Illuminating the Fundamentals & Applications of Spectro-Electrochemistry

27 Feb 2025

Ritesh Vyas, Ph.D.

Assoc. Director – Product Commercialization & Strategy

BASi Research Products

Outline – Spectro-EC Applications

- UV-Vis Spectro-EC
  - Organic Dyes in Solar Cells
  - Bio-sensor development – Dopamine Detection
  - Thin film Spectro-EC – Optical Sensors R & D
  - Thin film Deposition Monitoring – Spectro-EC
- VIS-NIR Spectro-EC
  - Synthesis of novel organic materials for Dyes and EC applications
- UV-Vis, ATIR-IR, Raman Spectro-EC
  - Electrocatalysis – Ammonia Oxidation Reaction
- UV-VIS – Fluorescence Spectro-EC
  - Electrochemical Fluorescence

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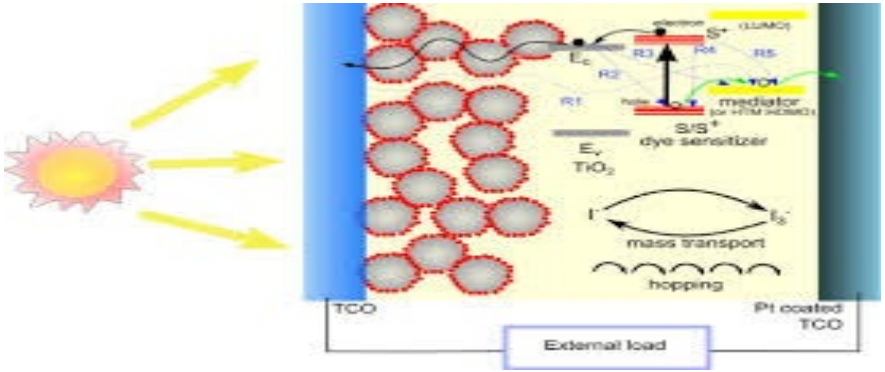
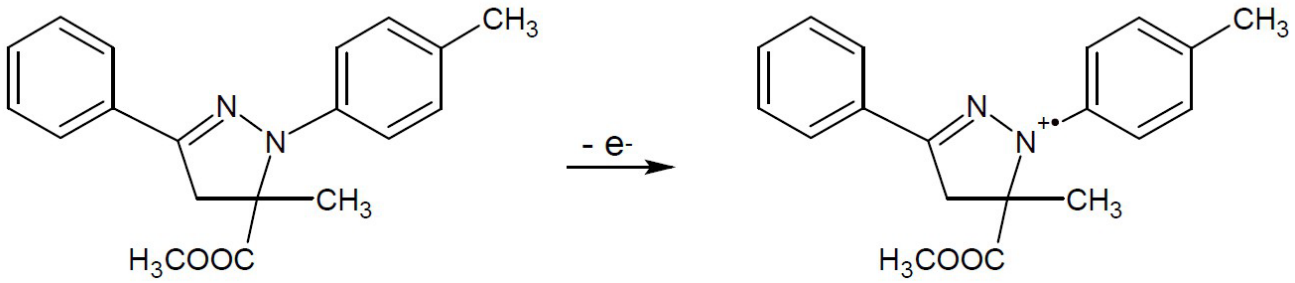


DSSC Solar cells Research
Organic Dye Characterization

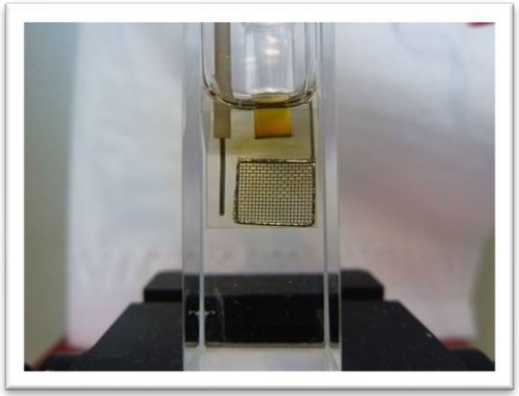
Solar Cell Applications: Analysis of Novel Organic Dyes

- Spectroelectrochemical analysis of Methyl 5-methyl-3-phenyl-1-p-tolyl-4,5-dihydro-1H-pyrazole-5-carboxylate

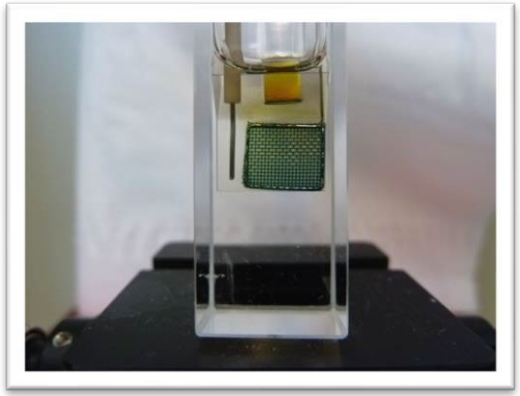


Solar Cell Applications: Analysis of Novel Organic Dyes

- Oxidation of the compound leads to significant change in λ_{MAX} (bathochromic shift: yellow to green)



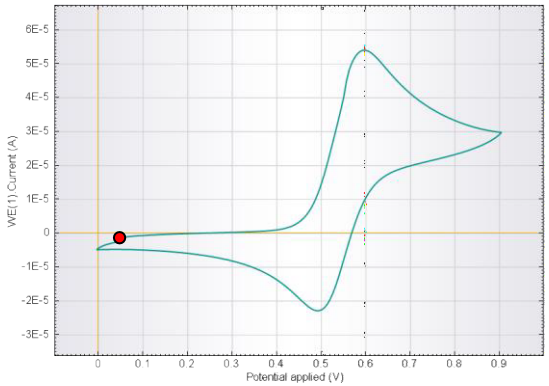
Reduced form

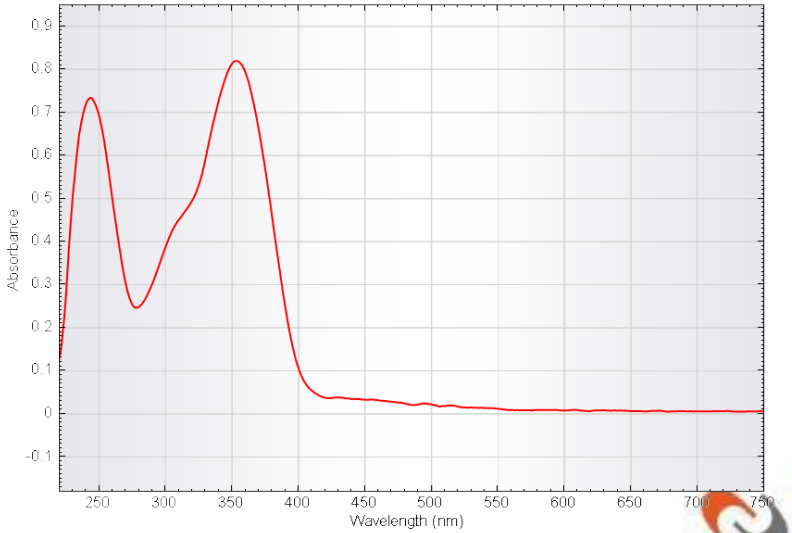


Oxidized form

Solar Cell Applications: Analysis of Novel Organic Dyes

- Spectra recorded at various voltages along the CV curve





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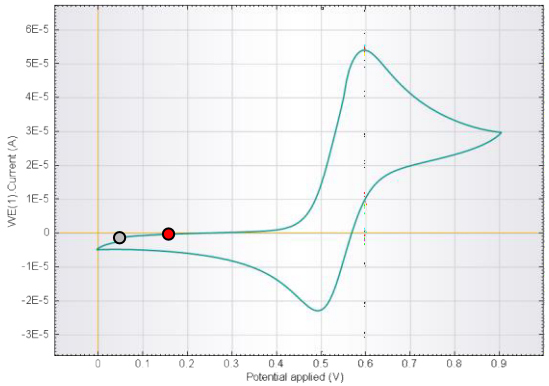
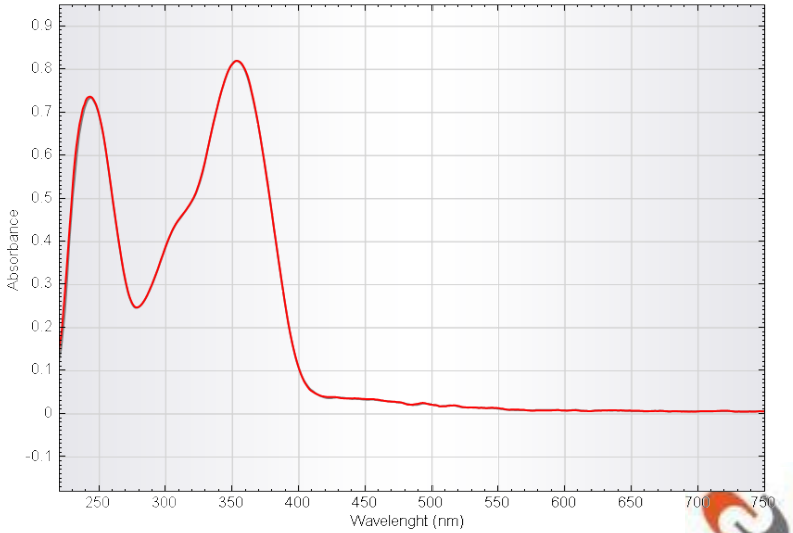
Solar Cell Applications: Analysis of Novel Organic Dyes

- Spectra recorded along the way





Solar Cell Applications: Analysis of Novel Organic Dyes

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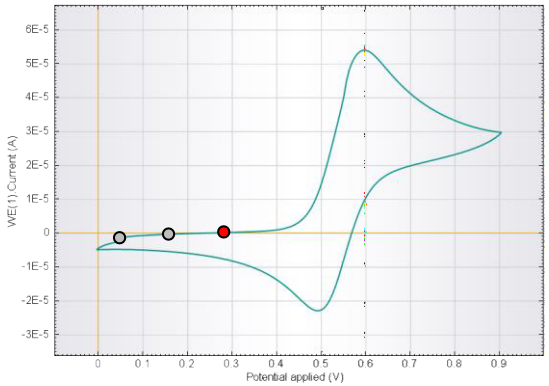

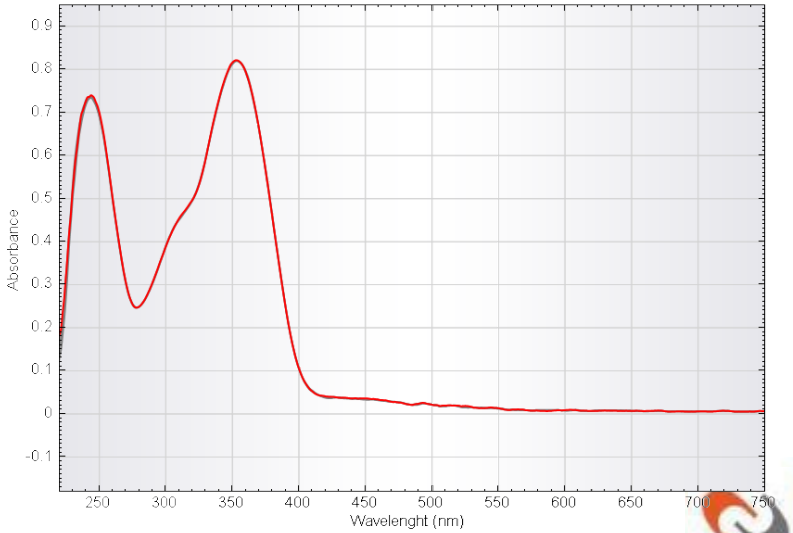

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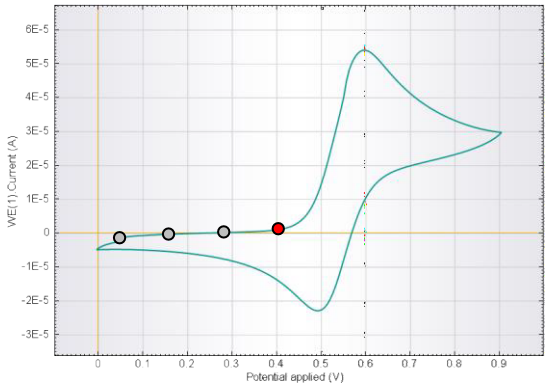

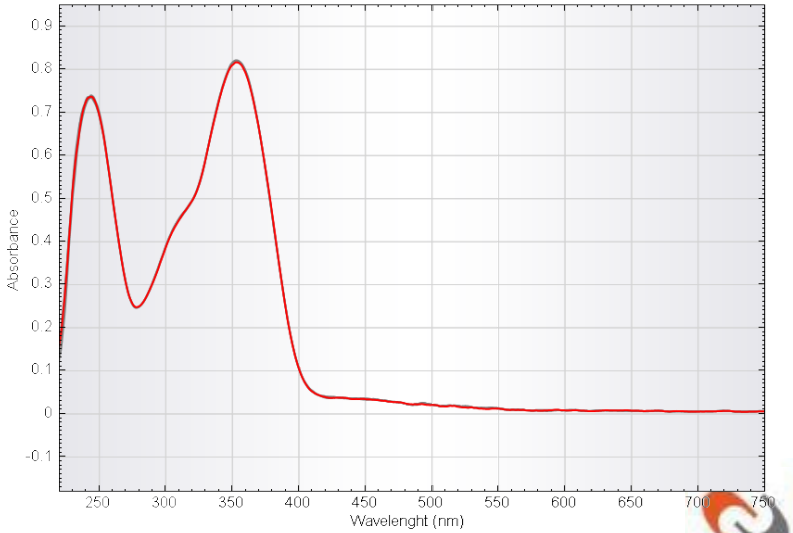

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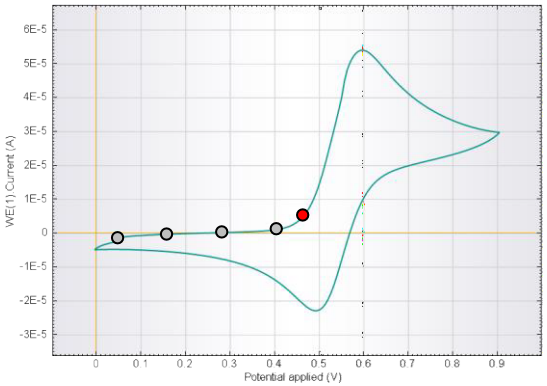

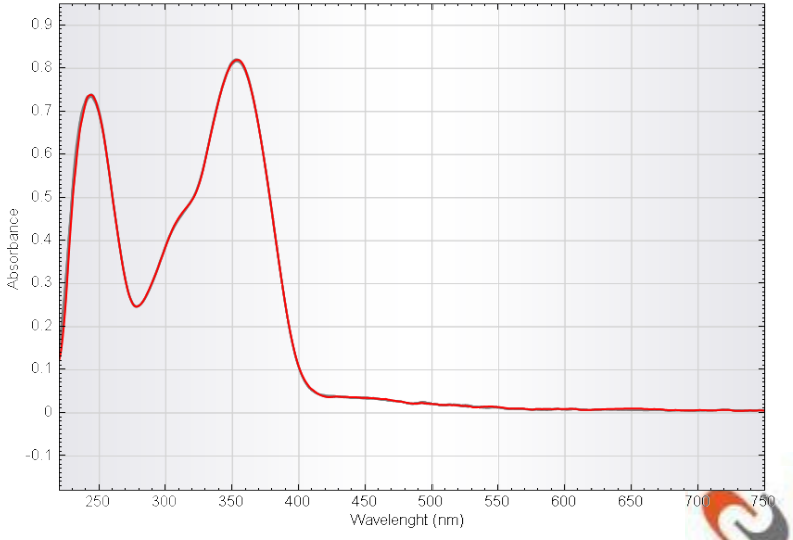

Solar Cell Applications: Analysis of Novel Organic Dyes

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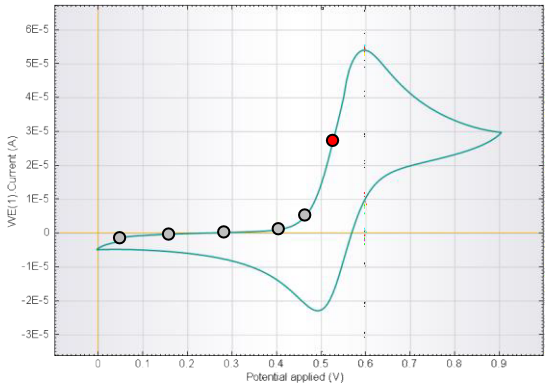

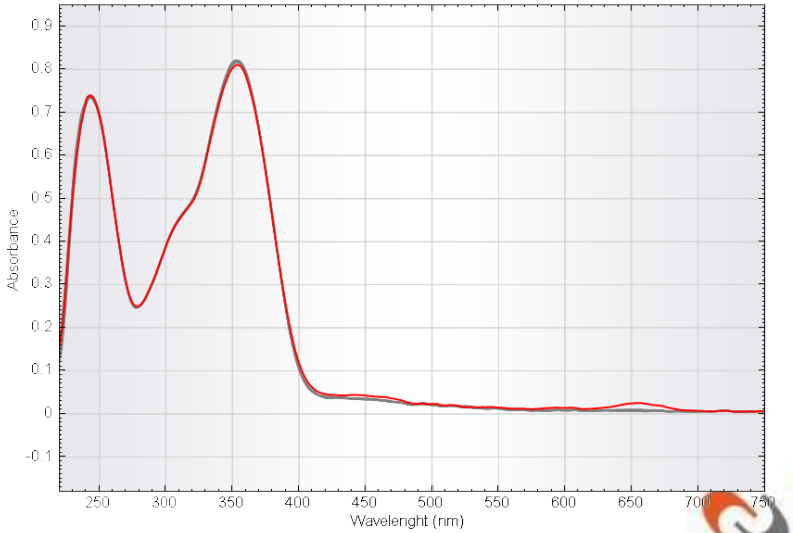

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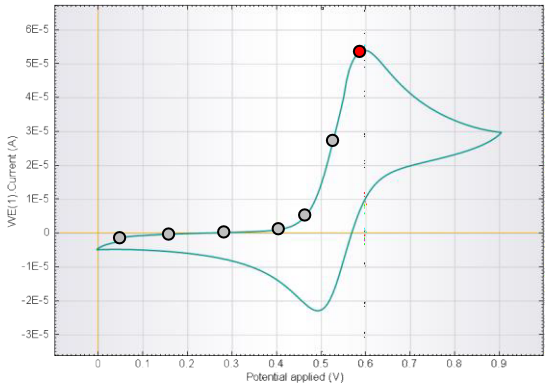

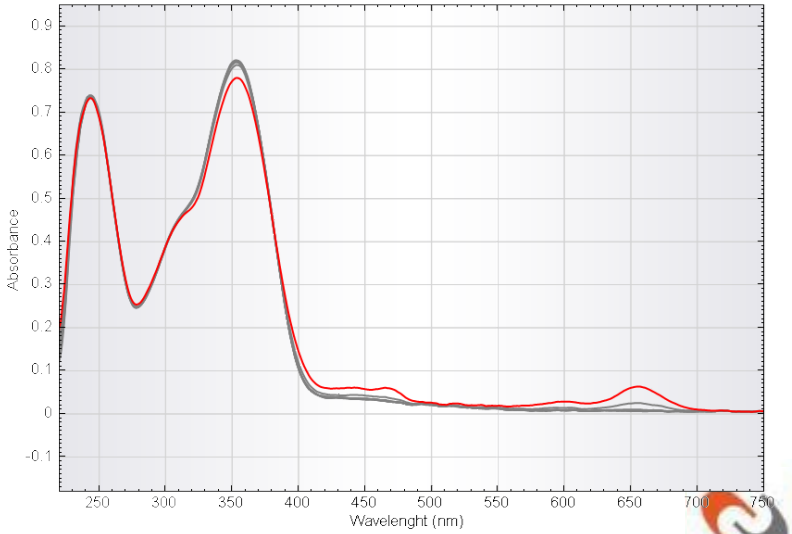

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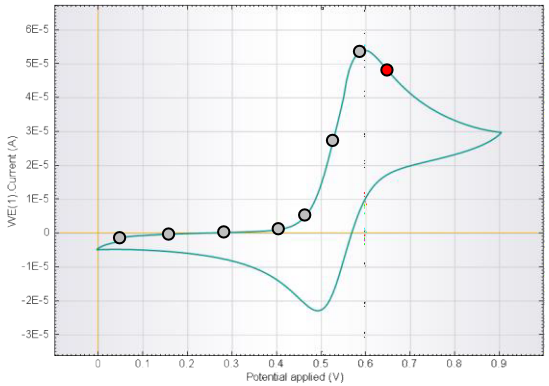

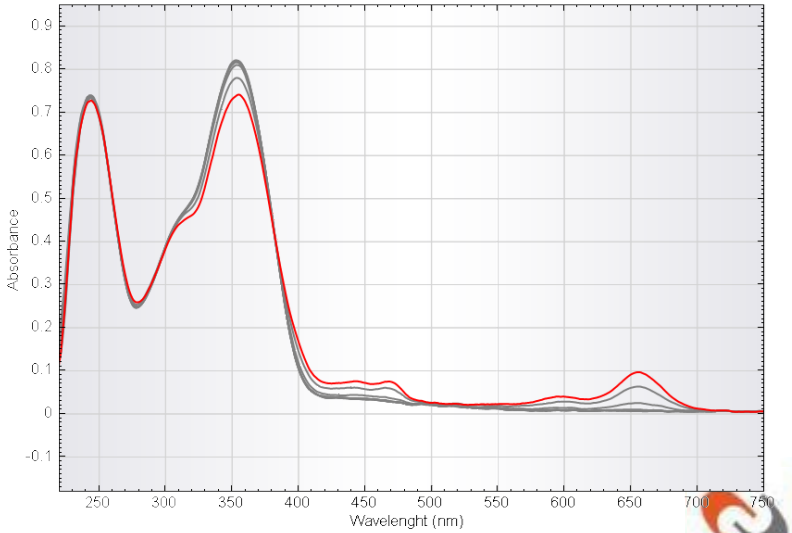

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Solar Cell Applications: Analysis of Novel Organic Dyes

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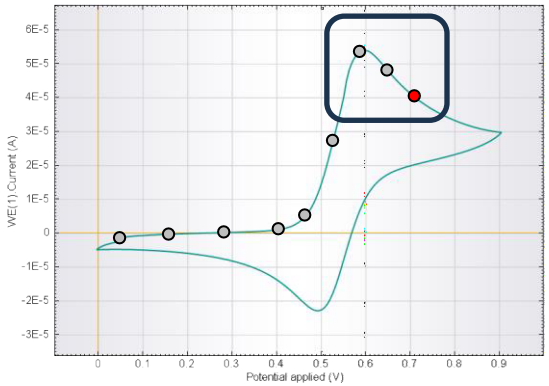

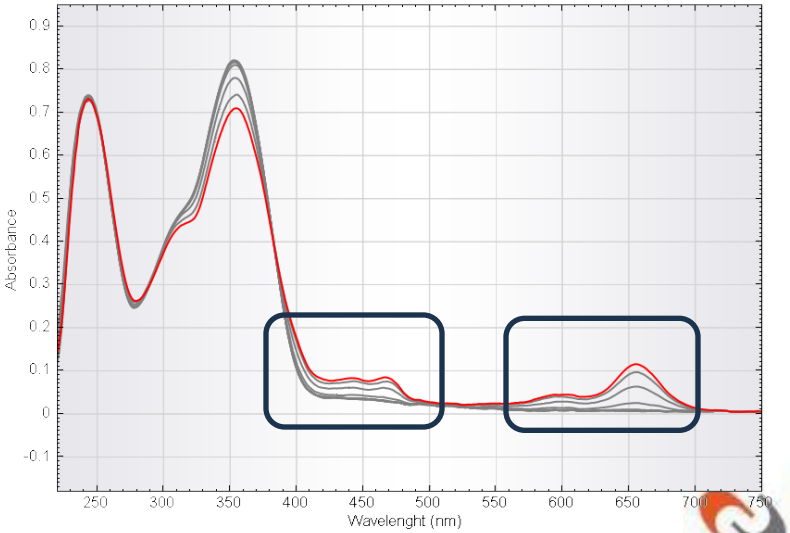

Solar Cell Applications: Analysis of Novel Organic Dyes

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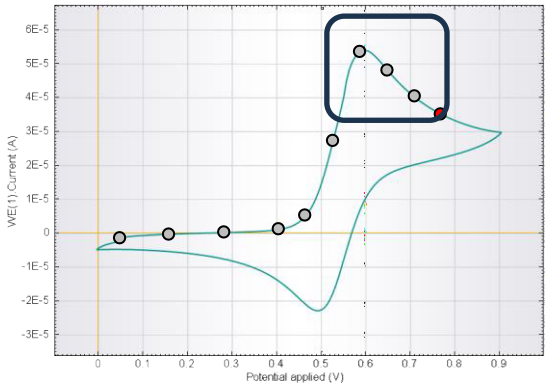

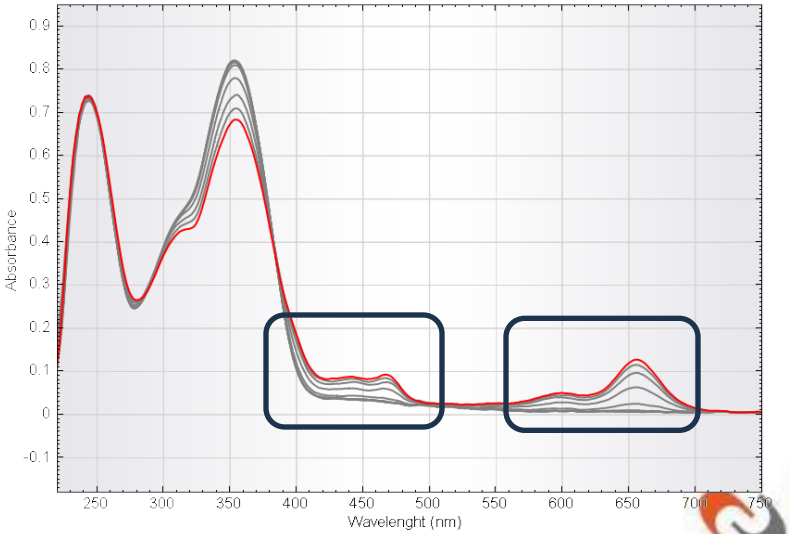

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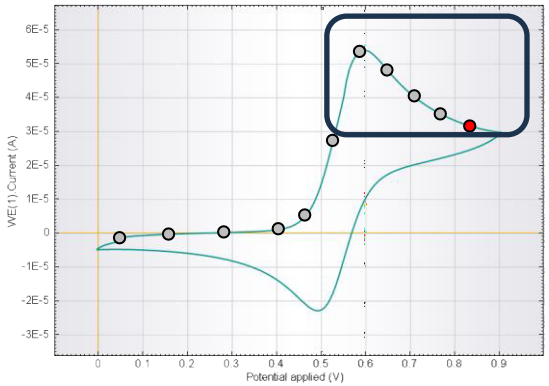
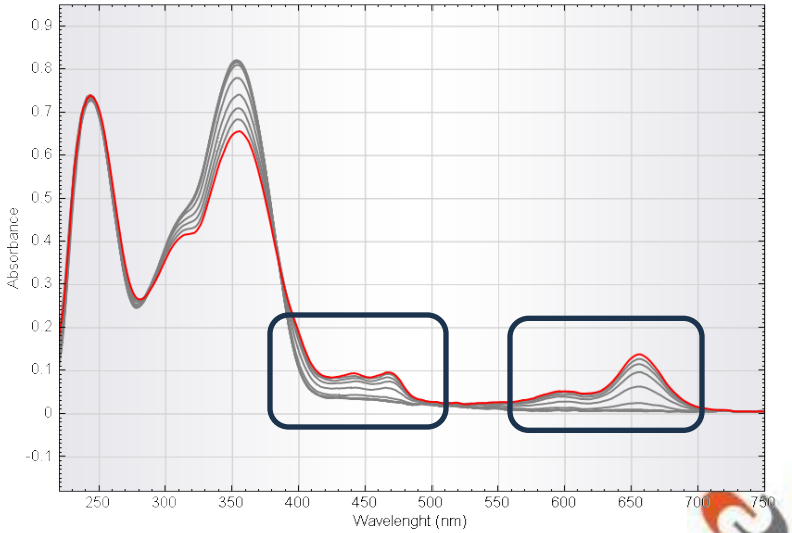
Solar Cell Applications: Analysis of Novel Organic Dyes

- Spectra recorded along the way





Solar Cell Applications: Analysis of Novel Organic Dyes

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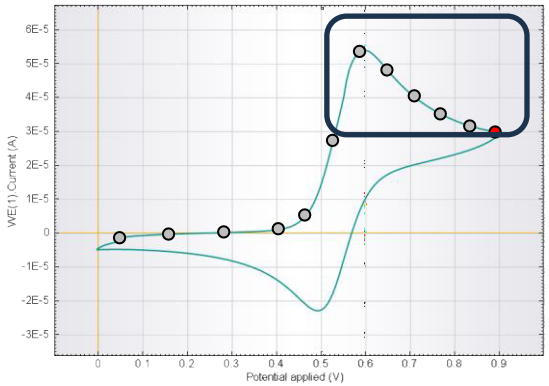
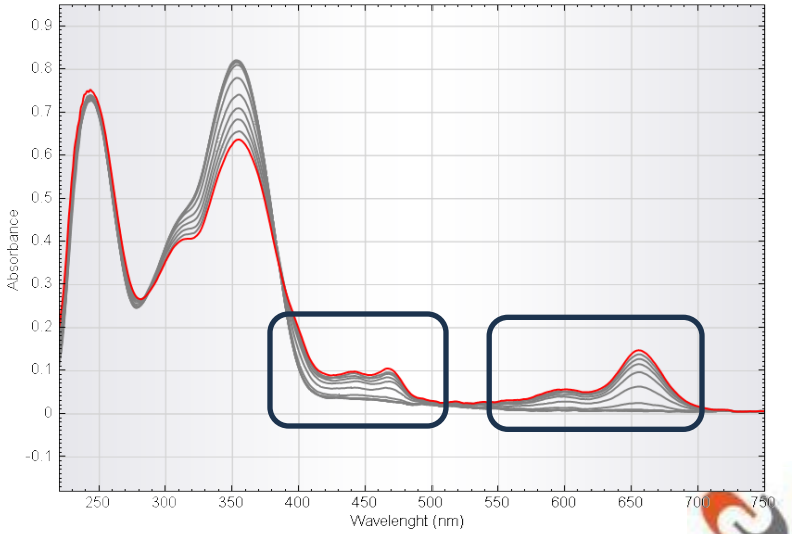
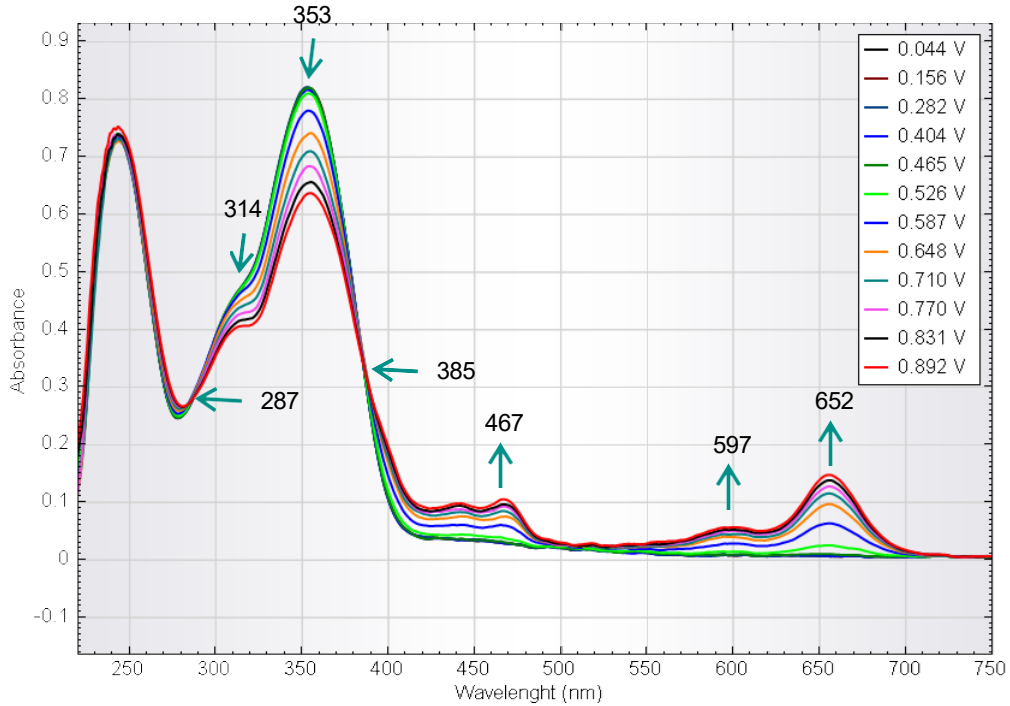
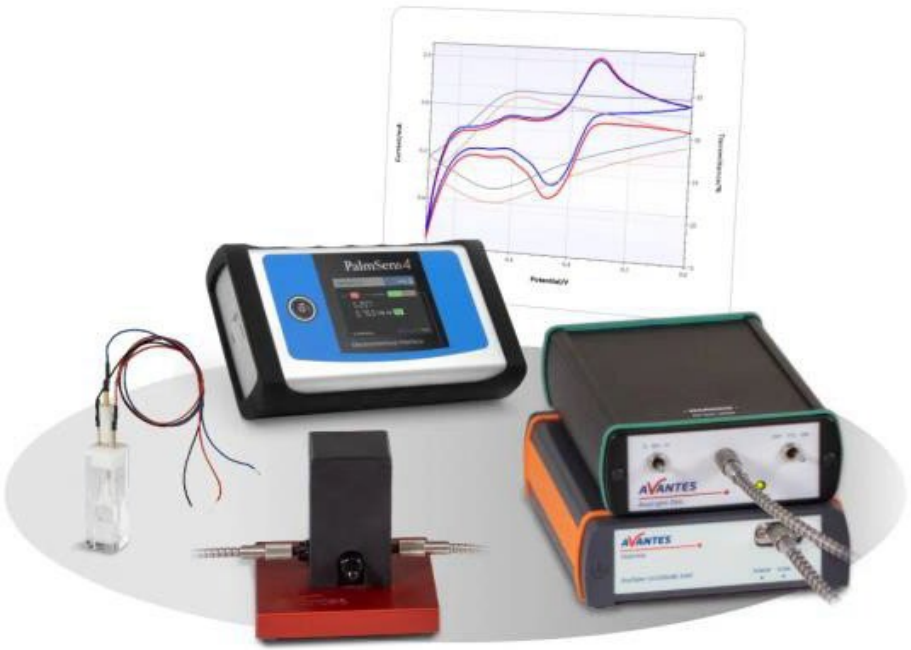




Chrono Based Spectro-Electrochemistry
UV-Vis Absorption Spectrum at Different Voltages



Upgradable UV-Vis Spectro-EC Package Solution



- Plug-n-play operation
- UV-Vis Range: Absorbance & Transmittance
- Customizations available
- All accessories included
- Application Note Available
- Spectro-EC Software
- Auto-trigger capability
- Real-time Plot Display
- Baseline Subtraction

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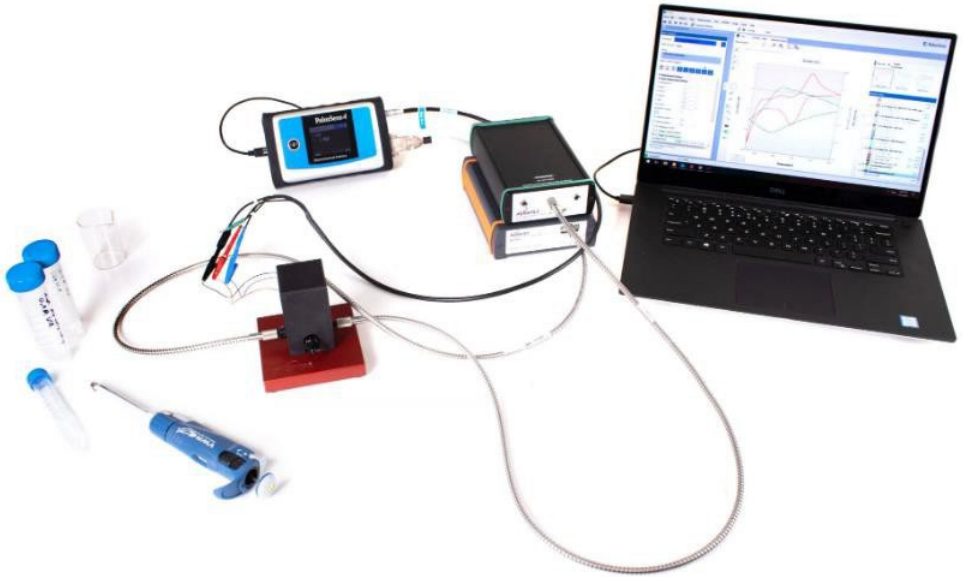
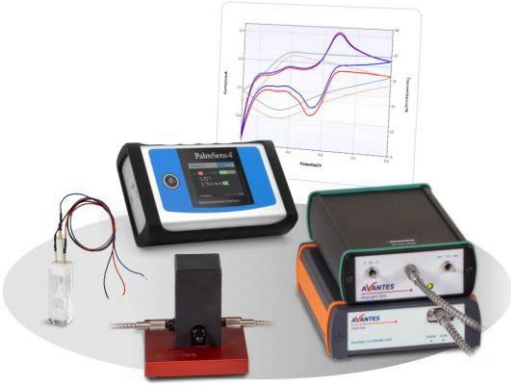
PalmSens – Complete SEC Set-up with Accessories





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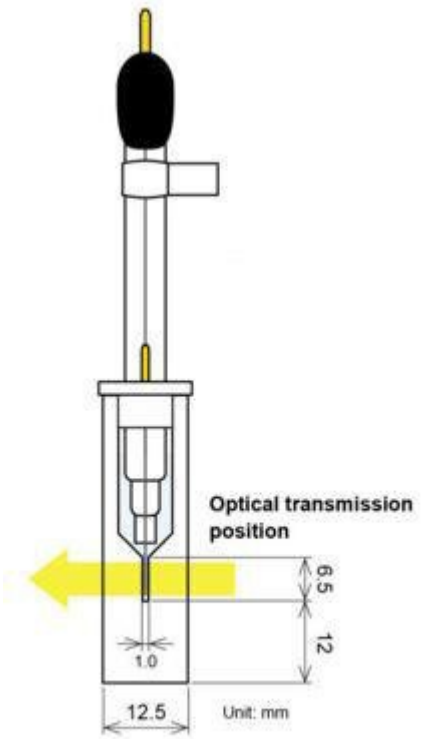
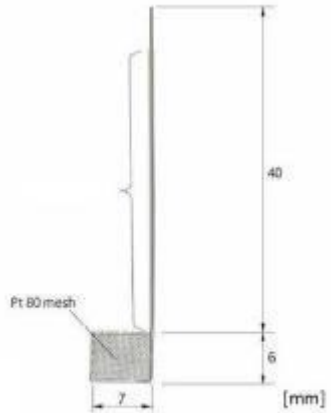
Spectro-EC Cell Complete Kit





Optical Path Length 1 or 0.5 mm

Pt or Au Grid WE

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Published Article for Guidance with PalmSens

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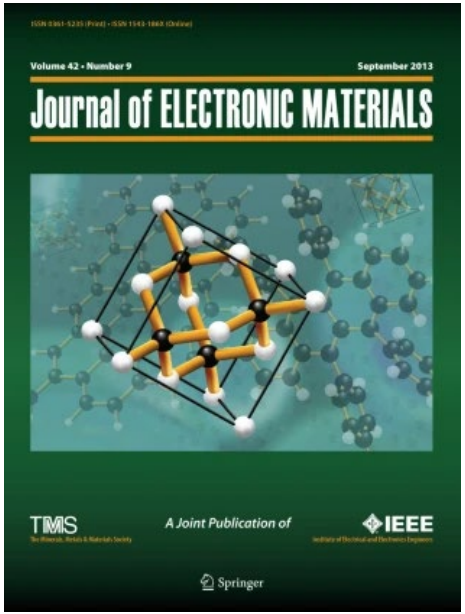
Home > Journal of Electronic Materials > Article

Design, Synthesis and Application of Imidazole-Based Organic Dyes in Dye Sensitized Solar Cells

Published: 28 March 2020

Volume 49, pages 3735–3750, (2020) Cite this article



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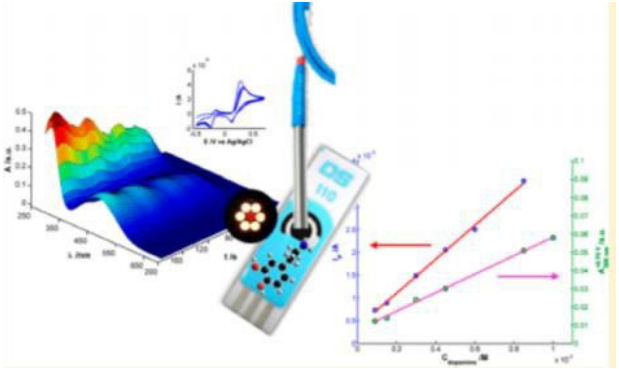


Bio Sensor Research & Development
Dopamine Detection

Bio-Sensor Applications
Publication – Dopamine Determination at SPE

analytical chemistry

Article

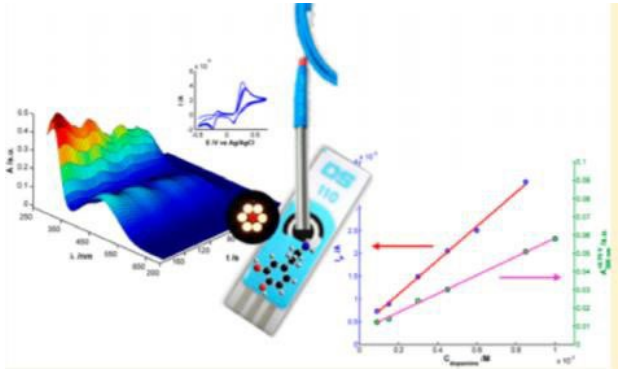
pubs.acs.org/ac

Anal. Chem. 2012, 84, 21, 9146–9153

Spectroelectrochemistry at Screen-Printed Electrodes: Determination of Dopamine

Noelia González-Diéguez, Alvaro Colina, Jesús López-Palacios, and Aránzazu Heras*

Department of Chemistry, Universidad de Burgos, Pza. Misael Bañuelos s/n, E-09001 Burgos, Spain



Advantage Using SPE

- Fresh new surface each time
- Sample volume as little as one drop
- Fast, easy and accurate

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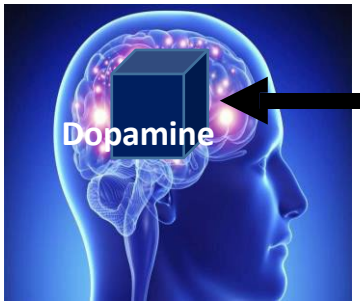
Dopamine – A Chemical Messenger



Schizophrenia

High Concentrations

Cognition, emotion, endocrine regulation, motivation, locomotion, etc.

Low Concentrations

Parkinsonism

Requirement: A fast and accurate method for studying dopamine oxidation reaction with intermediates formed at high and lower concentrations

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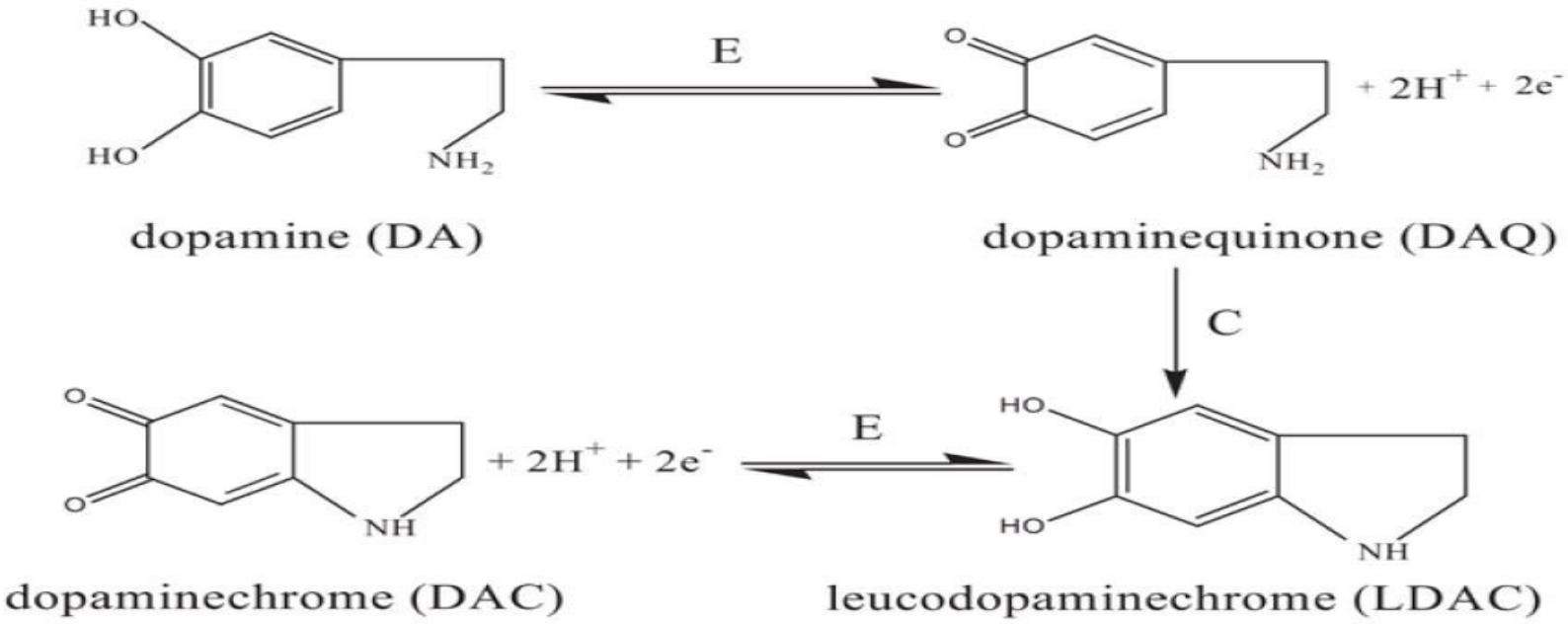
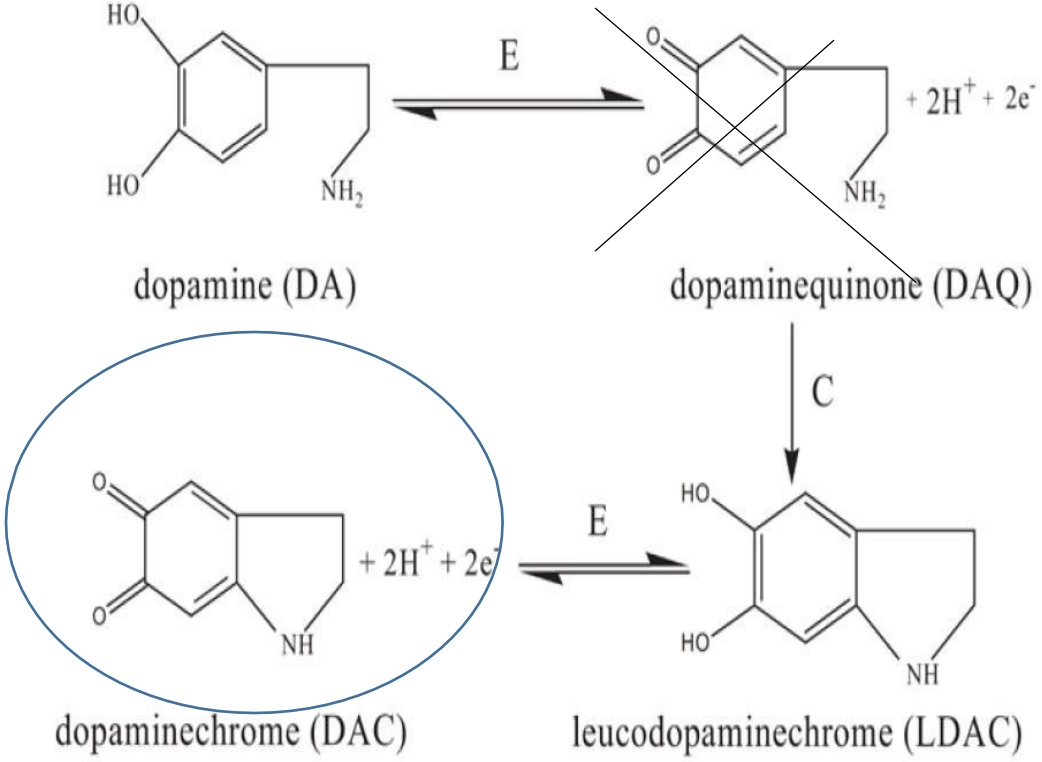
A Typical Dopamine Oxidation Process



Dopamine Oxidation @ Conc. < 0.001M



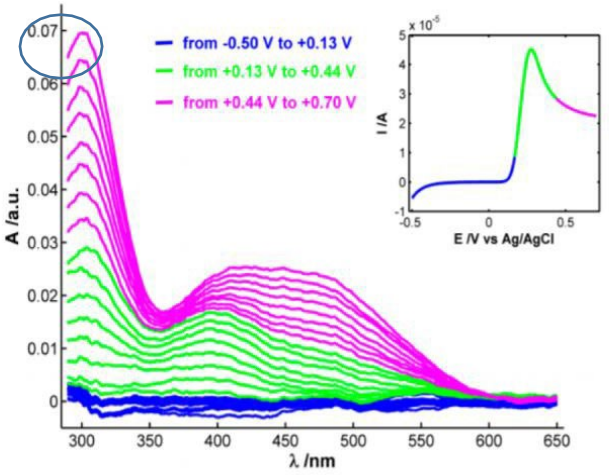


Figure 2. Spectra evolution during oxidation of dopamine 10^{-3} M in PBS buffer solution (pH = 7). Inset: Linear voltammogram registered during dopamine oxidation; $E_{initial}$ = −0.50 V, E_{final} = +0.70 V, scan rate = 0.05 V s^{-1}, $t_{integration}$ = 135 ms.

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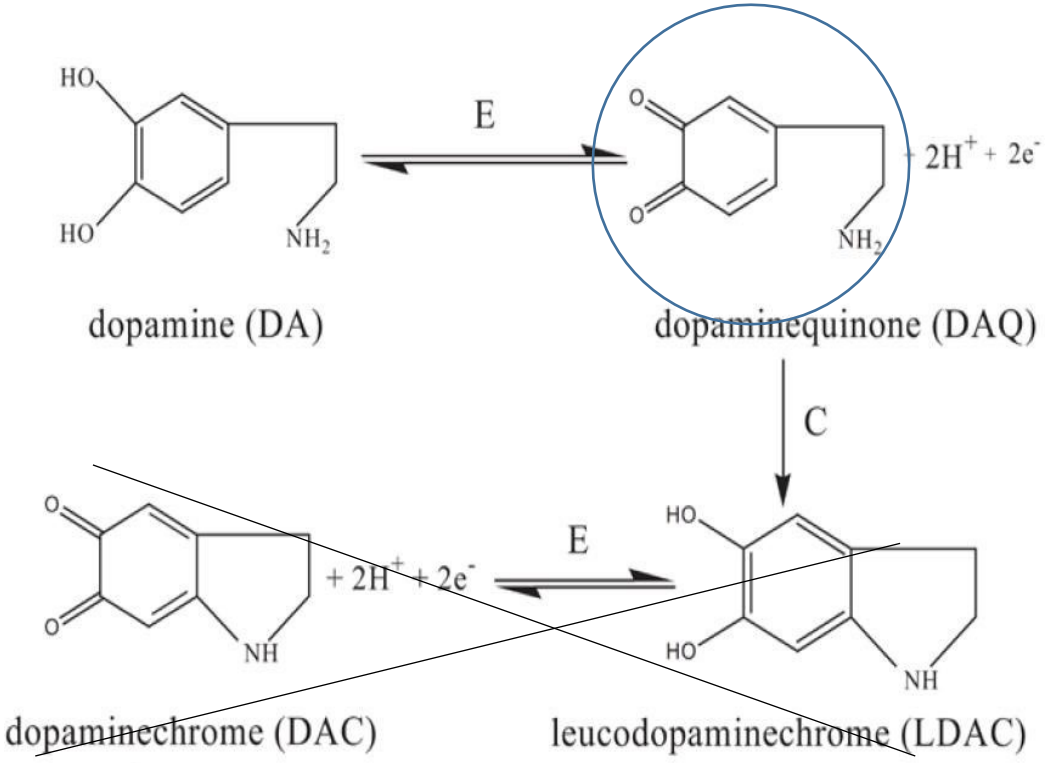
Dopamine Oxidation @ Conc. > 0.001M



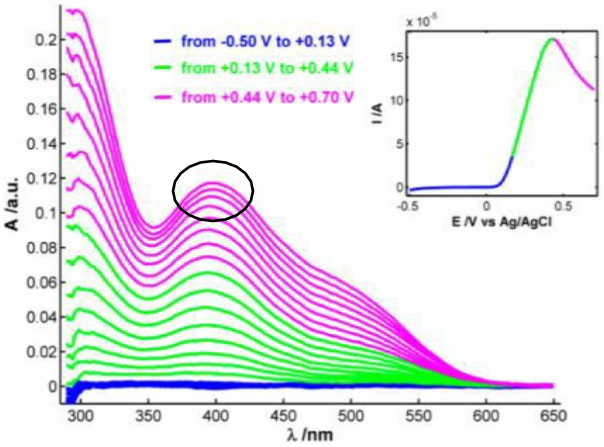
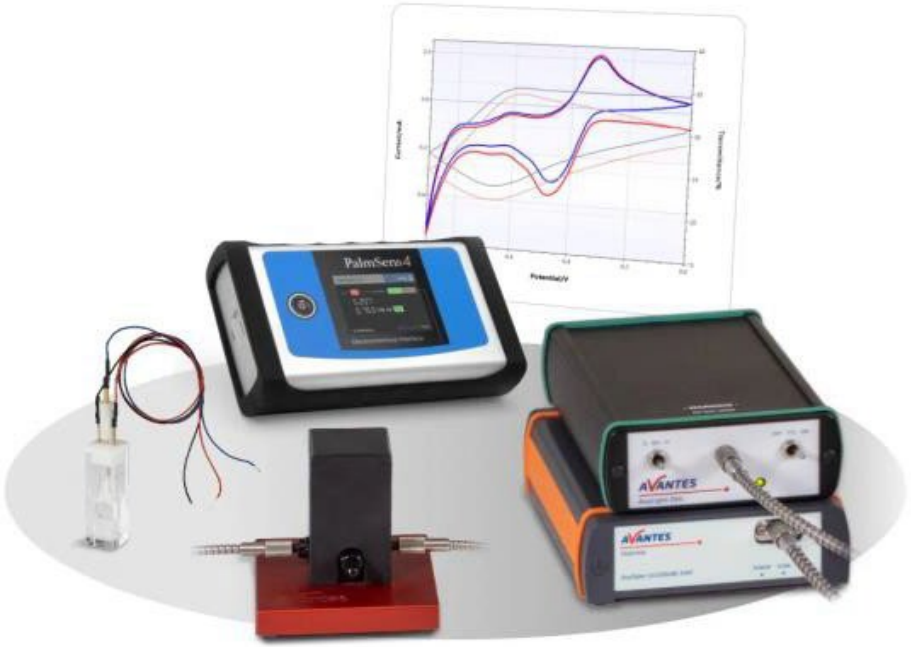


Figure 3. Spectra evolution during oxidation of dopamine 6×10^{-3} M in PBS buffer solution (pH = 7). Inset: Linear voltammogram registered during dopamine oxidation. $E_{initial}$ = −0.50 V, E_{final} = +0.70 V, scan rate = 0.05 V s^{-1}, $t_{integration}$ = 135 ms.

Upgradable UV-Vis Spectro-EC Kit FOR SPE



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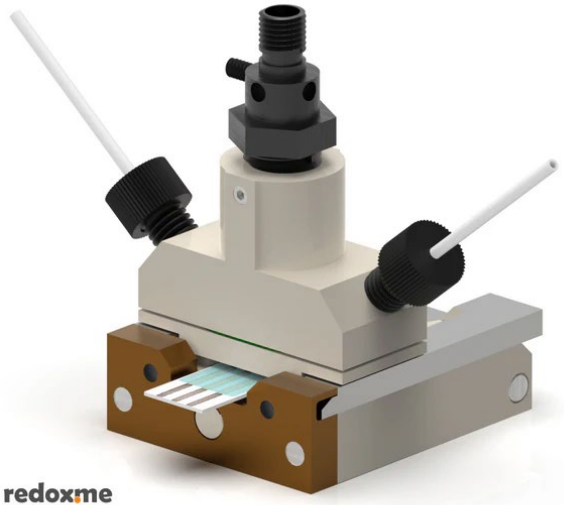

redoxme
SPECTRO-EFC CELL ATTACHMENT
for SPE holder, UV-vis-NIR

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Published Reference Article with PalmSens - Biosensor

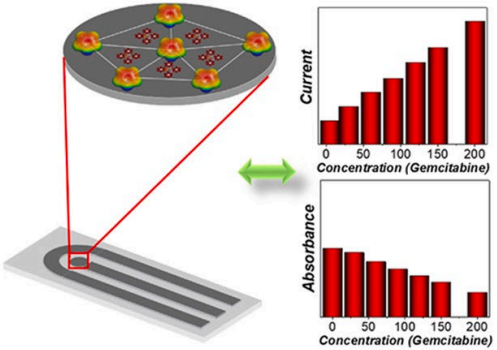
ELSEVIER

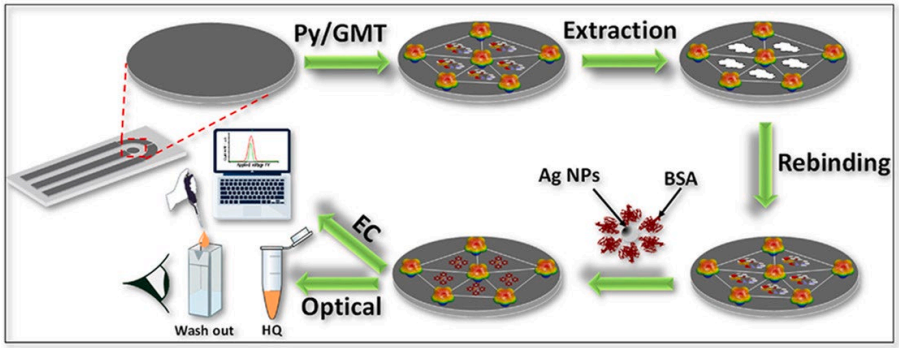
Talanta

Volume 267, 15 January 2024, 125233

An innovative and universal dual-signal ratiometric spectro-electrochemical imprinted sensor design for sandwich type detection of anticancer-drug, gemcitabine, in serum samples; cross validation via computational modeling

Shaista Ijaz Khan [a b], Ayaz Hassan [b], Rehana Bano [c], Mazhar Amjad Gilani [c], Jean Louis Marty [d], Hongxia Zhang [a] ✉, Akhtar Hayat [a b] ✉





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Optical Sensors & Electrochromic Windows
Conducting Polymer Characterization
Optical Nanoparticle Deposition

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Electrochromic / Optical Sensor Development
THIN FILM SPECTRO-EC

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Sensors and Actuators B: Chemical

Volume 248, September 2017, Pages 527-535

Hybrid electrochemical/electrochromic Cu(II) ion sensor prototype based on PANI/ITO-electrode

Megha A. Deshmukh [a, b], Mindaugas Gicevicius [a], Almira Ramanaviciene [c], Mahendra D. Shirsat [b], Roman Viter [a, d], Arunas Ramanavicius [a]

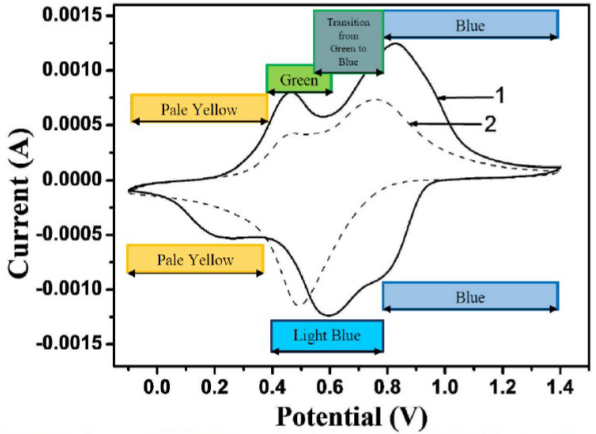
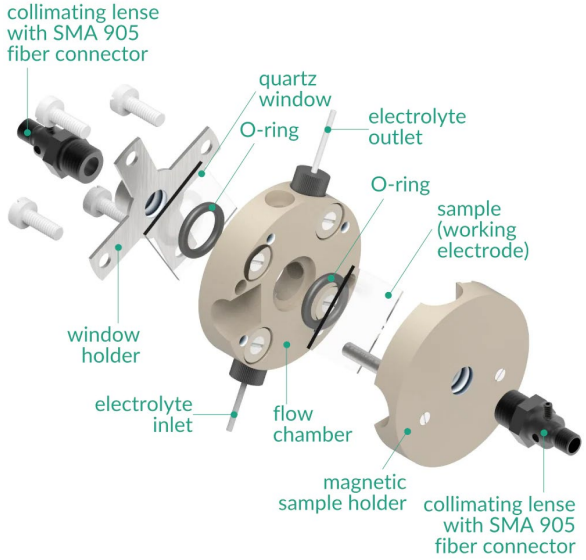
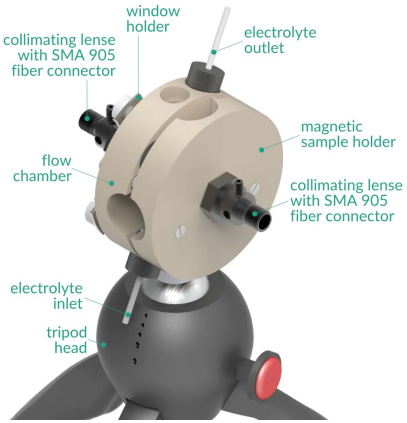


Fig. 4. CVs of: pristine PANI/ITO-electrode (solid line) and Cu(II)/PANI/ITO-electrode, which was formed by incubation of PANI/ITO-electrode (dash line) in 0.02 M solution of $CuCl_2$.





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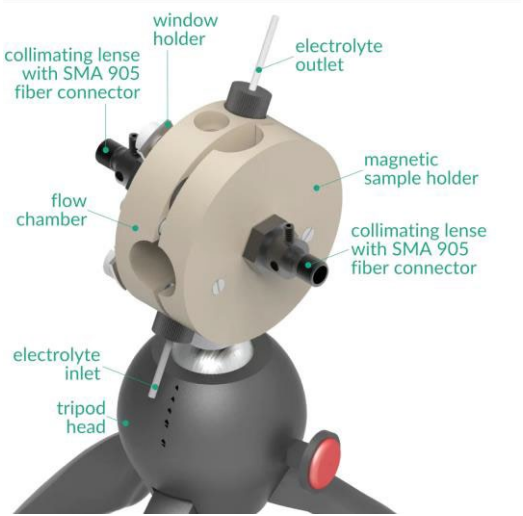
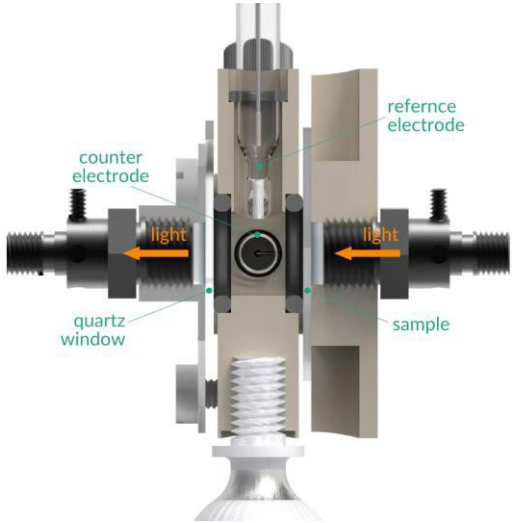
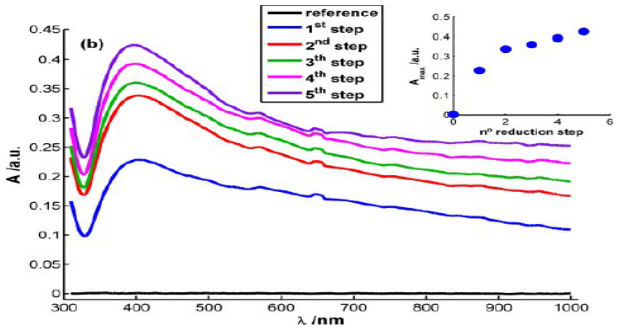
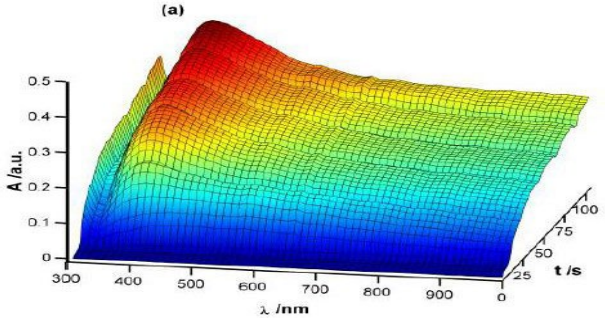
Spectro-EC for Thin Film Analysis on ITO / FTO Slides

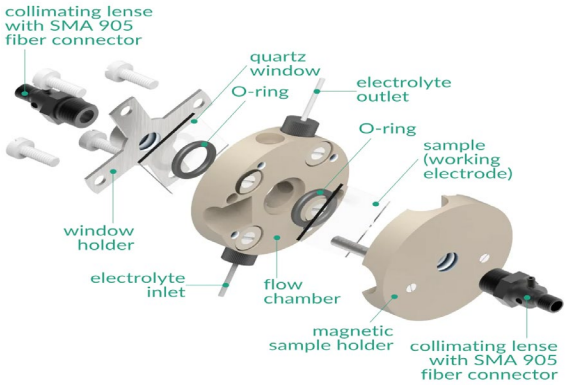




Monitoring Ag Nanoparticle Deposition via SEC







Sensors **2013**, *13*, 5700-5711; doi:10.3390/s130505700

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Article

UV/Vis Spectroelectrochemistry as a Tool for Monitoring the Fabrication of Sensors Based on Silver Nanoparticle Modified Electrodes

Cristina Fernández-Blanco, Álvaro Colina and Aránzazu Heras *

Department of Chemistry, Universidad de Burgos, Pza. Misael Bañuelos s/n, E-09001 Burgos, Spain; E-Mails: acfernandez@ubu.es (C.F.-B.); acolina@ubu.es (Á.C.)

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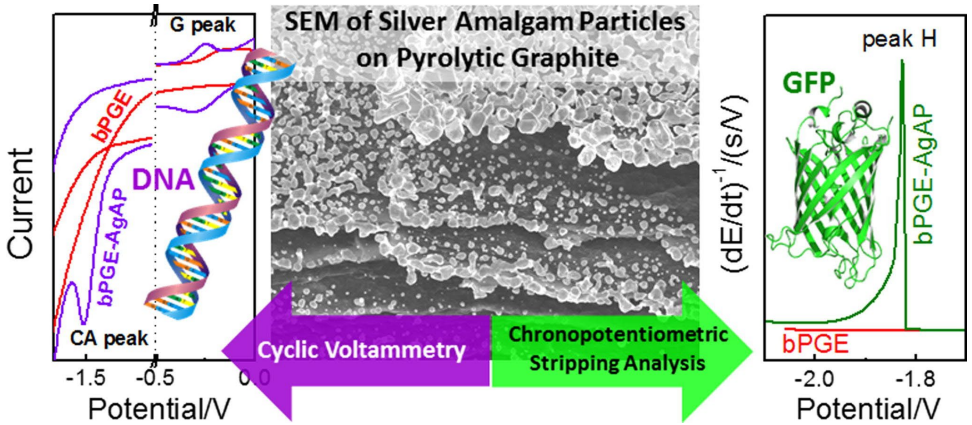
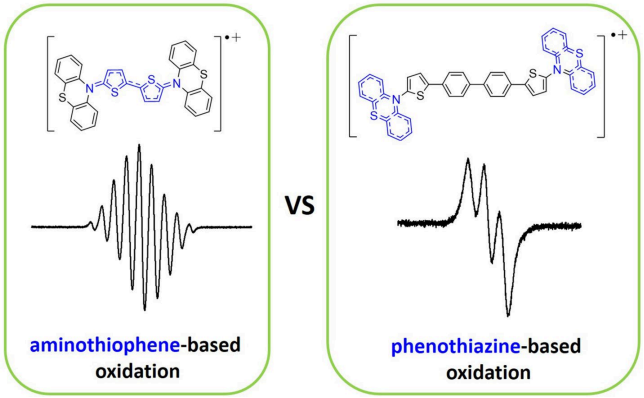
Published Reference Article with PalmSens

Bioelectrochemistry
Volume 132, April 2020, 107436

Electrodeposited silver amalgam particles on pyrolytic graphite in (spectro)electrochemical detection of 4-nitrophenol, DNA and green fluorescent protein

Peter Sebest [a], Lukas Fojt [a], Veronika Ostatna [a], Miroslav Fojta [a b], Ales Danhel [a]





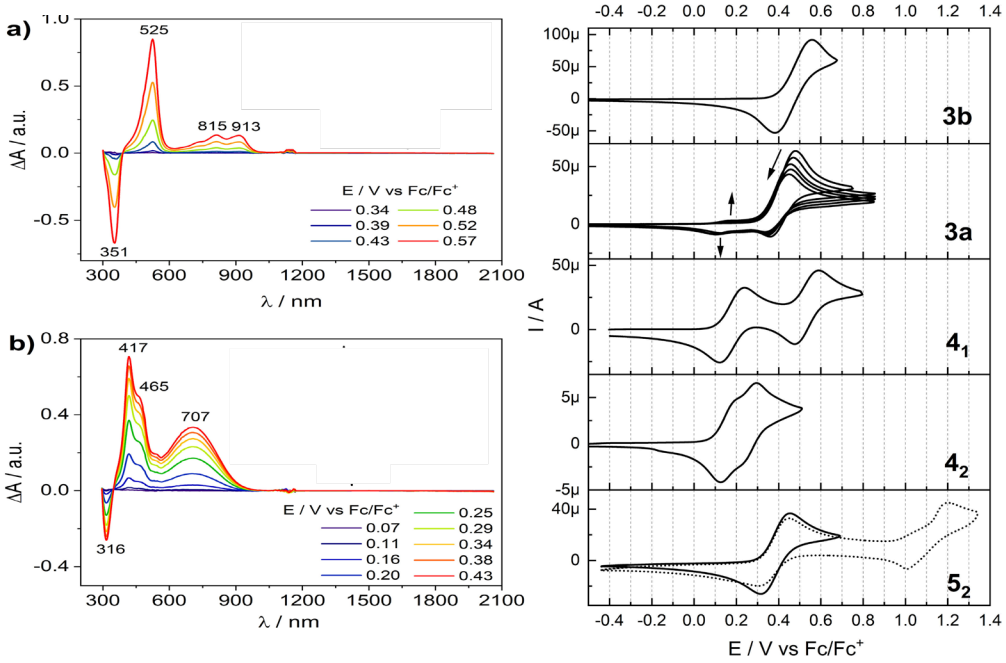
Highly Conductive + Long Wavelength Electronic Materials Synthesis UV-Vis-NIR Spectro-Electrochemistry

UV-Vis NIR Spectro-EC Analysis – Organic Synthesis

Electrochimica Acta
Volume 515, 1 March 2025, 145714

EPR/UV–Vis–NIR spectroelectrochemical characterization of 10*H*-phenothiazinyl-substituted oligothiophenes

Evgenia Dmitrieva [a], Alexey A. Popov [a], Horst Hartmann [b]



(a) *In situ* UV–Vis–NIR spectra measured in dichloromethane solution (0.1 M *n*-Bu_4NPF_6) during the oxidation of **3b** (a) and $\mathbf{4_1}$ (b). Each UV–Vis–NIR spectrum was collected relative to that of the neutral (uncharged)

Plug-n-Play UV-Vis-NIR Spectro-electrochemistry Kit

- Plug-n-play operation
- Range: 200-2500 nm
- Resolution: 0.2 to 7 nm
- Customizations available
- Dual Light Source Synchronized
- Spectro-EC Software
- Auto-trigger capability
- Real-time Plot Display
- Baseline Subtraction

Potentiostat Included at No Charge

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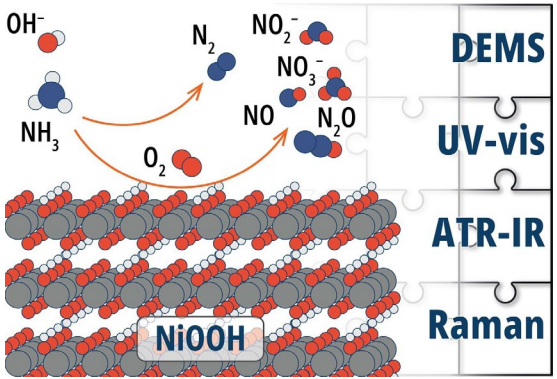


Electrocatalysis Applications
Ammonia Oxidation Reaction
UV-Vis, Raman, ATR-IR Spectro-EC Analysis

Electro-catalysis Studies – BASi – MF- SPEC-EC KIT

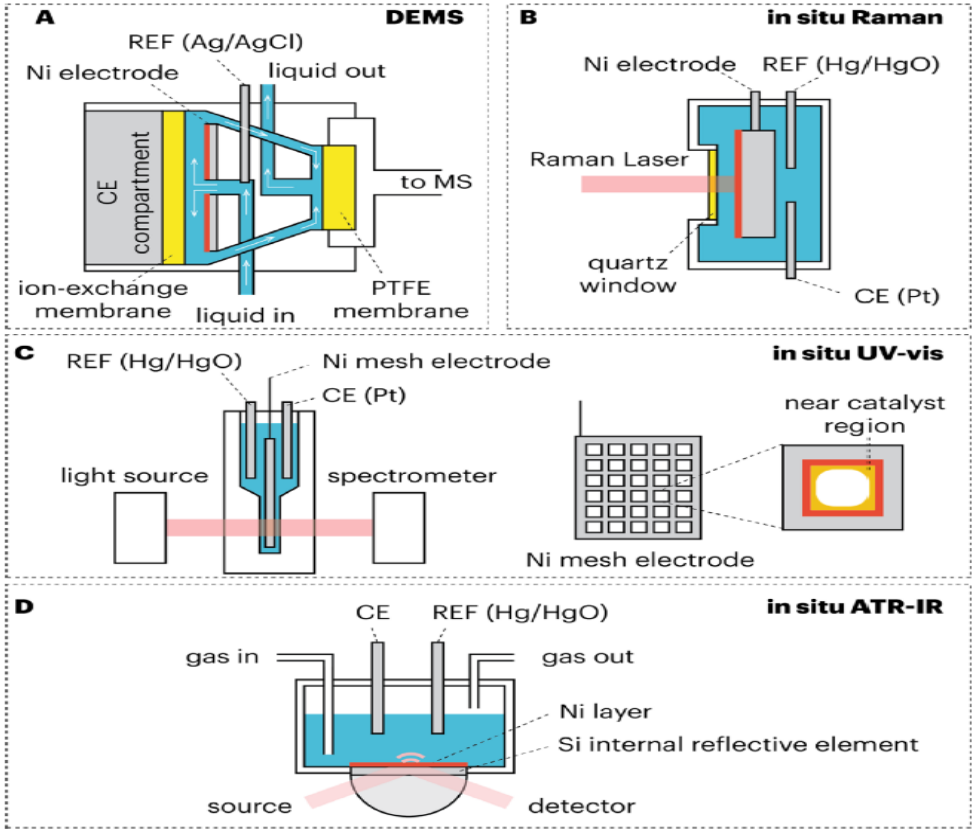
ELSEVIER

Journal of Catalysis

Volume 438, October 2024, 115720

Correlative *in situ* analysis of the role of oxygen on ammonia electrooxidation selectivity on NiOOH surfaces

Jing Chen [a 1], Sijie Chen [a b 1], Jinghao Gao [b c], Xiaowu Huang [b c e], Elissaios Stavrou [b d e], Charlotte Vogt [b] ✉, Weiran Zheng [a b e] ✉



Electro-catalysis Studies with UV-Vis Spectro-EC

ELSEVIER

Journal of Catalysis
Volume 438, October 2024, 115720

Correlative *in situ* analysis of the role of oxygen on ammonia electrooxidation selectivity on NiOOH surfaces

Jing Chen [a l], Sijie Chen [a b l], Jinghao Gao [b c], Xiaowu Huang [b c e], Elissaios Stavrou [b d e], Charlotte Vogt [b] ✉, Weiran Zheng [a b e] ✉

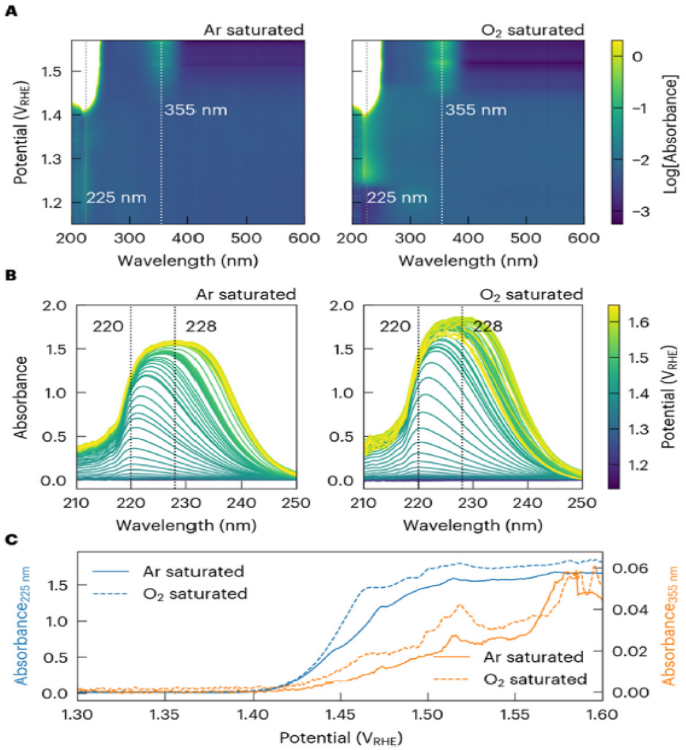
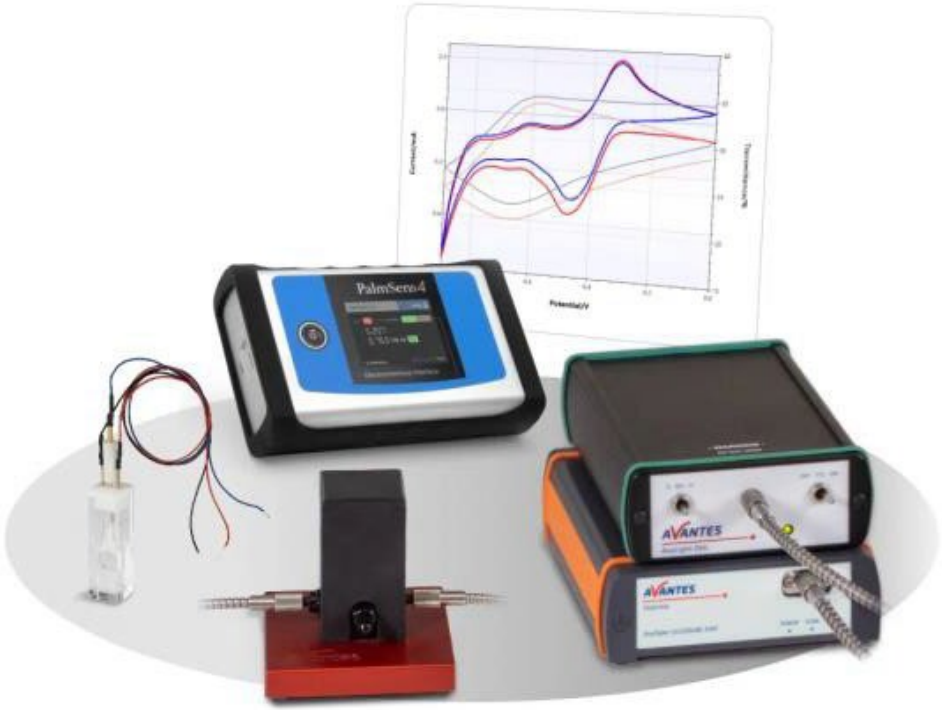


Fig. 6. *In situ* UV–vis spectra of $NiOOH/Ni(OH)_2$ mesh electrode in electrolytes (1.0 M KOH+100 mM NH_3). (A) Ar/O_2-saturated electrolytes; (B) Stacked spectra showing the absorbance between 210 and 250 nm; (C) Correlation between the applied potential and absorbance at 225 and 355 nm. White color indicates absorbance higher than 1.5.

Upgradable UV-Vis Spectro-EC Package Solution



- Plug-n-play operation
- UV-Vis Range: Absorbance & Transmittance
- Customizations available
- All accessories included
- Application Note Available
- Spectro-EC Software
- Auto-trigger capability
- Real-time Plot Display
- Baseline Subtraction

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Electro-catalysis Studies - Raman Spectro-EC

ELSEVIER

Journal of Catalysis

Volume 438, October 2024, 115720

Correlative *in situ* analysis of the role of oxygen on ammonia electrooxidation selectivity on NiOOH surfaces

Jing Chen [a 1], Sijie Chen [a b 1], Jinghao Gao [b c], Xiaowu Huang [b c e], Elissaios Stavrou [b d e], Charlotte Vogt [b], Weiran Zheng [a b e]

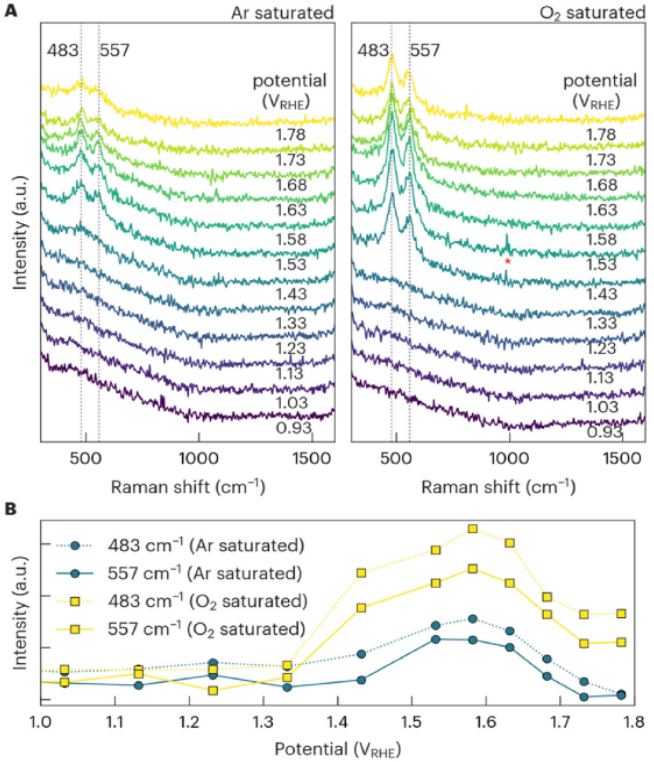

Fig. 7. *In situ* Raman spectra of NiOOH/$Ni(OH)_2$ electrode in electrolytes (1.0 M KOH+100 mM NH_3). (A) Ar/O_2-saturated electrolytes; (B) Correlation between the applied potential and peak intensity at 483 and 557 cm^{-1}. Red mark indicates the minor signal at 1002 cm^{-1}. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Plug-n-Play Raman Spectro-EC Kit

- Plug-n-play operation
- Range: 100 cm^{-1} – 3000 cm^{-1}
- AvaLaser 785 nm Diode
- Customizations available
- Spectro-EC Software
- Auto-trigger capability
- Real-time Plot Display
- Baseline Subtraction

Potentiostat included at No Charge

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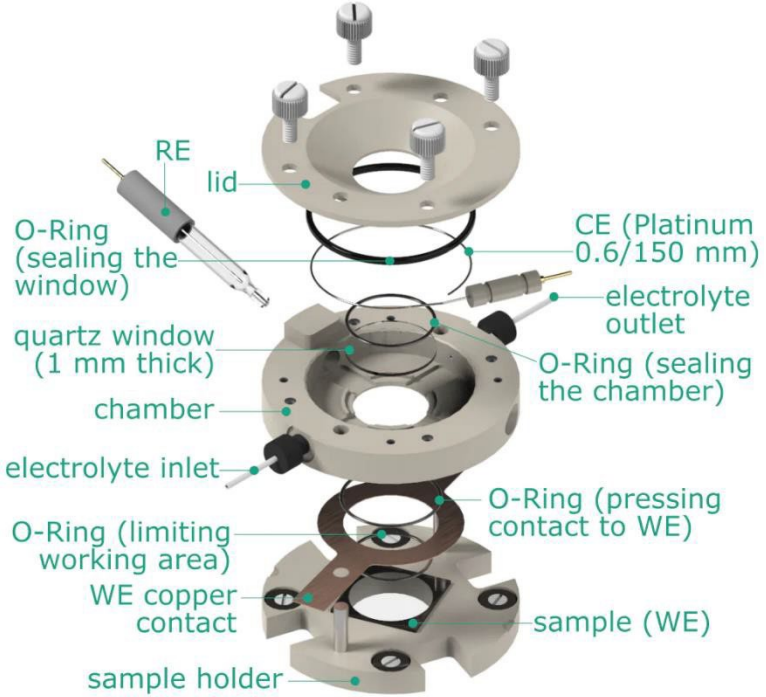
In-situ Raman Based Spectro-EC Cell Kit



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Electro-catalysis Studies – ATR-IR Spectro-EC

ELSEVIER

Journal of Catalysis

Volume 438, October 2024, 115720

Correlative *in situ* analysis of the role of oxygen on ammonia electrooxidation selectivity on NiOOH surfaces

Jing Chen [a 1], Sijie Chen [a b 1], Jinghao Gao [b c], Xiaowu Huang [b c e], Elissaios Stavrou [b d e], Charlotte Vogt [b] ✉, Weiran Zheng [a b e] ✉

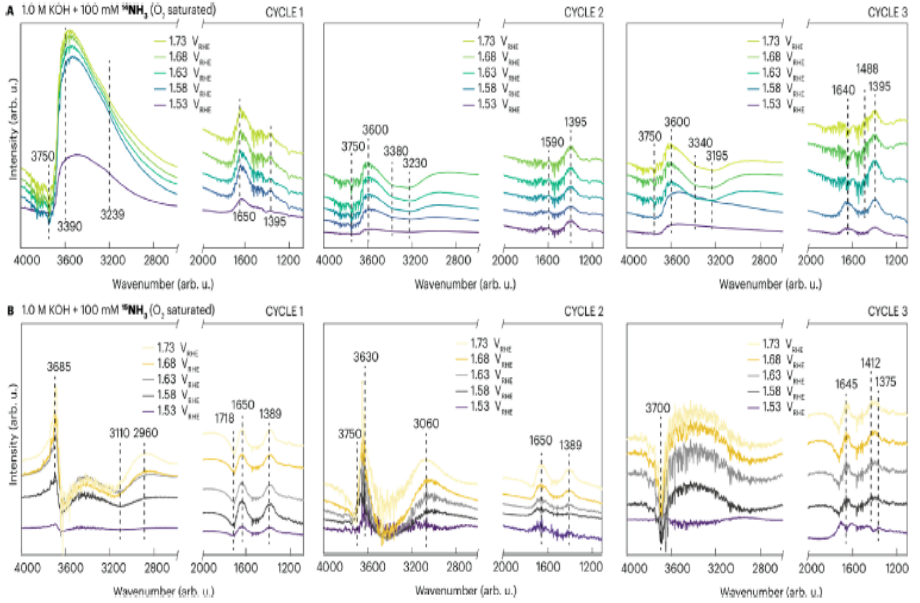

Fig. 10. *In situ* electrochemical ATR-IR study of staircase electrolysis of NiOOH/$Ni(OH)_2$ electrode in O_2-saturated KOH electrolytes: (A), in $^{14}NH_3$, (B), in $^{15}NH_3$. Three cycles were performed and shown from left to right. Results are shown as differential spectra, where the first spectrum of each cycle was subtracted from the subsequent spectra.

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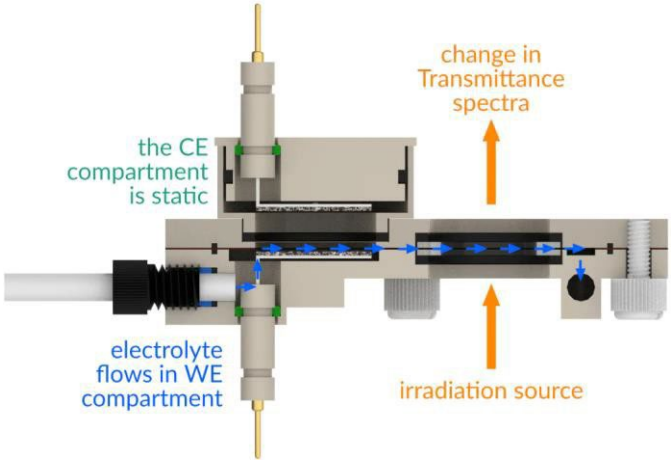
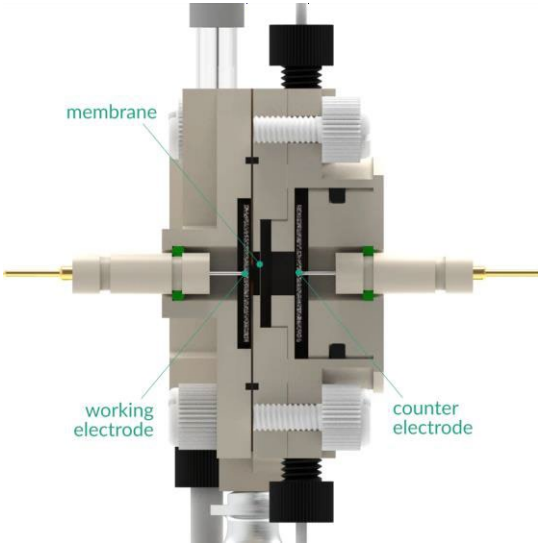
Spectro-Electrosynthesis H-Cells for UV-Vis, NIR, IR (CaF2) & Ultra Fast Laser Spectroscopy





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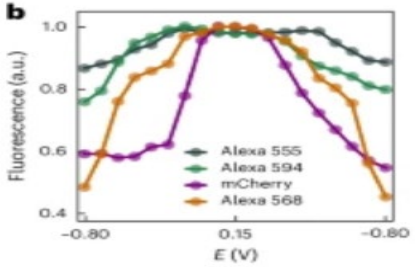

Spectro-EC Fluorescence Applications
Dissecting Biological Matrix

Spectro-EC with Fluorescence Modulation

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Electrochemical fluorescence modulation enables simultaneous multicolour imaging

Ying Yang, Yuanqing Ma ✉, Alexander Macmillan, Richard Tilley & J. Justin Gooding ✉

Nature Photonics **19**, 718–724 (2025) | Cite this article

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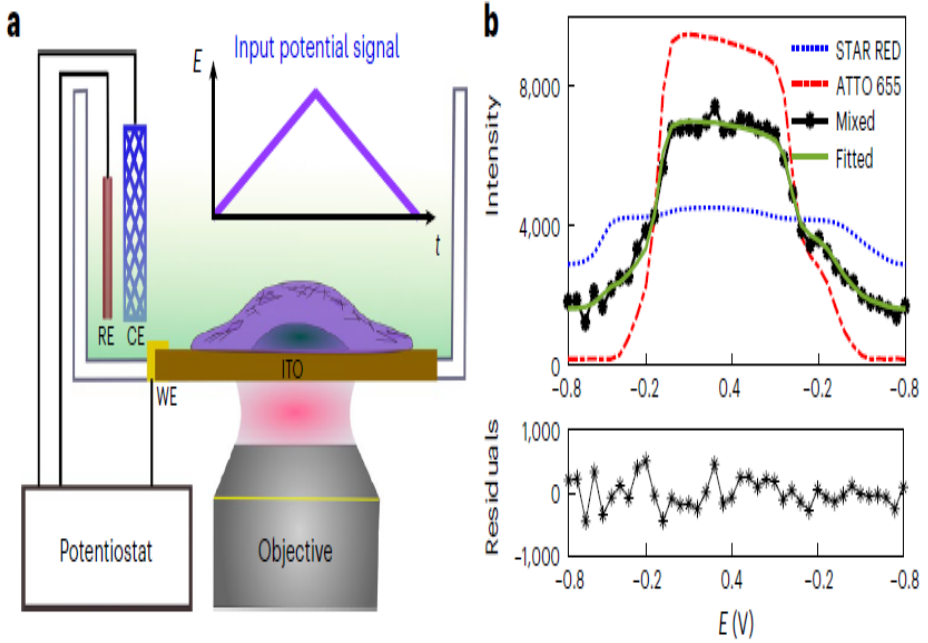

Plug-n-Play Fluorescence Spectro-electrochemistry Kit

- Plug-n-play operation
- Range: 200-1100 nm
- Resolution: 0.2 to 7 nm
- Customizations available
- 90 Degree Excitation
- Wavelength specific operation
- Spectro-EC Software
- Auto-trigger capability
- Real-time Plot Display
- Baseline Subtraction

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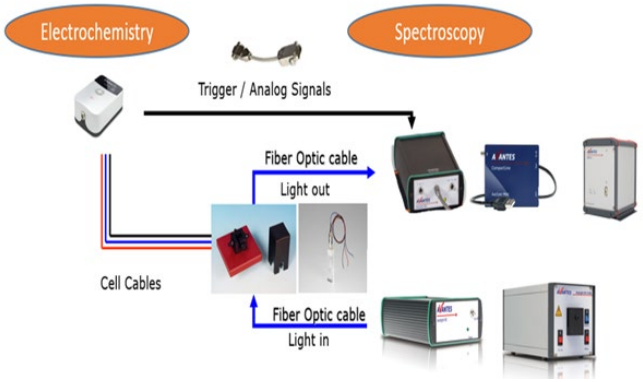
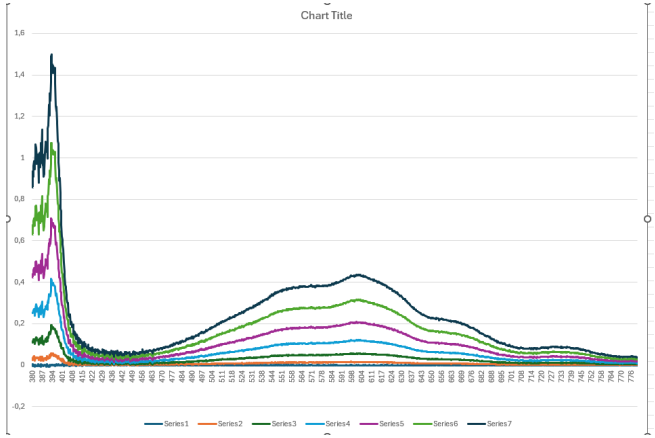


Spectro-EC Application Note - PalmSens

App Note: UV-Vis Spectro-EC of Methyl Viologen



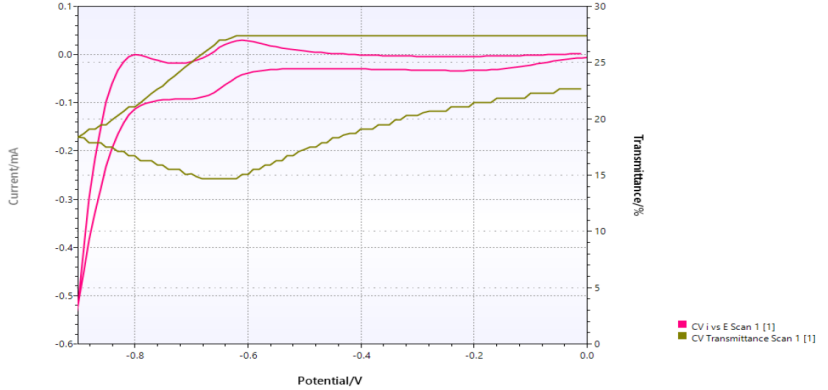


Figure 14: Example of resulted CV scan (pink, scan rate 0.01 V/s) of 1 mM MV solution in 0.1 M KCl. The transmittance in percentage (ecru) while performing the scan is plotted as a second Y-axis.

Spectroelectrochemistry

Get more insight into electrochemistry by adding a spectrometer to your potentiostat. This application note describes how to perform spectroelectrochemistry with a PalmSens4 and an Avantes potentiostat.

Download application note

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Installation, Training and Warranties

- 3 Year Manufacturer Warranty available
- Life time remote support – no charge
- 1 full day on-site training for Avantes and EC < $7500.00
  - $2500.00 – Avantes Expert – Ryan Flaherty -Set-up and Training for Spectro-EC Part
  - $5000.00 – EC Expert – Ritesh Vyas – Set up and Training

Compatibility in Glove-box

- USB-3 and Ethernet connectivity
- Compatible inside glove-box
- Will need one feed-through for connection with computer
- Software and future upgrades are included at no charge
- Videos, remote support available: https://www.youtube.com/@avantesbv

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