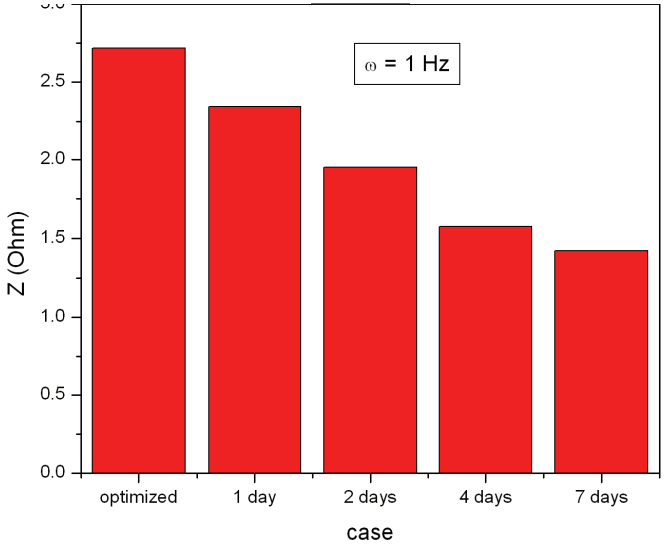


This work is supported by Science Foundation Ireland under grant 07/CE/I1147

Biofouling



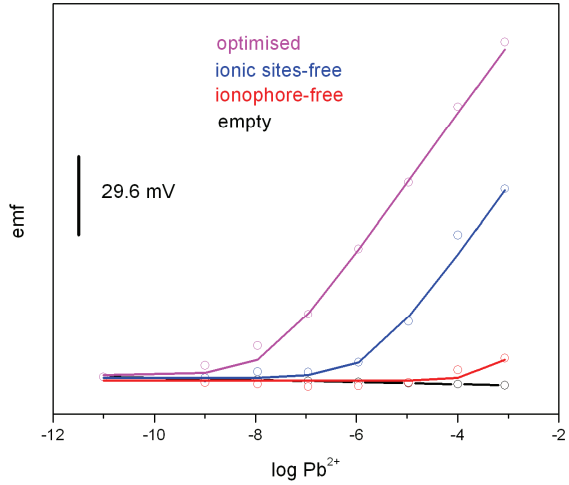


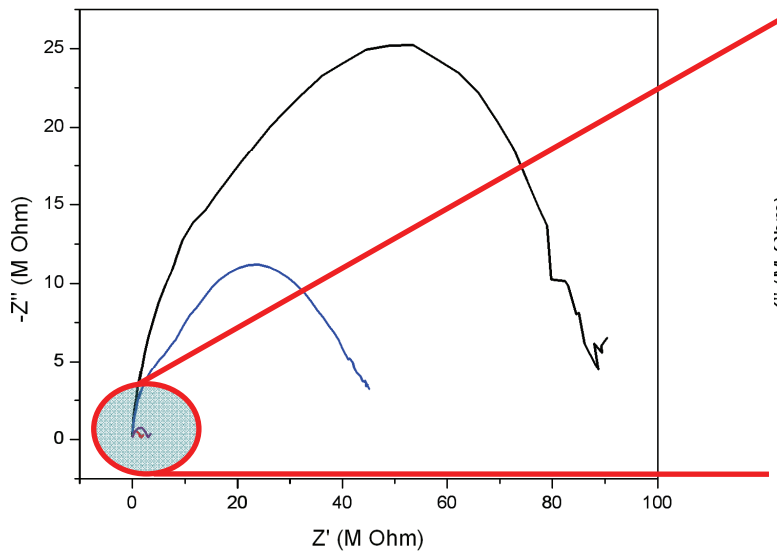


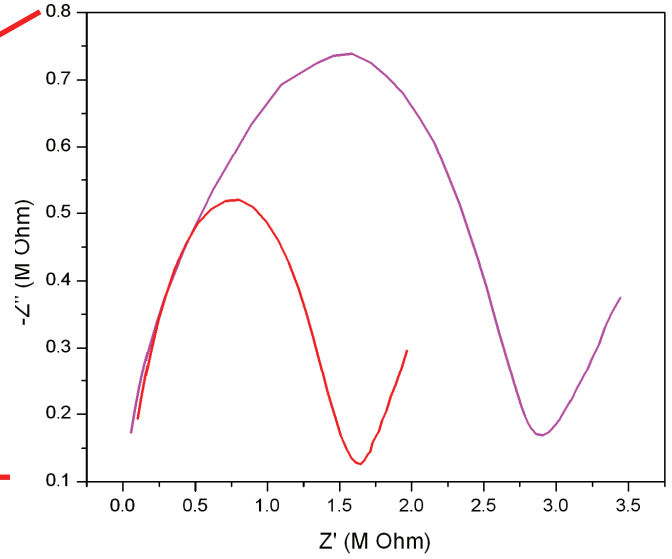
This work is supported by Science Foundation Irelar

UNIVERSITY COLLEGE DUBLIN
DUBLIN CITY UNIVERSITY
TYNDALL NATIONAL INSTITUTE

Leaching of membrane components

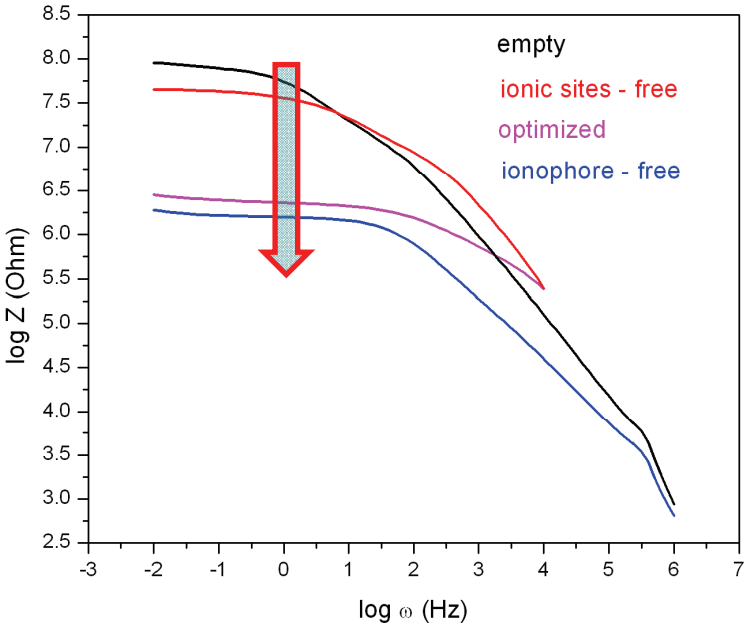


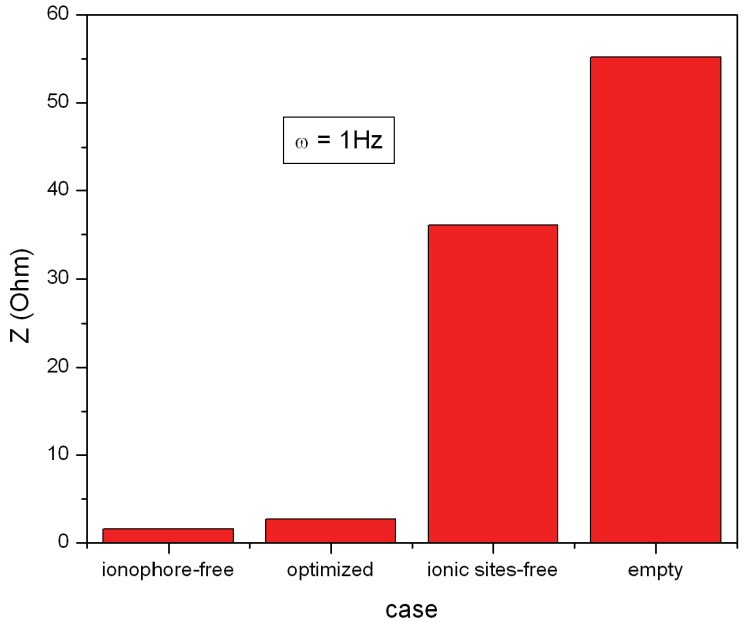




This work is supported by Science Foundation Ireland under grant 07/CE/I1147

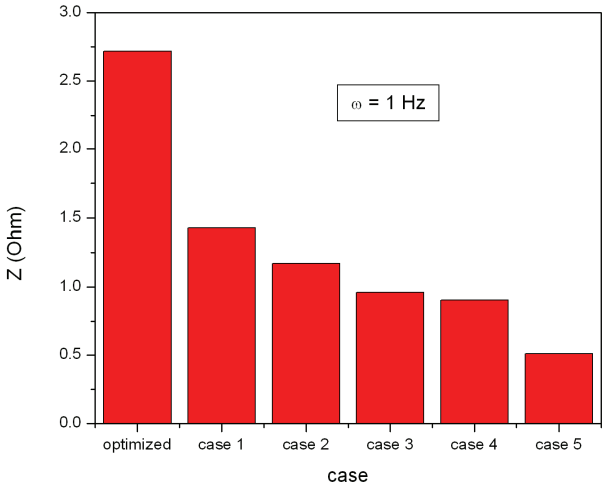
Leaching of membrane components

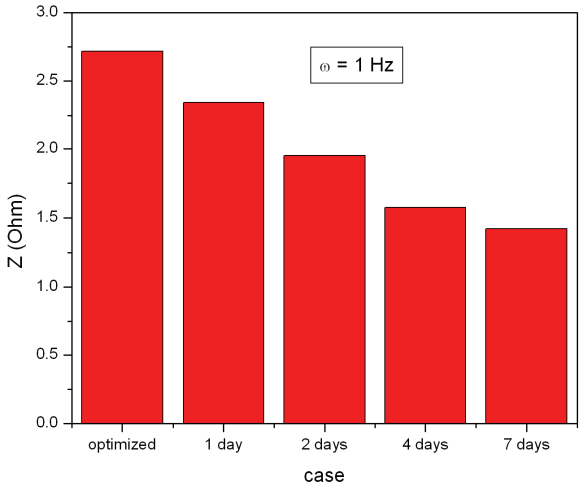


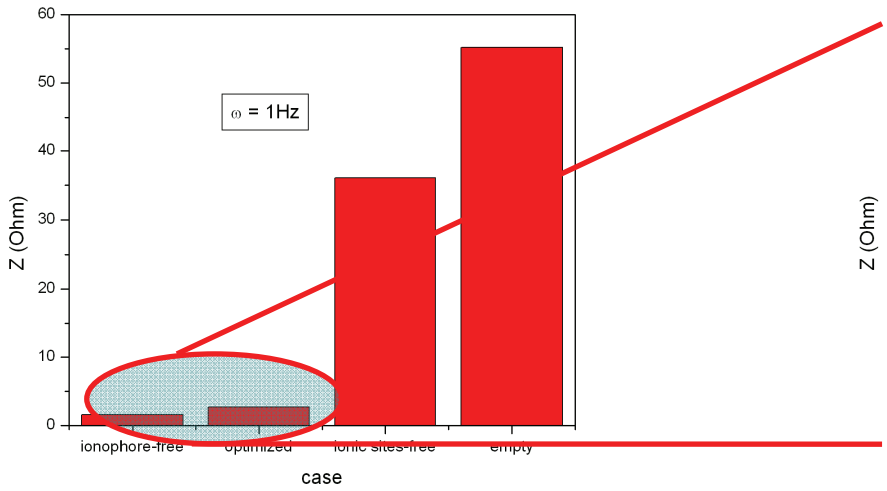


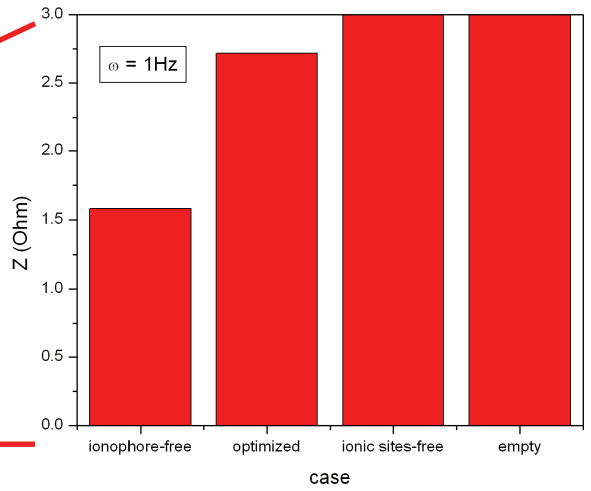
This work is supported by Science Foundation Ireland under grant 07/CE/I1147

Critical parameters for the diagnostic of sensor functionality









This work is supported by Science Foundation Ireland under grant 07/CE/I1147

Conclusions

- Using EIS enabled two important conclusions:
  - AC current can be used as a diagnostic tool for estimate functionality of ISEs (cases when physical damage, biofouling, leaching of components render ISEs non-functional)
  - Optimal current parameters (ω, amplitude) can be identified in order to design simple circuitry for evaluation of functionality of ISEs
- Severely damaged solid-contact ISEs continue to function albeit with loss of detection limit
- Biofouling is serious problem and require designing of methodology for storage and conditioning of ISEs in deployable sensing devices
- Methodology for the determination of concentration of membrane components using EIS could be designed

This work is supported by Science Foundation Ireland under grant 07/CE/I1147

UNIVERSITY COLLEGE DUBLIN
DUBLIN CITY UNIVERSITY
TYNDALL NATIONAL INSTITUTE

Acknowledgments

- Dr. Salzitsa Anastasova
- Prof. Dermot Diamond

- Dr. Beata Paczosa-Bator (AGH Krakow, Poland)
- Prof Marek Danielewski (AGH Krakow, Poland)

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

•DCU Research Career Start 2008;
•Enterprise Ireland (grant 07/RFP/MASF812)
MASTRA; FP6 MATERA-ERA-NET
•Science Foundation Ireland (grant 07/CE/I1147)

This work is supported by Science Foundation Ireland under grant 07/CE/I1147