Disposable Polymer Flow Cells with Screen Printed Electrodes for Voltammetric and Electrochemiluminescence (ECL) Applications

Zainab Mohammed Redha, Sara J. Baldock, Peter R. Fielden,

Nick J. Goddard, Bernard J. Treves Brown.

(University of Manchester)

Roberto Andres, Barry G. D.Haggett and Brian J. Birch

(Luton Institute of Reasearch in the Applied Natural Science)

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Overview

* Flow Cell Fabrication Process

* Electrochemical Evaluation of the Flow Cell Using Some Common Redox Systems

* Application of the Sensor for Anodic Stripping Voltammetry

* Application of the Sensor for the Electrochemiluminescence (ECL) of Luminol

* Application of the Sensor for the Stripping-ECL Determination of Metal Ions

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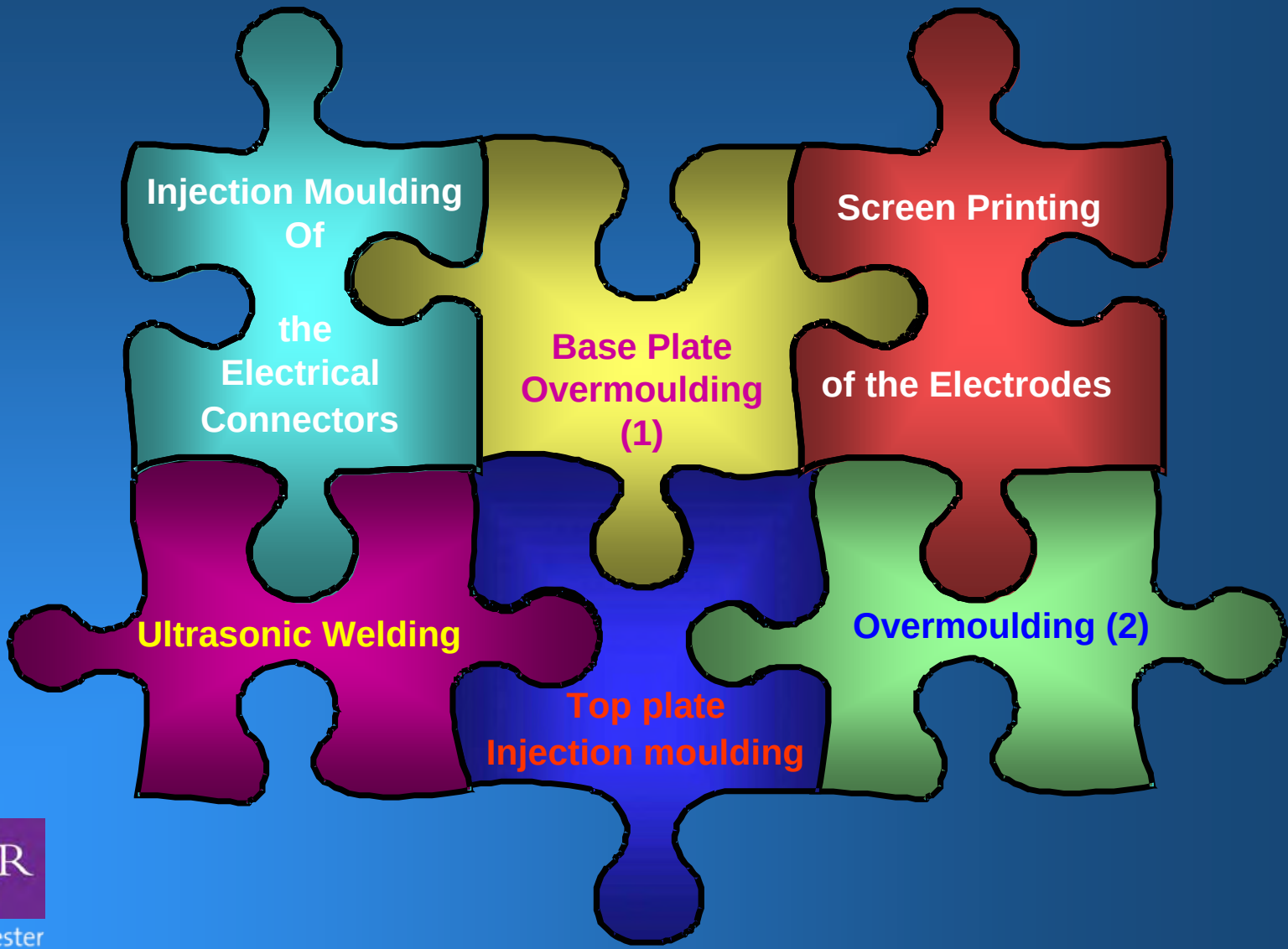
Fabrication Process of the Electrochemical Flow Cell



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Fabrication Process of the Electrochemical Flow Cell

AutoCAD Design

* Creating a 3D solid model of the connectors using AutoCAD.

* Then converting it into macro commands using EdgeCAM 10.5 for a CNC milling machine

CNC Milling

*Blocks of aluminium (75 mm x 75 mm x 10 mm)
*Milled using micrograin tungsten-carbide 2 flute routers

Fixed Part

Moving Part

Mould Cavity for the Electrical Connectors

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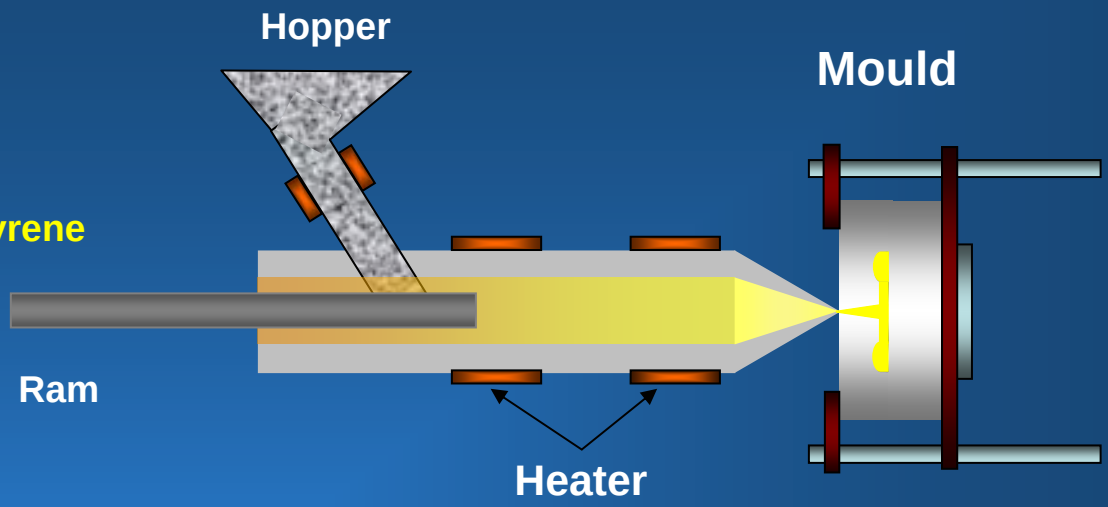
Fabrication Process of the Electrochemical Flow Cell

Injection Moulding Of the Electrical Connectors

Carbon Fibre Loaded (40%) Polystyrene

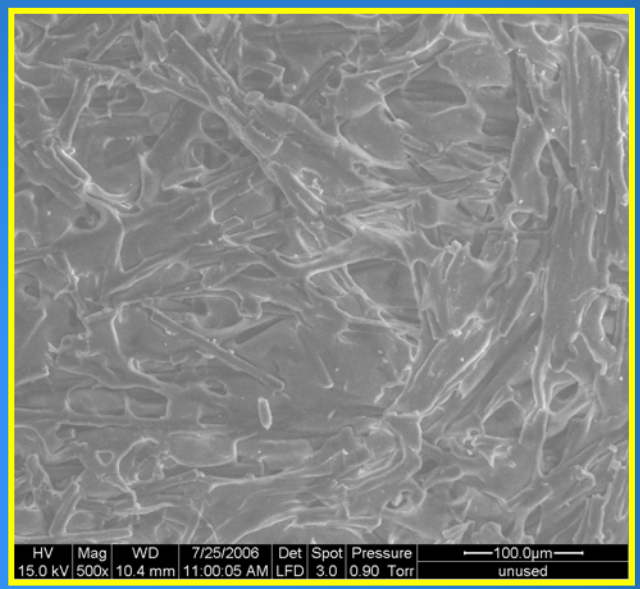


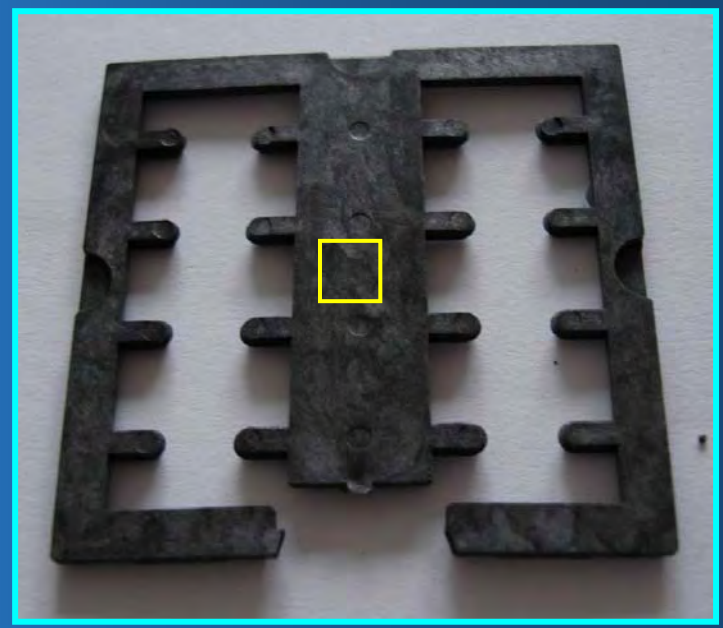
Contains carbon fibres:

Length 100-150 µm

Diameter 7 µm.

SEM Image of
Carbon Fibre Loaded (40%) Polystyrene





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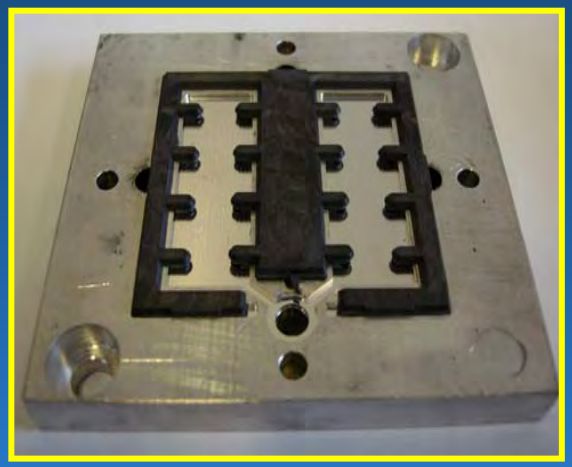
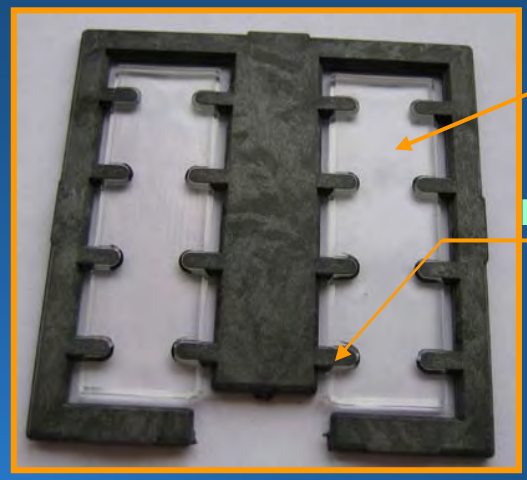
Fabrication Process of the Electrochemical Flow Cell

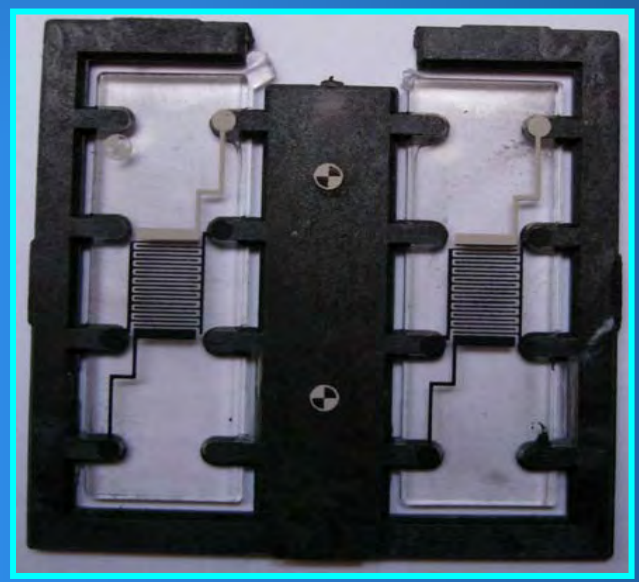
Base Plate Overmoulding(1)



Overmoulding with Zeonor



Carbon
(C2000802P2)
Platinised Carbon
(C2000511D1)
(60/40) Silver/Silver Chloride Paste
(C61003P7)



Screen Printing

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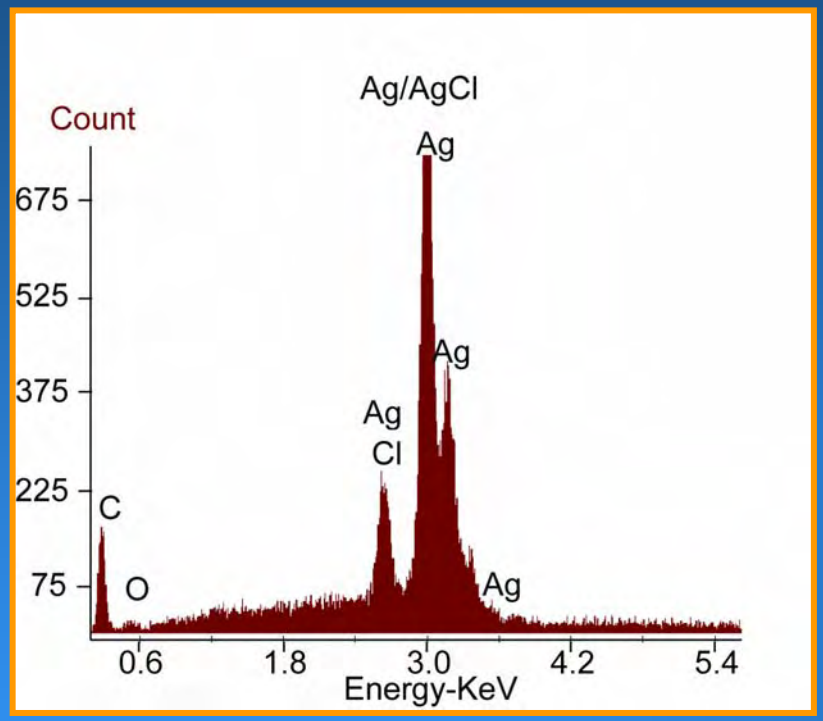
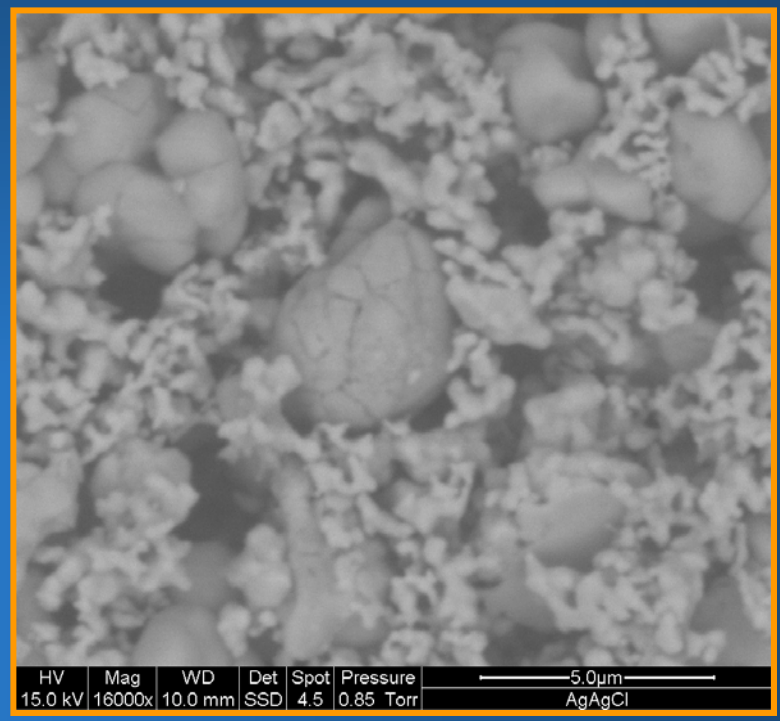
Fabrication Process of the Electrochemical Flow Cell

Screen Printing





SEM Image of (60/40) Silver/Silver Chloride Paste and the Corresponding EDX Spectra

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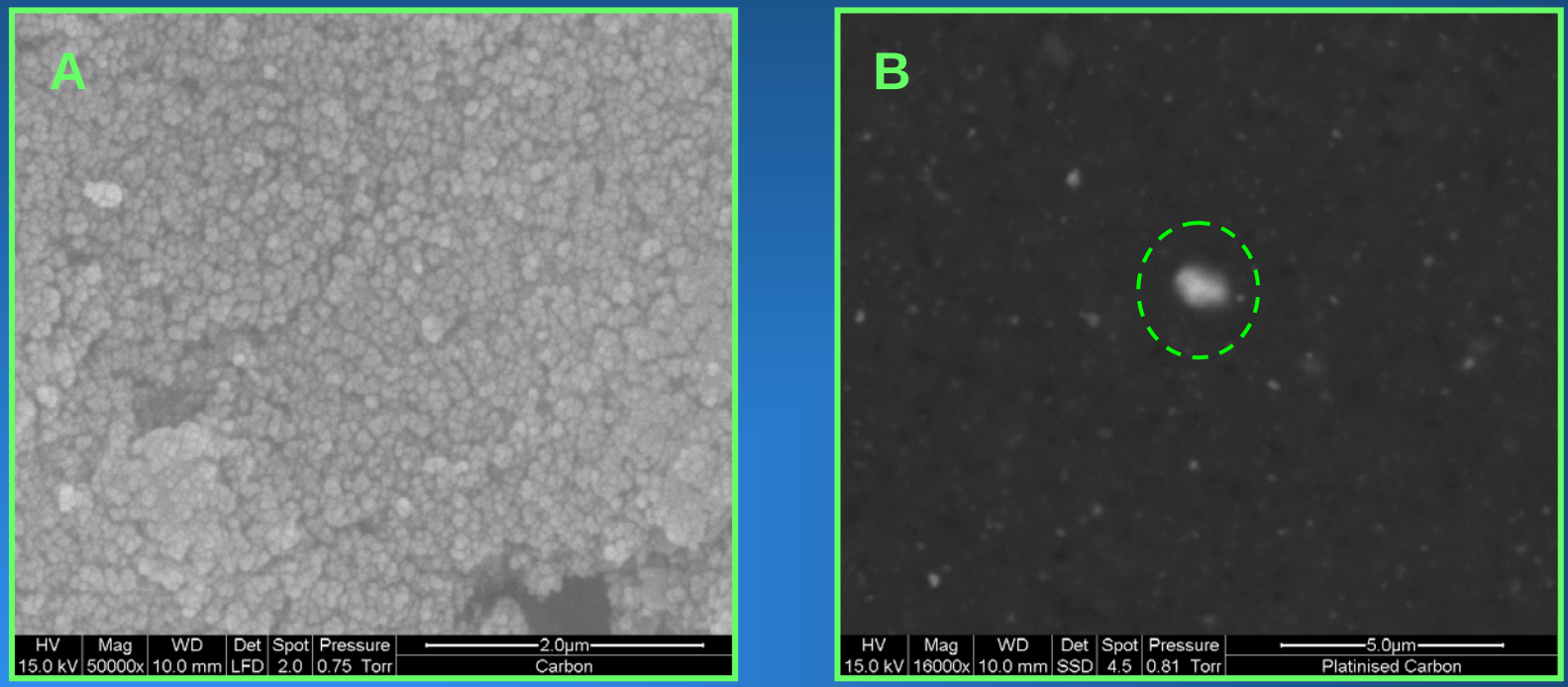
Fabrication Process of the Electrochemical Flow Cell

Screen Printing



SEM Images of A) Carbon, and B) Platinised Carbon Inks

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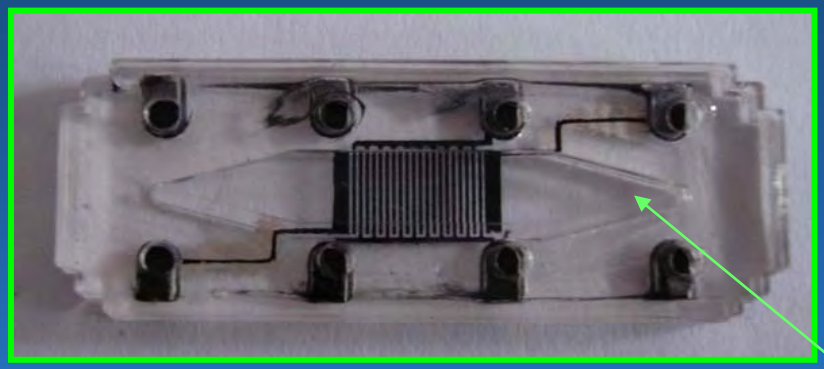
Fabrication Process of the Electrochemical Flow Cell

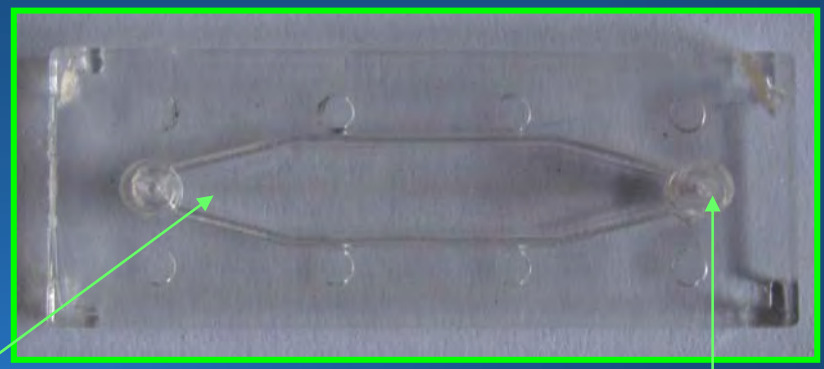
Base Plate Overmoulding (2)



Overmoulding with Zeonor

Flow Channel

Top Plate Injection Moulding



Top Plate

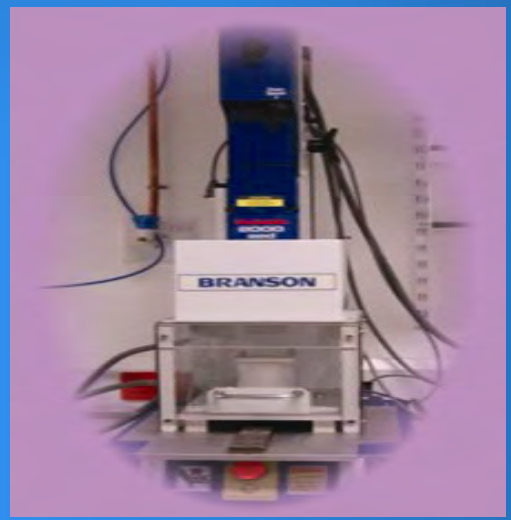
Fluidic Connectors

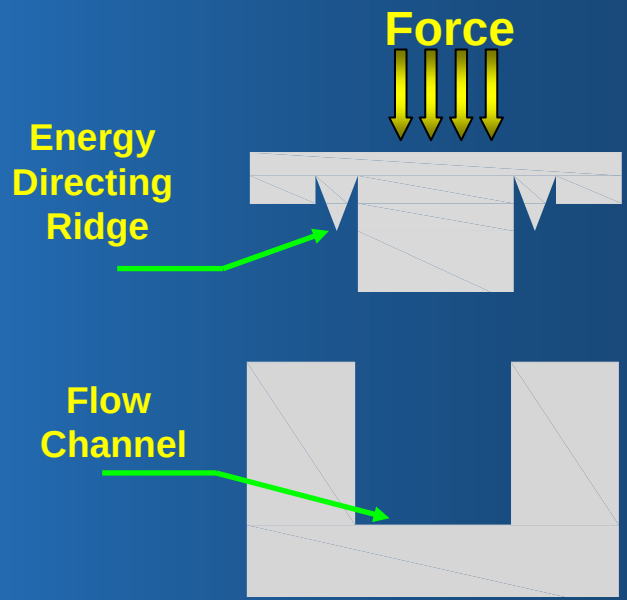
Ultrasonic Welding

Welding Conditions:

Collapse Distance 0.25 mm

Hold Time 3 s





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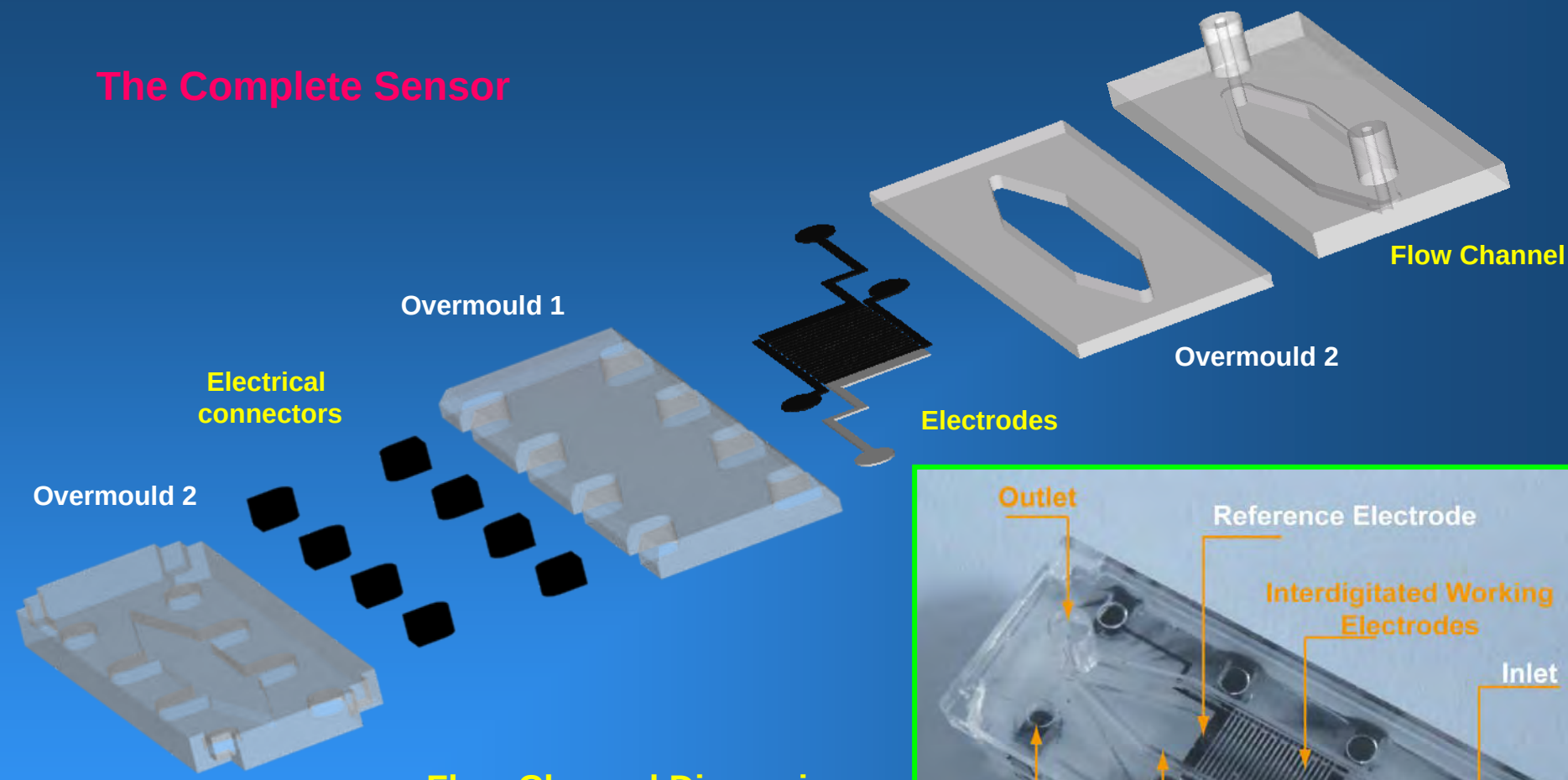
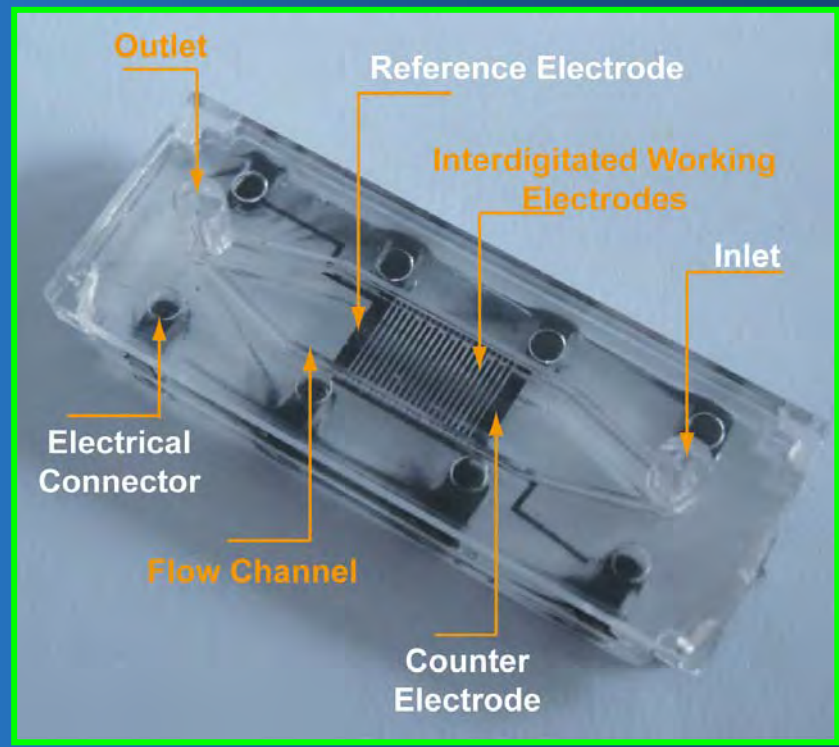
Fabrication Process of the Electrochemical Flow Cell

The Complete Sensor





Flow Channel Dimensions:

Width: 5mm

Length: 30mm

Depth: 100µm

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Electrochemical Evaluation of the Flow Cell Using Some Common Redox Systems

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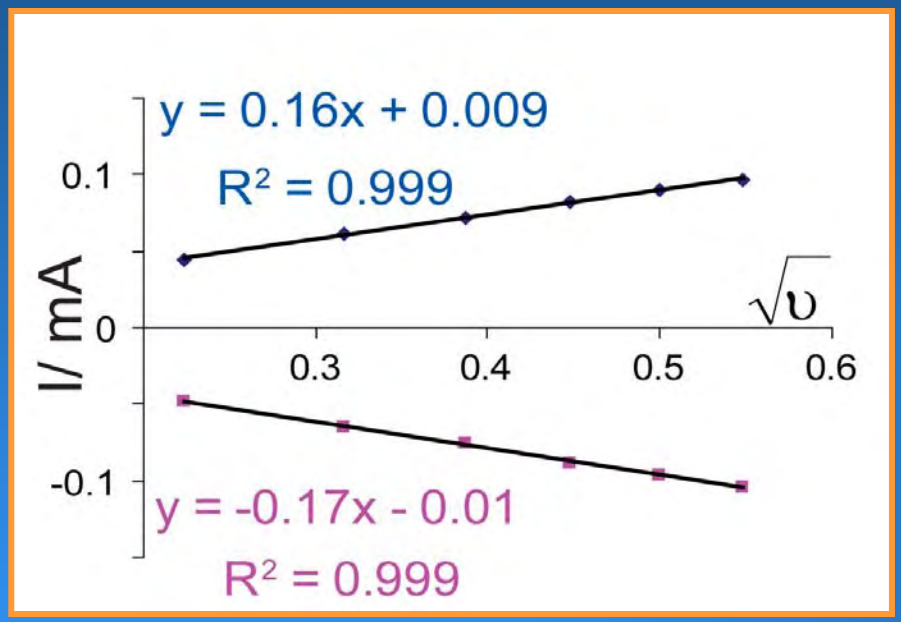
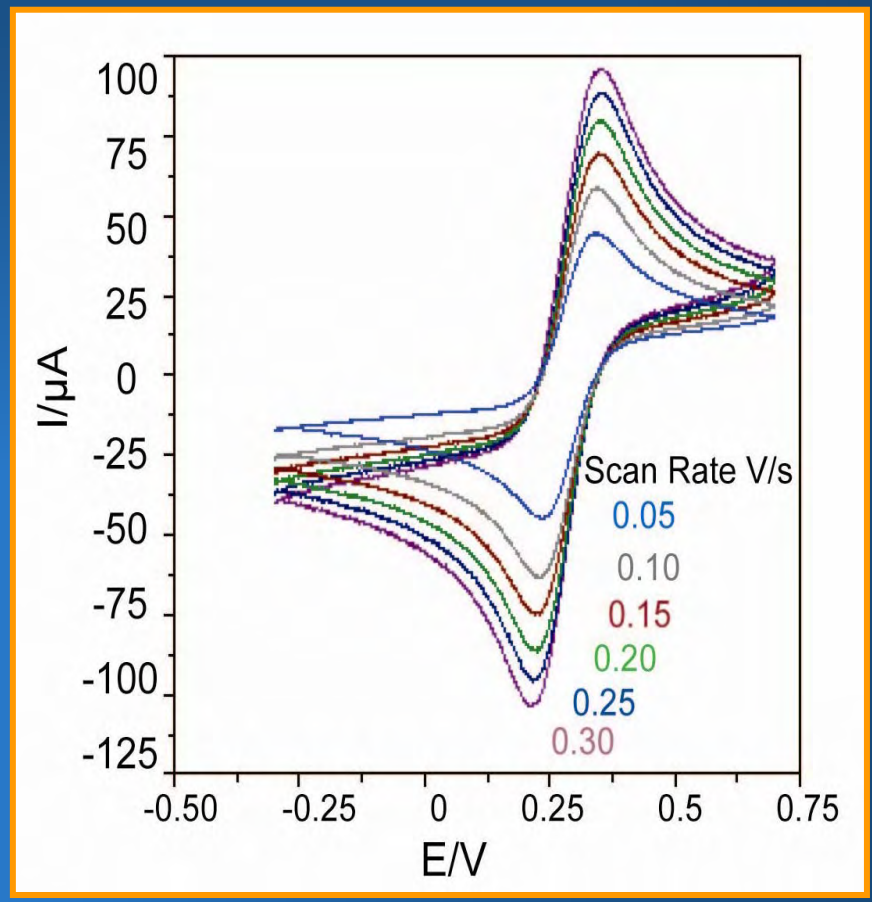
Electrochemical Evaluation of the Flow Cell

Cyclic Voltammetry of Potassium Ferricyanide





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Effect of Scan Rate on 3 x10^{-3} M Potassium Ferricyanide in 0.1 M KCl (vs.Ag/AgCl RE).
Initial & final potential -0.3 V , Vertex 0.7 V.

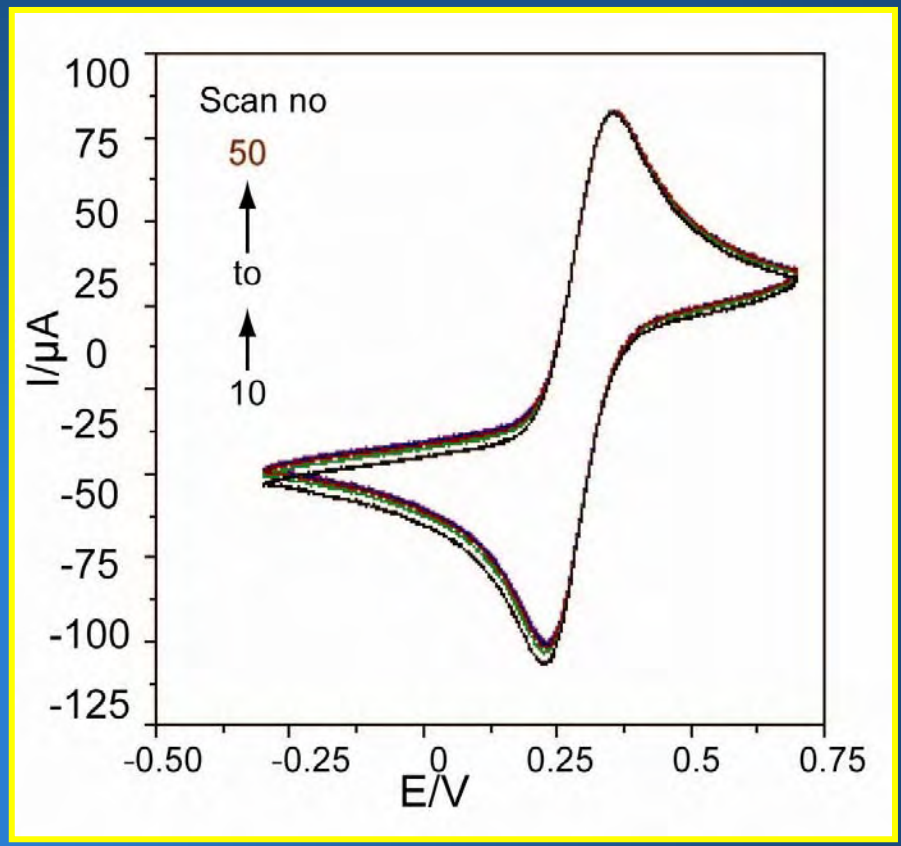
Electrochemical Evaluation of the Flow Cell

Cyclic Voltammetry of Potassium Ferricyanide

Scan Stability

50 scans
saved every 10th

%RSD of Peak Heights:
3.4% forward, and 2.8% reverse



3 x10^{-3} M Potassium Ferricyanide in 0.1 M KCl (vs. Ag/AgCl RE).
Initial & final potential -0.3 V , Vertex 0.7 V.
Scan rate 0.2 V/s

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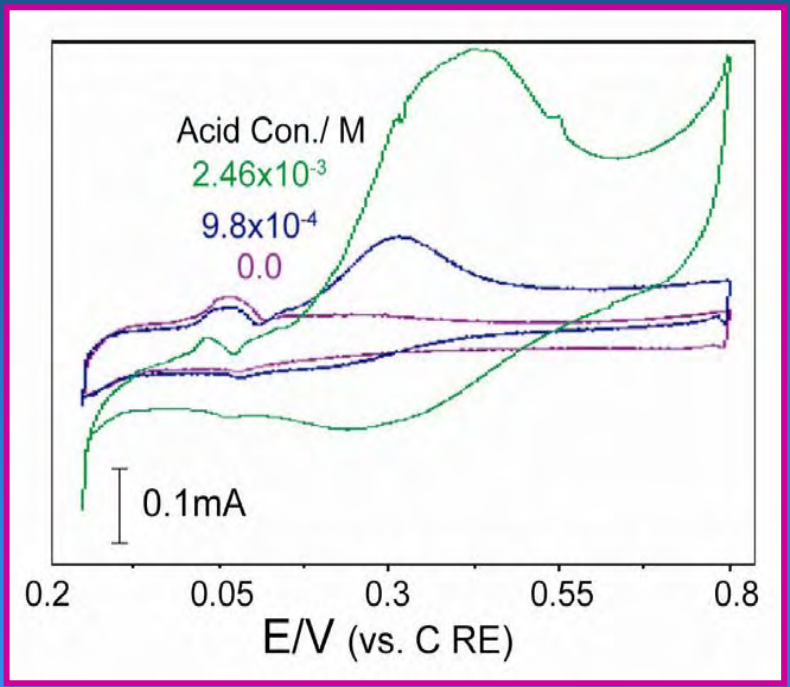
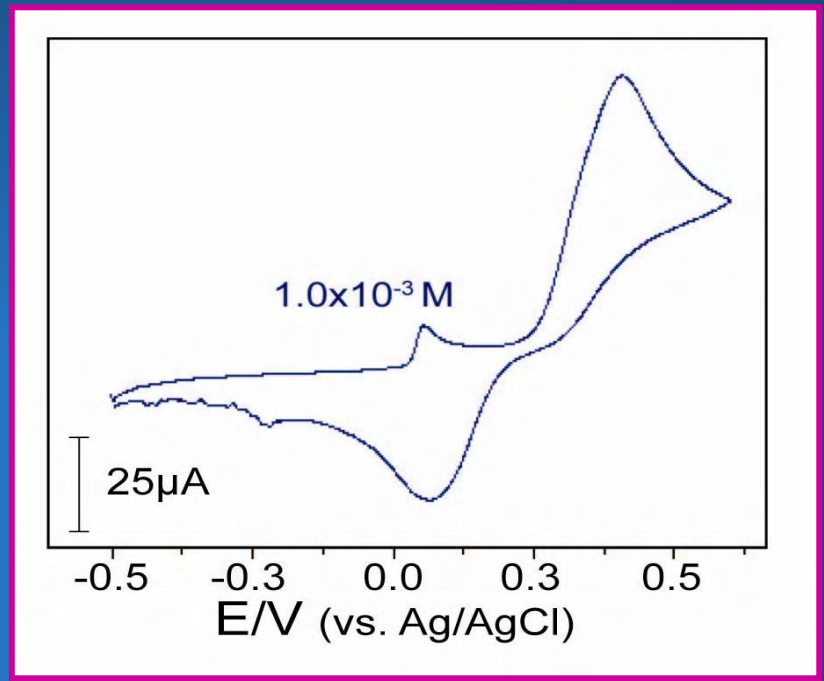
Electrochemical Evaluation of the Flow Cell

Cyclic Voltammetry of Ascorbic Acid



Peak potentials 0.303 V and 0.239 V

Cyclic Voltammetry of Hydroquinone



Peak Potentials −0.069 and 0.401 V
Peak Separation of 0.47 V.

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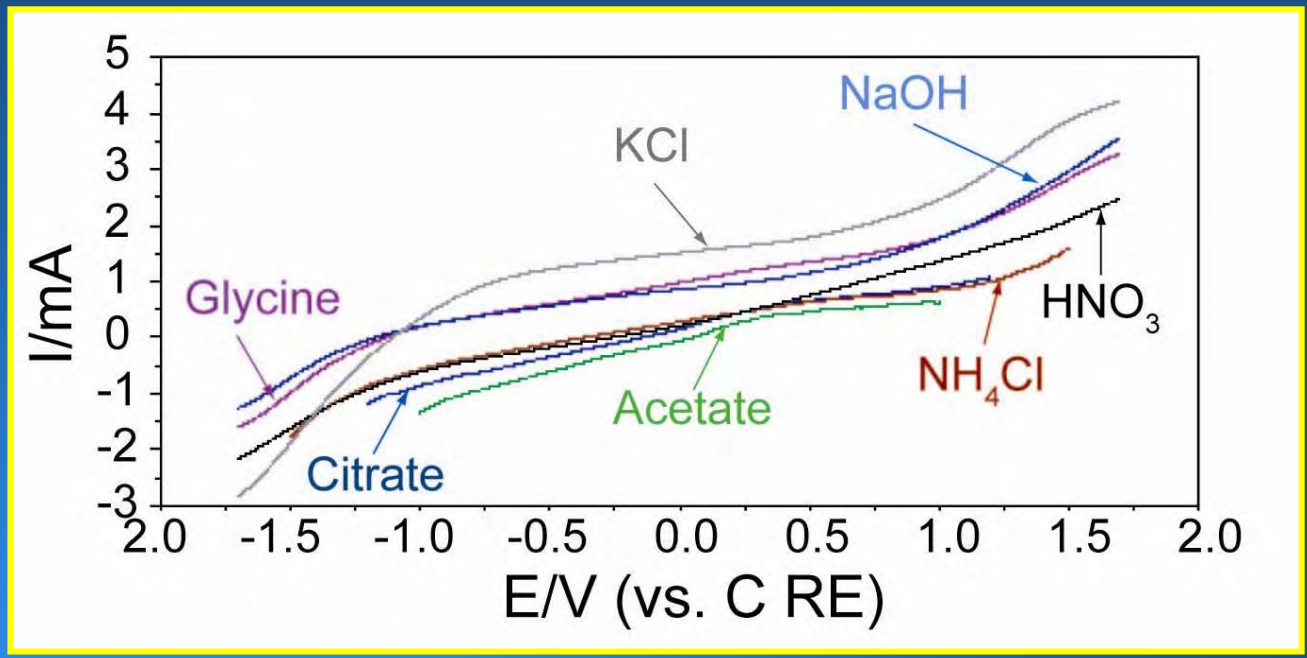
Supporting Electrolyte 0.1 M HCl.
0.15 V/s Scan Rate.

Accessible Potential Window of the Screen Printed Carbon WE



Linear Sweep Voltammetry scanned at 0.3 V/s.

0.1 M Electrolyte Concentration

Glycine and Ammonium Chloride pH9

Sodium Hydroxide pH 12

Acetate Buffer pH 4.6

Citrate Buffer pH 2.5

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Application of the Sensor for Anodic Stripping Voltammetry

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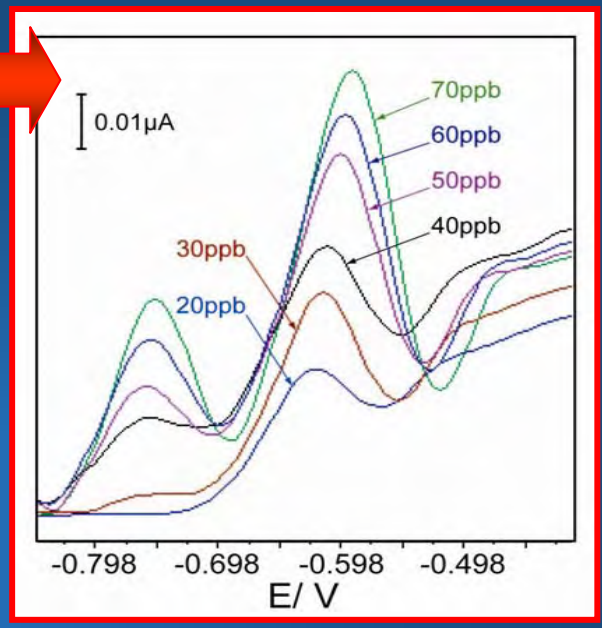
Application of the Sensor for Anodic Stripping Voltammetry

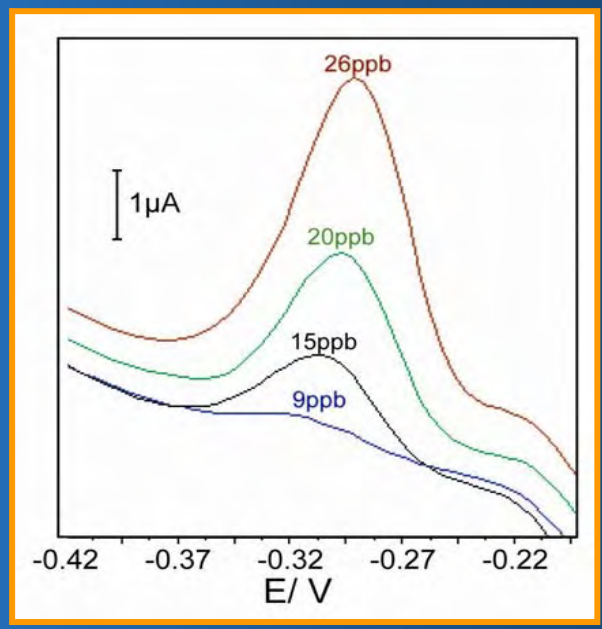
Pb (II)

SWASV of Pb (II) in pH 9 glycine buffer. Deposition at -0.8 V for 300 s



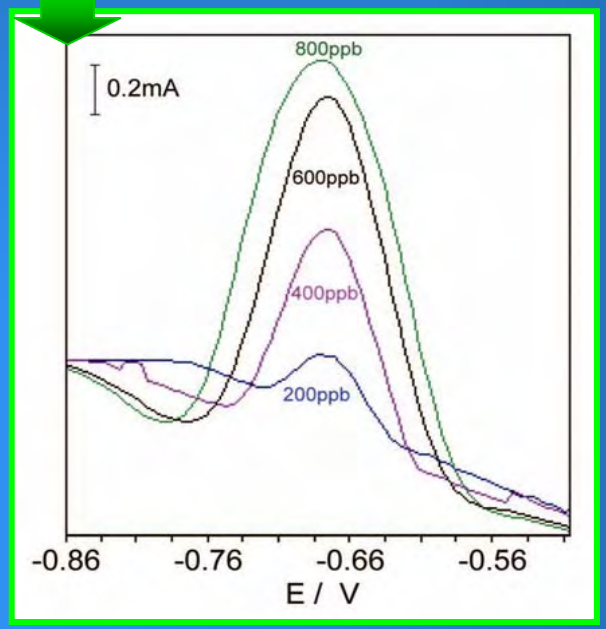
Cu (II)

DPASV of Cu (II) in 0.1 M nitric acid. Deposition at -0.6 V for 500 s



Cd (II)

DPASV of Cd (II) in pH 9 ammonium citrate buffer. Deposition at -1.2 V for 120 s



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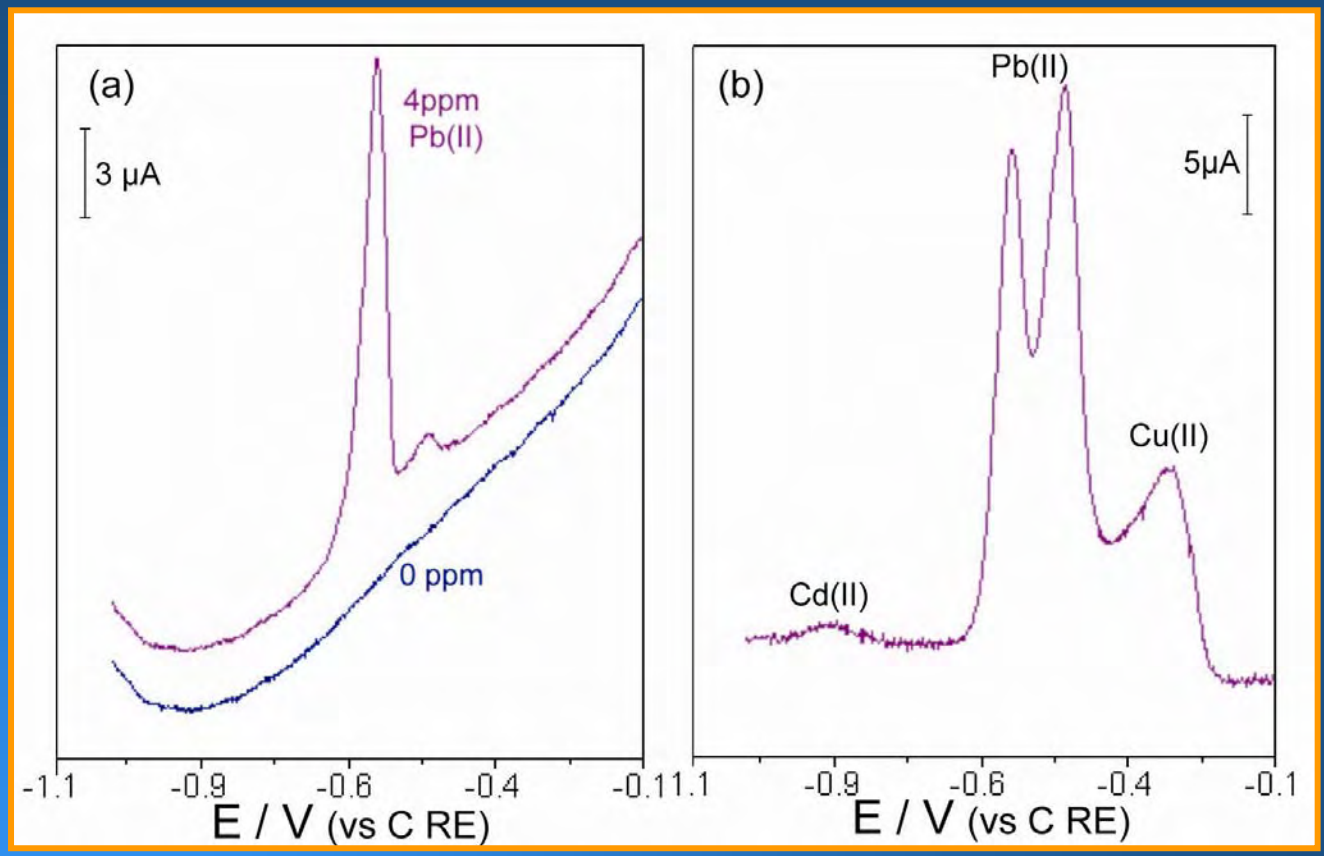
Application of the Sensor for Anodic Stripping Voltammetry



SWASV of :
a) Pb (II)
in pH 4.6 acetate buffer.

Preconcentration at:
a) -1 V for 90 s

SWASV of :
b) Cu (II), Pb (II) and Cd (II)
in pH 4.6 acetate buffer.

Preconcentration at:
b) -1.2 V for 120 s

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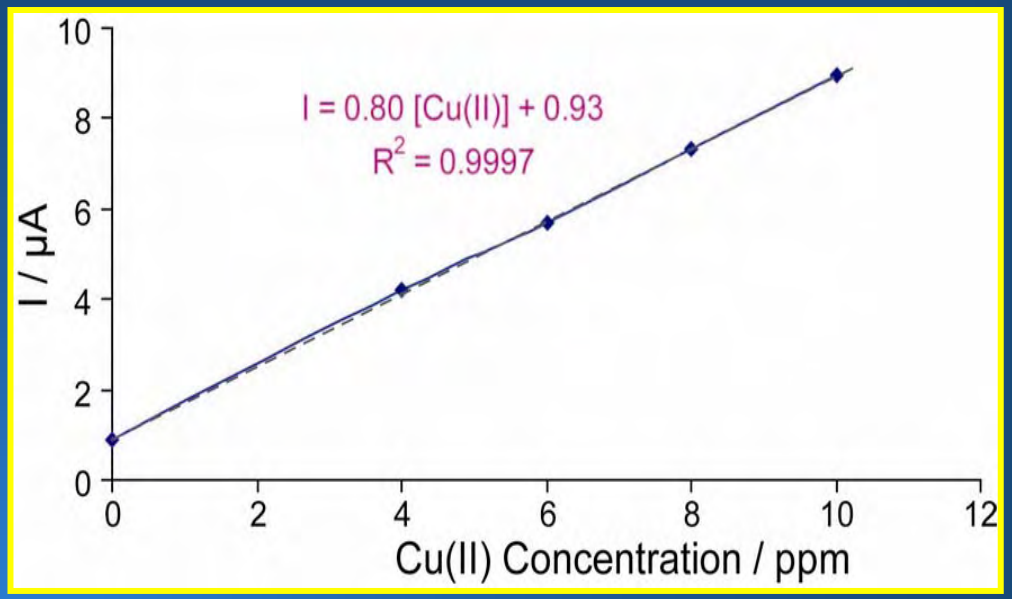
Application of the Sensor for Anodic Stripping Voltammetry

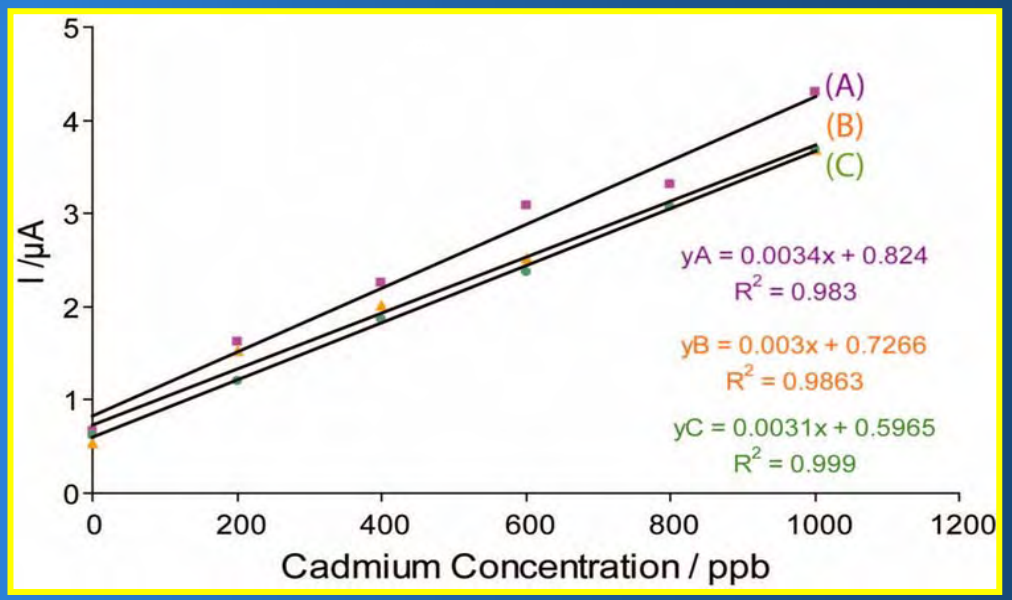
Copper (II) in Industrial Waste Sample

DPASV in Glycine Buffer.
Deposition at
-1 V for 60 s.
Calculated concentration 2.33±18.8%



Cadmium (II) Spiked in Lake Water Sample

DPASV in Ammonium Citrate Buffer.
Deposition at
-1.2 V for 60 s
Average Recovery 113%



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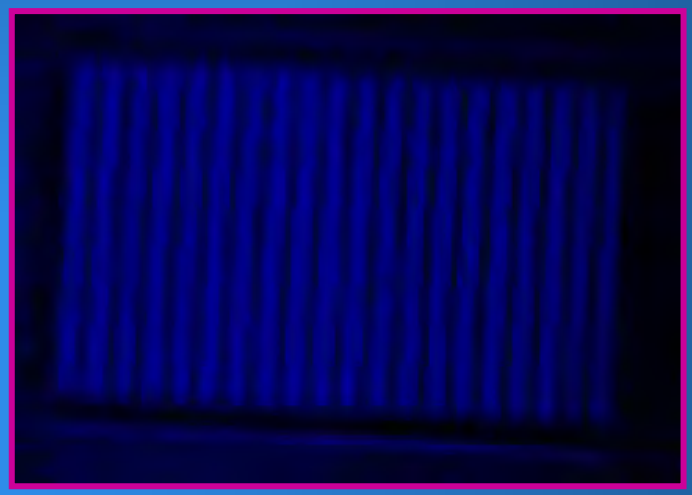
Application of the Sensor for the Electrochemiluminescence of Luminol



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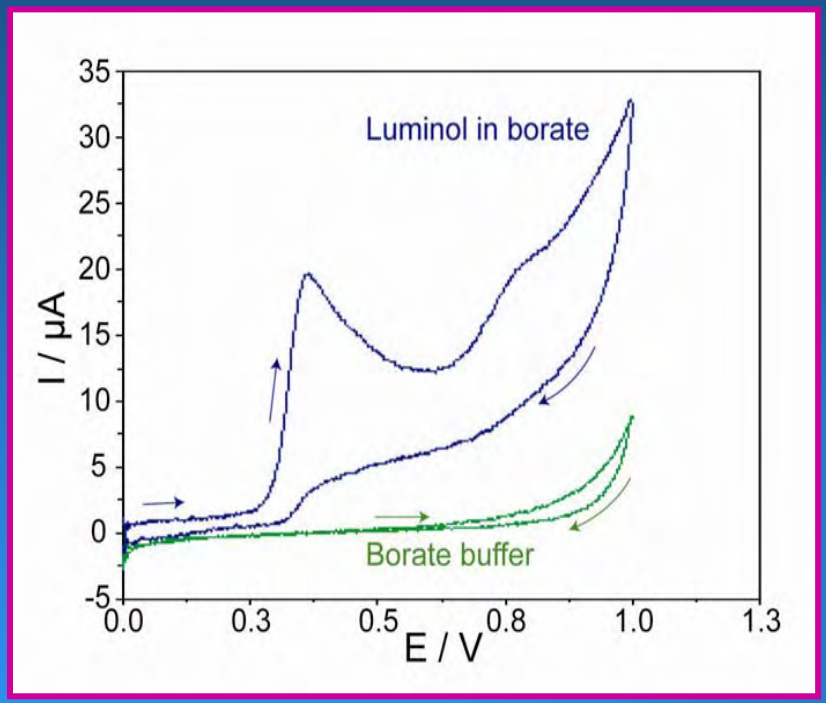
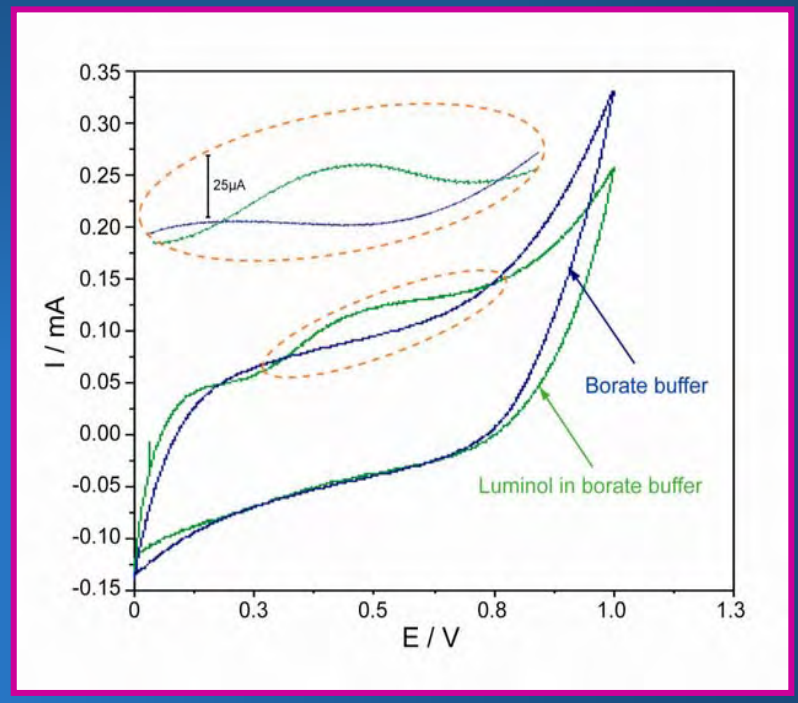
Application of the Sensor for the ECL of Luminol

Carbon WE



Platinised Carbon



Luminol Oxidation 0.36 V
Luminol Reduction 0.31 V

Luminol Oxidation 0.46 V

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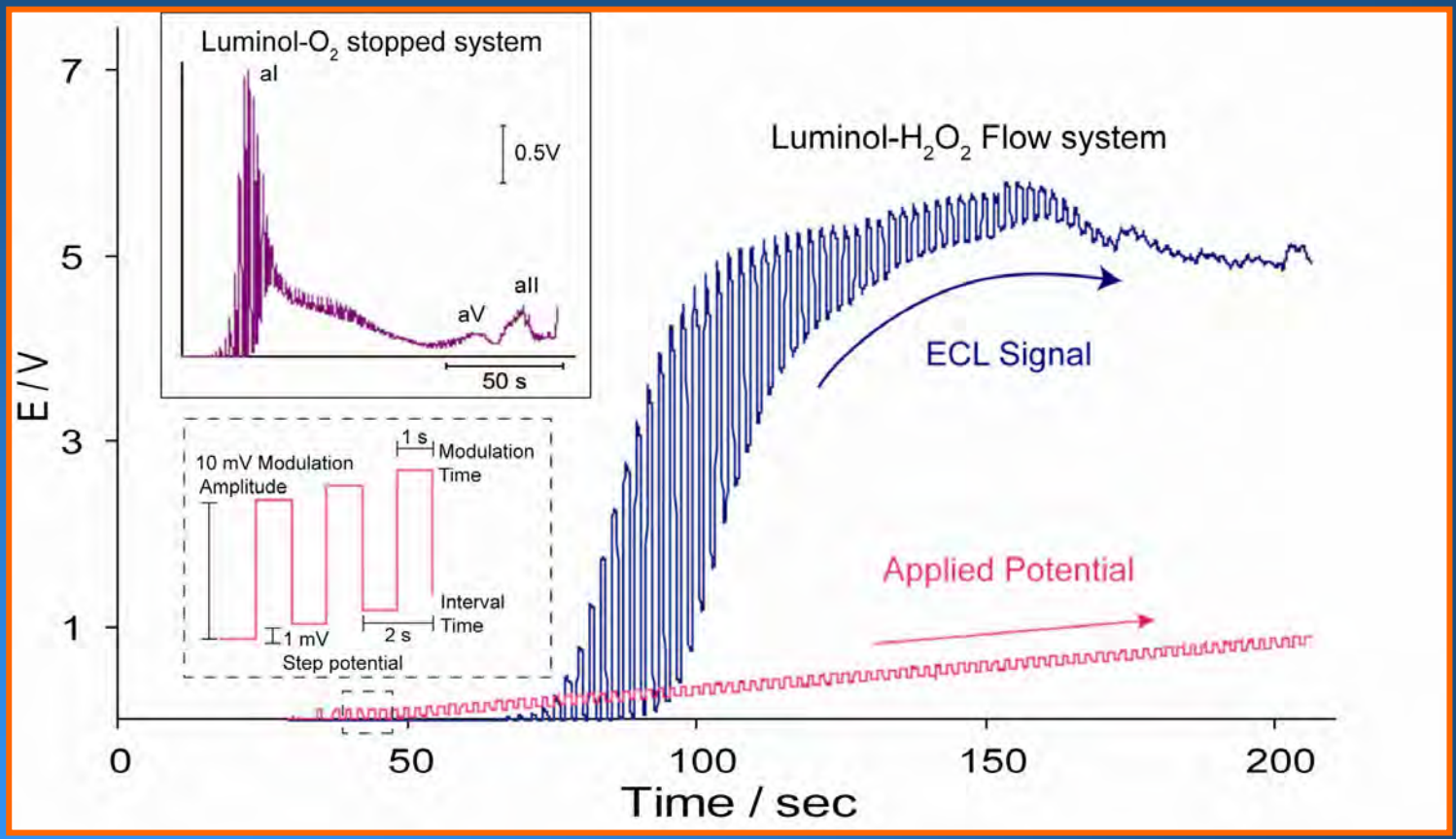
$1x10^{-3}$ M Luminol

$2x10^{-4}$ M Luminol

in Borate buffer pH 9 scanned at 0.15 V/s

Application of the Sensor for the ECL of Luminol

Carbon WE



Time-Dependence of the Potential Under DPV Conditions and the Corresponding ECL Response.

$2x10^{-4}$ M luminol with or without 0.05 M H_2O_2 solution in borate buffer pH 9 containing 0.1 M NaCl

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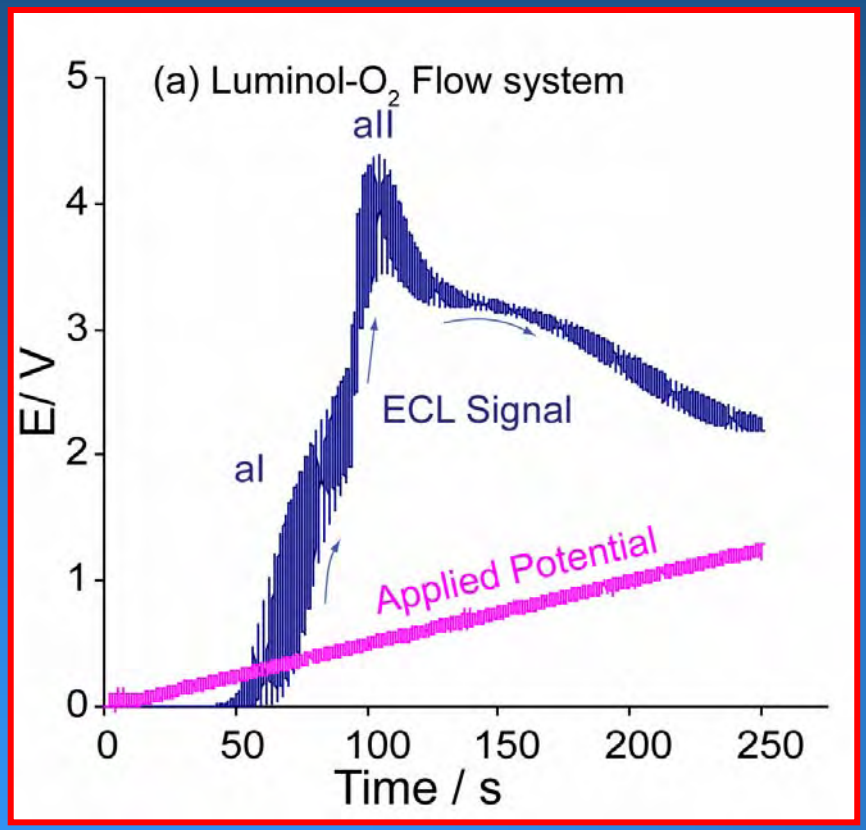
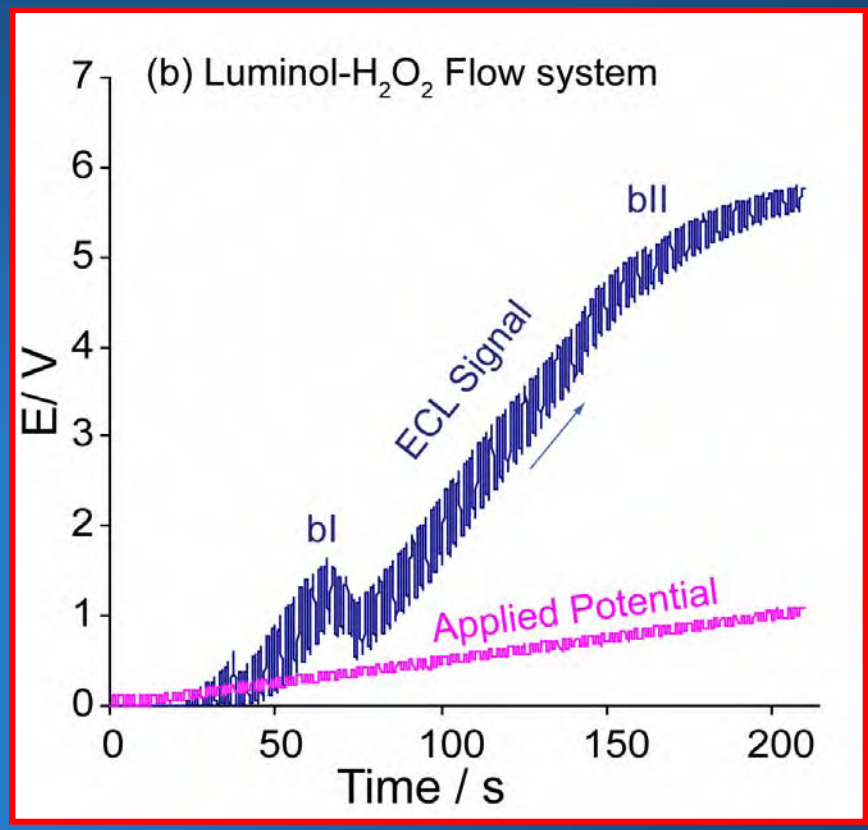
Application of the Sensor for the ECL of Luminol

Platinised Carbon WE





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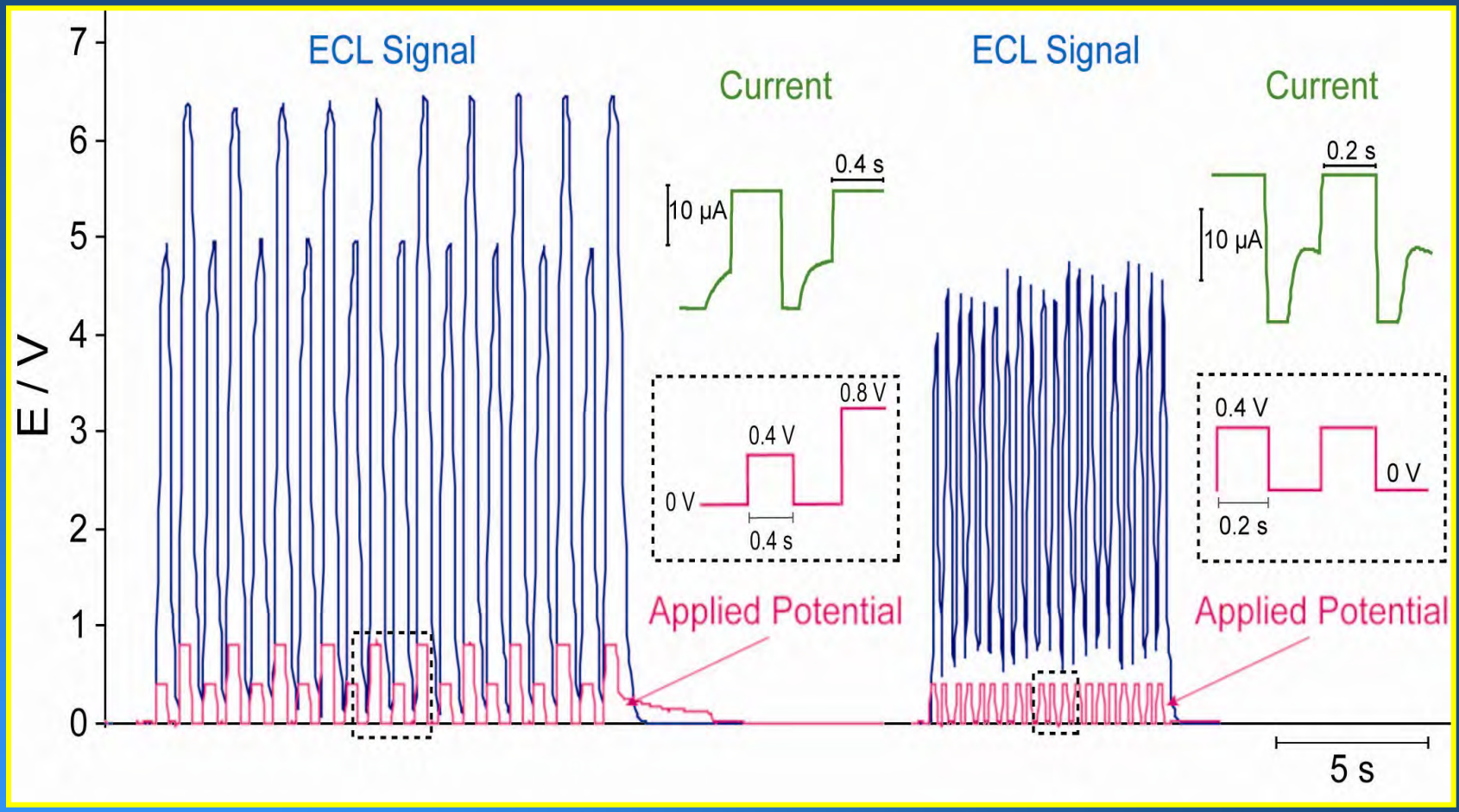
Application of the Sensor for the ECL of Luminol



Time Course Step Potentials and the Corresponding ECL Response of the Luminol-H_2O_2 System.

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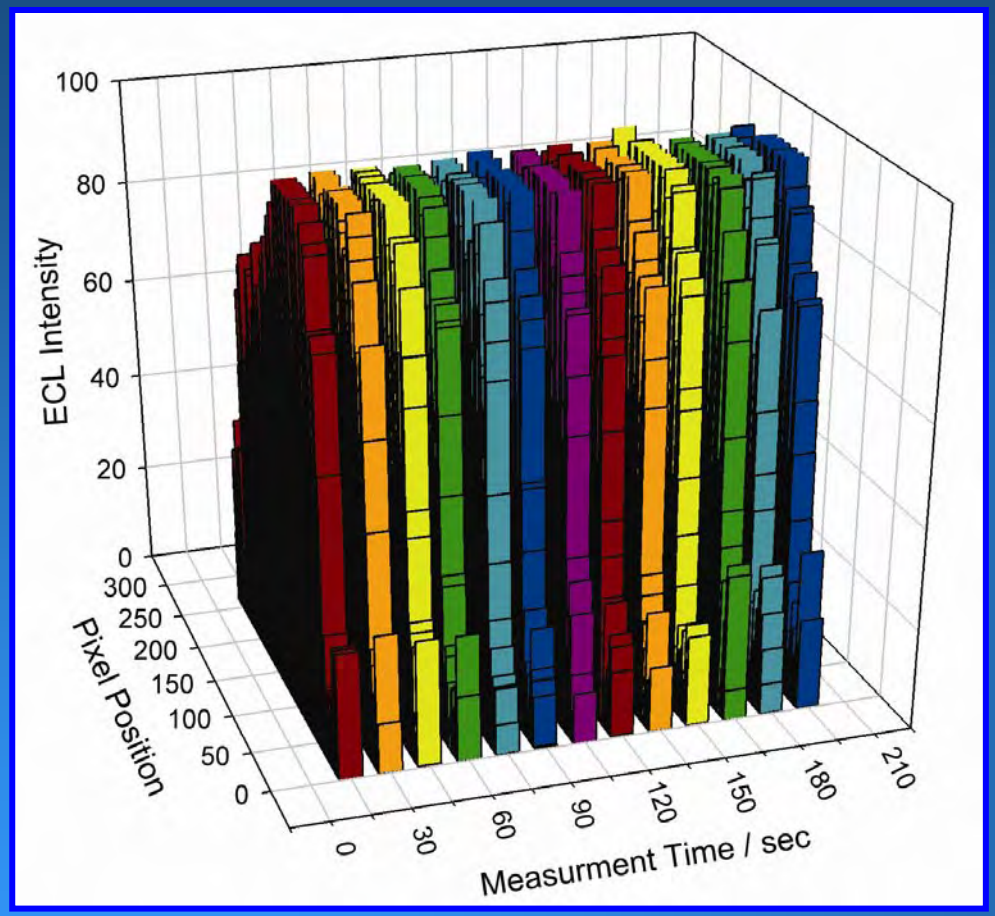
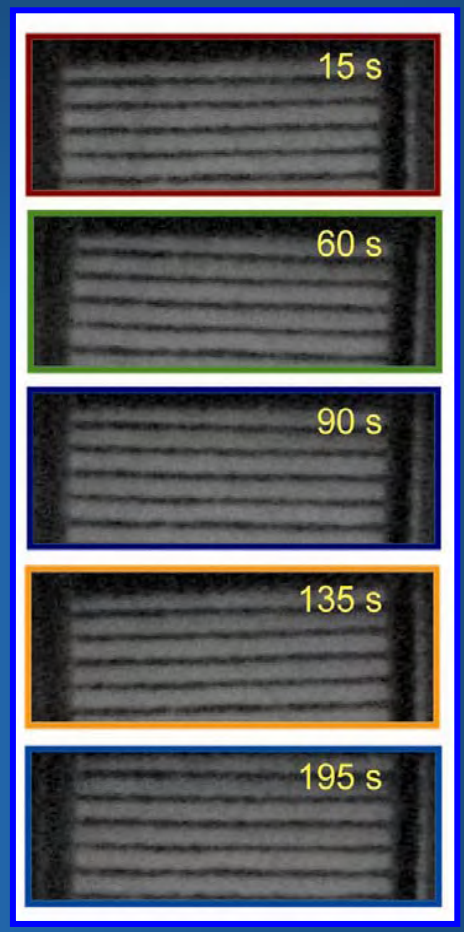
Application of the Sensor for the ECL of Luminol





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The Stability of the ECL Emission With Time for The Luminol-H_2O_2 System

Application of the Sensor for the Stripping ECL Determination of Metal Ions

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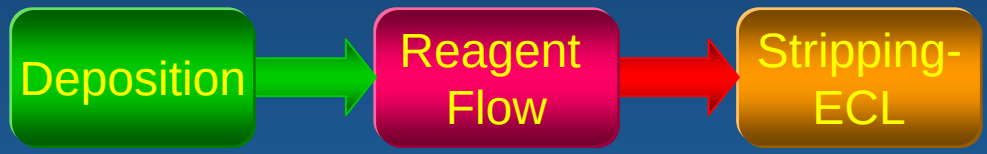
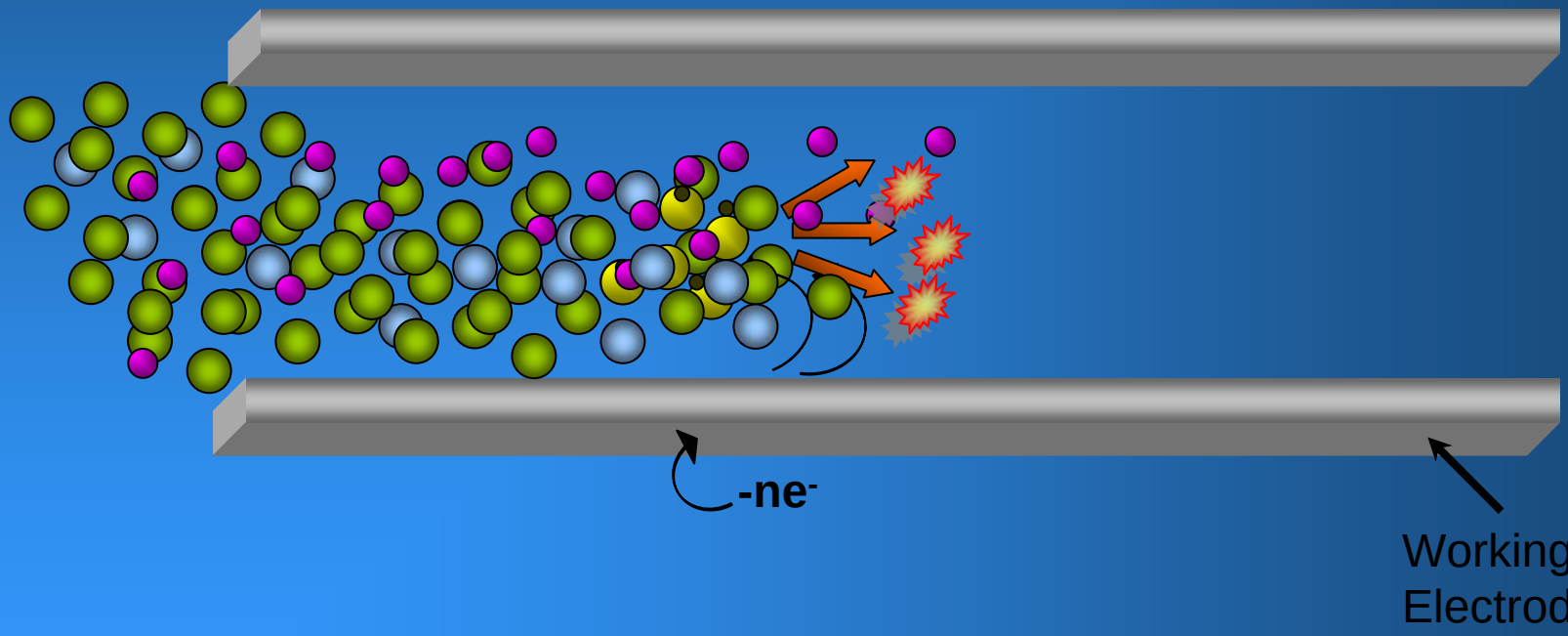
Application of the Sensor for the Stripping ECL Determination of Metal Ions





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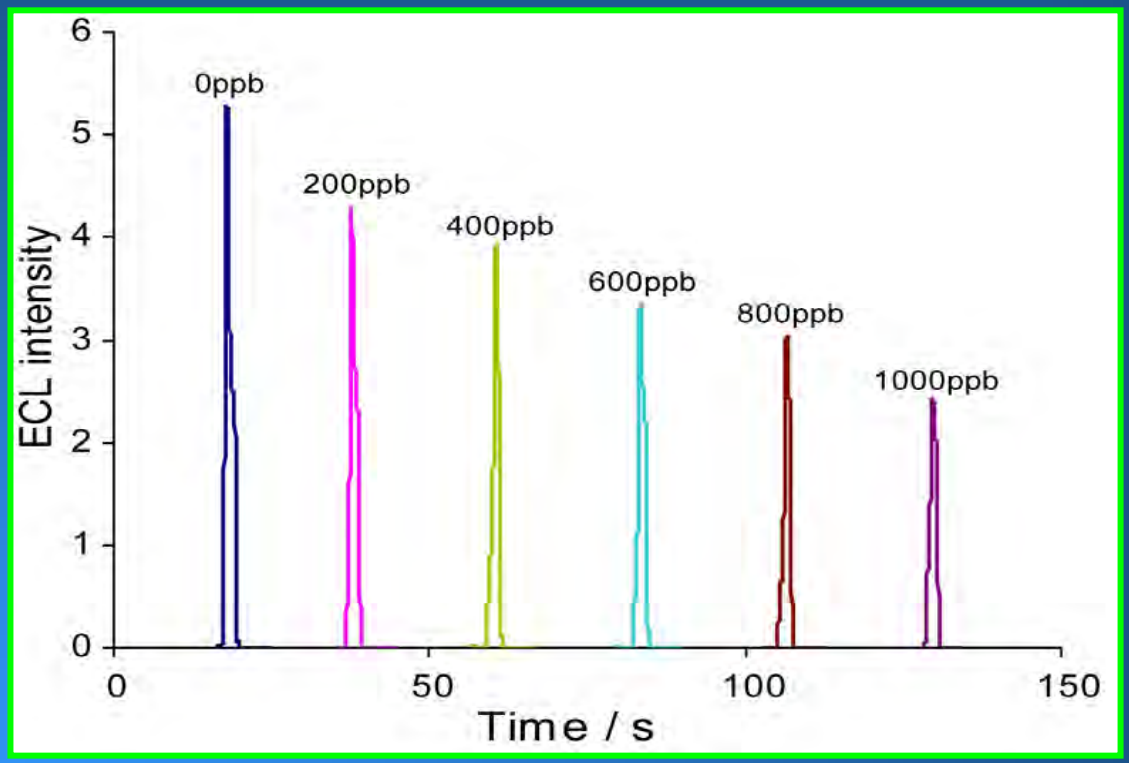
Analyte
ECL Reagents
Electrolyte
Luminol Radicl

Application of the Sensor for the Stripping ECL Determination of Metal Ions

Copper (II) Luminol- H_2O_2 System



Deposition in Glycine Buffer at
-0.7 V for 60 s
ECL in Glycine Buffer at
0.6 V for 2 s

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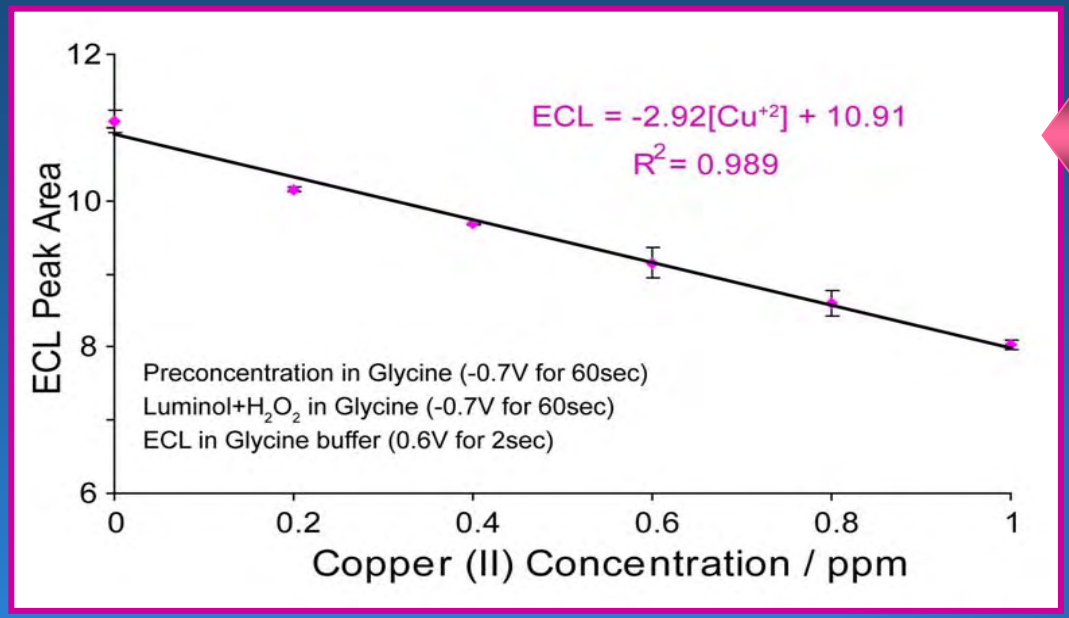
Application of the Sensor for the Stripping ECL Determination of Metal Ions

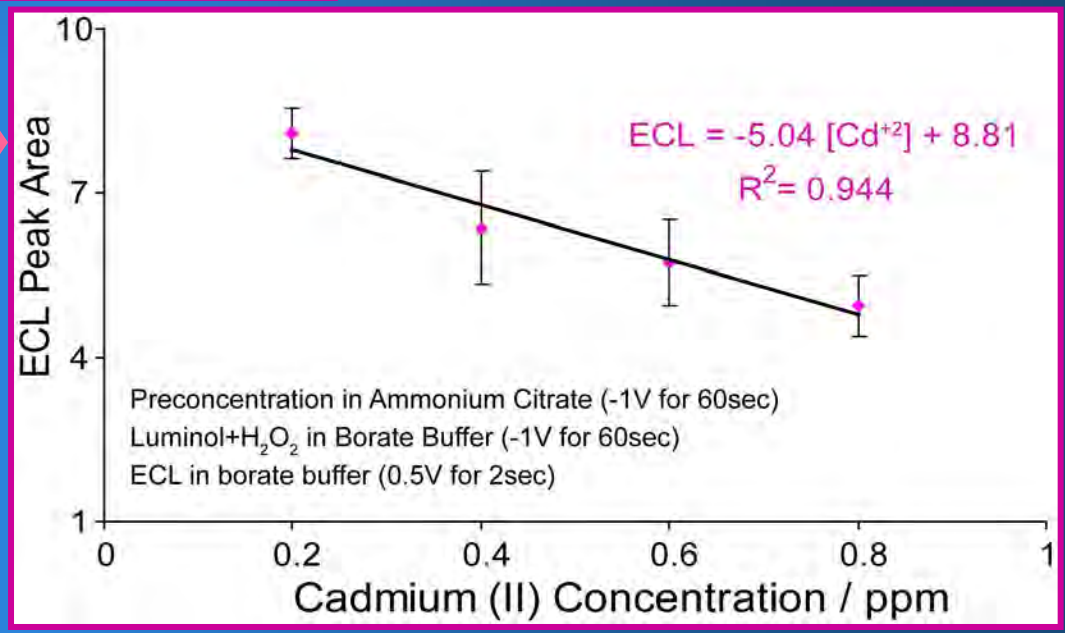


Cu (II) Stripping-ECl

Deposition in Glycine Buffer at
-0.7 V for 60 s
ECL in Glycine Buffer at
0.6 V for 2 s

Cd (II) Stripping-ECl

Deposition in Ammonium Citrate at
-1 V for 60 s
ECL in Borate Buffer at
0.5 V for 2 s



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Acknowledgements

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