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Fraunhofer Institute for Ceramic Technologies and Systems IKTS

TAC Meeting
Development of electrochemical aptamer-based sensor for the early detection of cardiac troponin I

10-08-23

Ivan Lopez Carrasco

Content

1. Research topic
2. Objective of research
3. Current status of research
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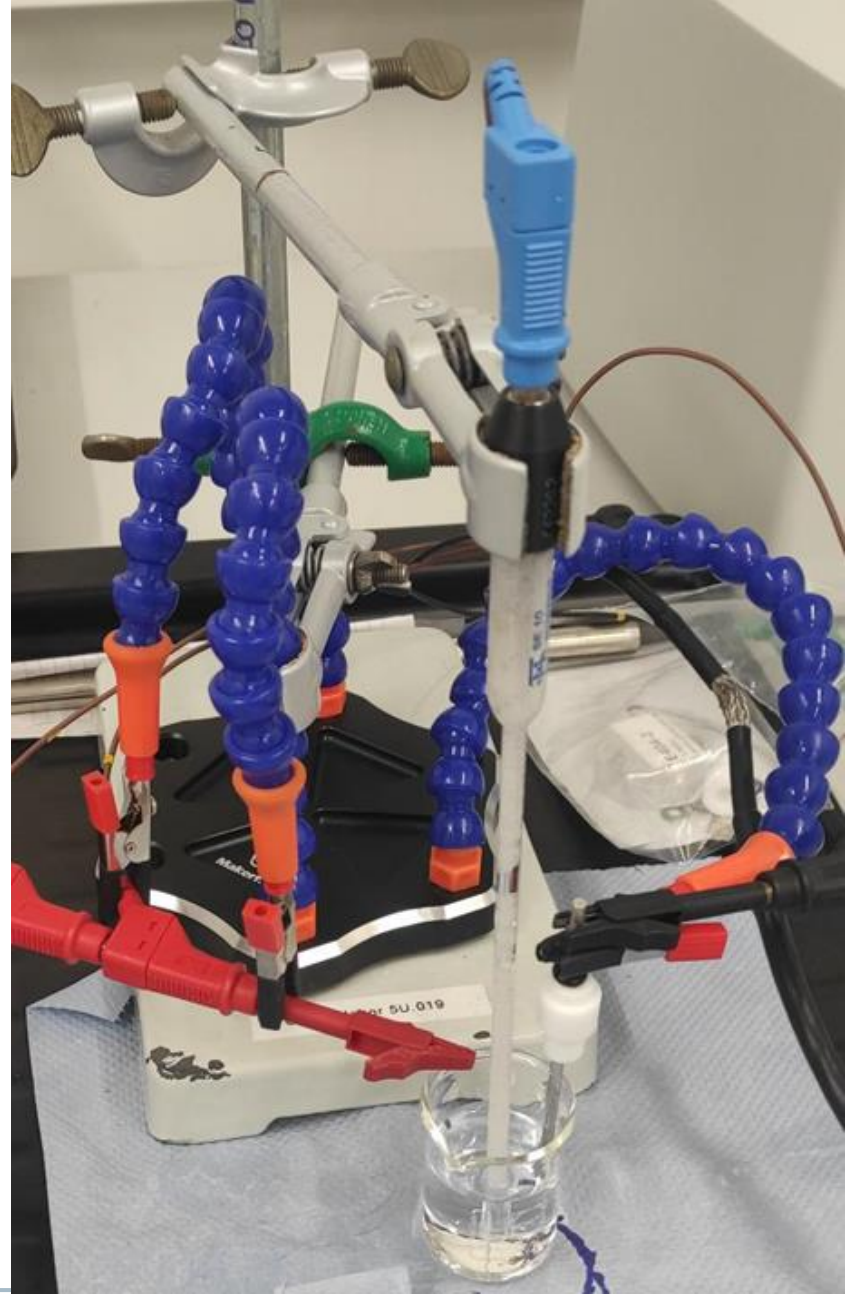

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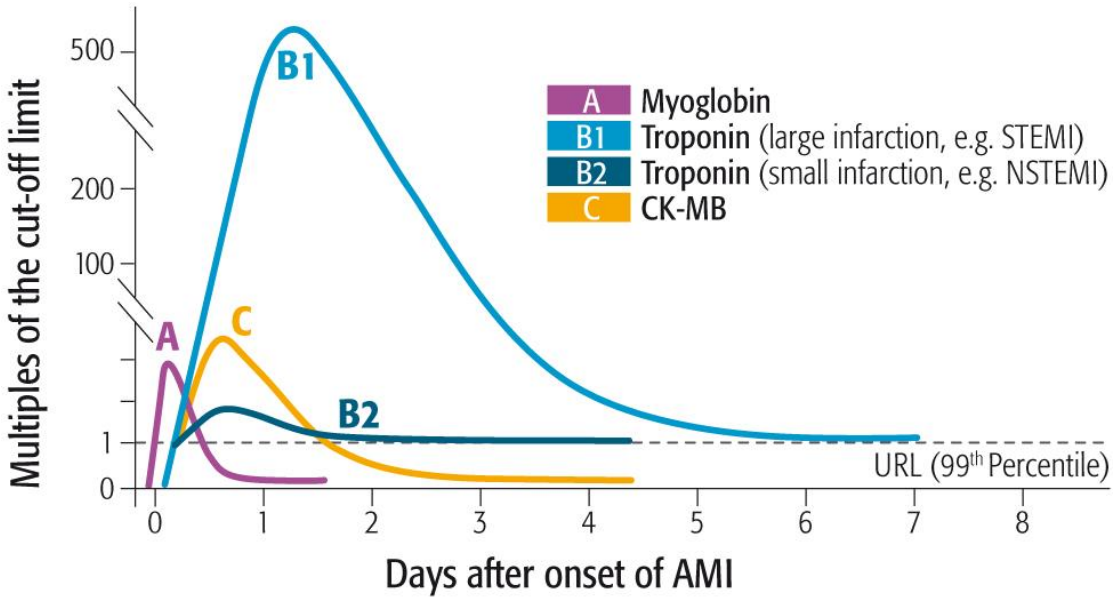
Ability of Troponin I to Predict Cardiac Events in Patients Admitted from the Emergency Department

Michael C. Kontos, MD, FACC, F. Philip Anderson, PHD, Ramin Alimard, MD,
Joseph P. Ornato, MD, FACC, James L. Tatum, MD, Robert L. Jesse, MD, PHD, FACC
Richmond, Virginia

- Reference value Troponin I: 0 - 0.04 ng/mL.
- Serum levels rise within the next 12 h after AMI.
- Optimal cutoff value for MI 1ng/ml.
- Cutoff values as markers of CT-induced cardiotoxicity cTnI > 0.50ng/ml cTnI > 0.08ng/ml



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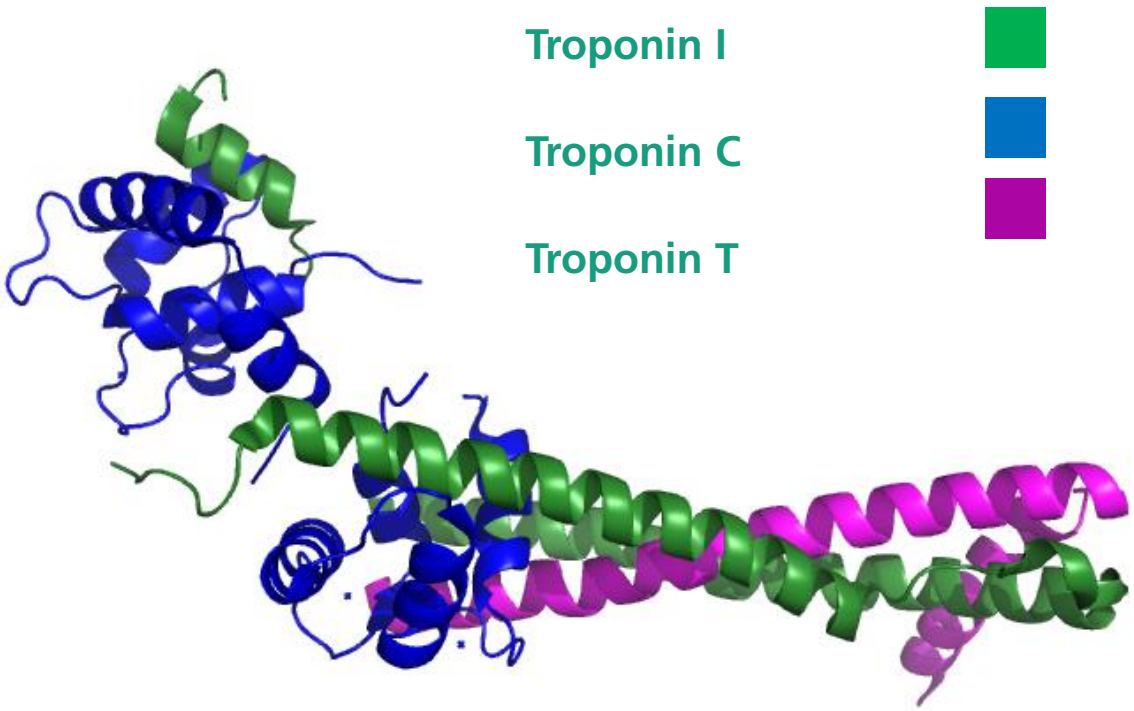
Troponin complex as biomarker of heart injury and aptamers that bind to troponin I

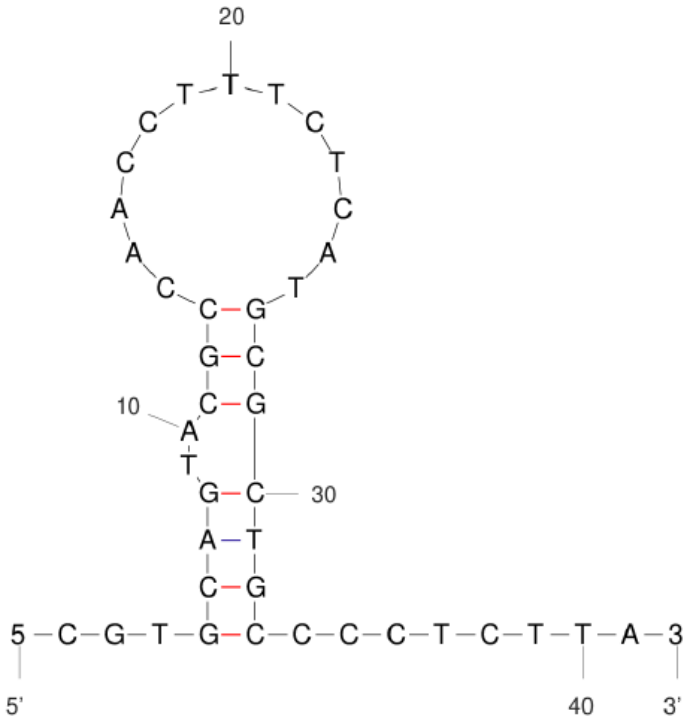


Troponin I

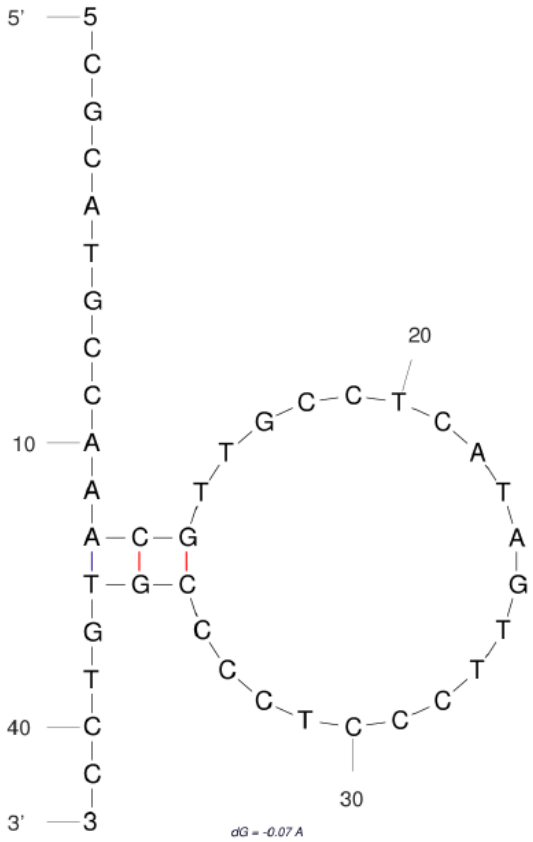
Troponin C

Troponin T

Tro4



Tro6



https://en.wikipedia.org/w/index.php?title=Troponin&oldid=1044978411

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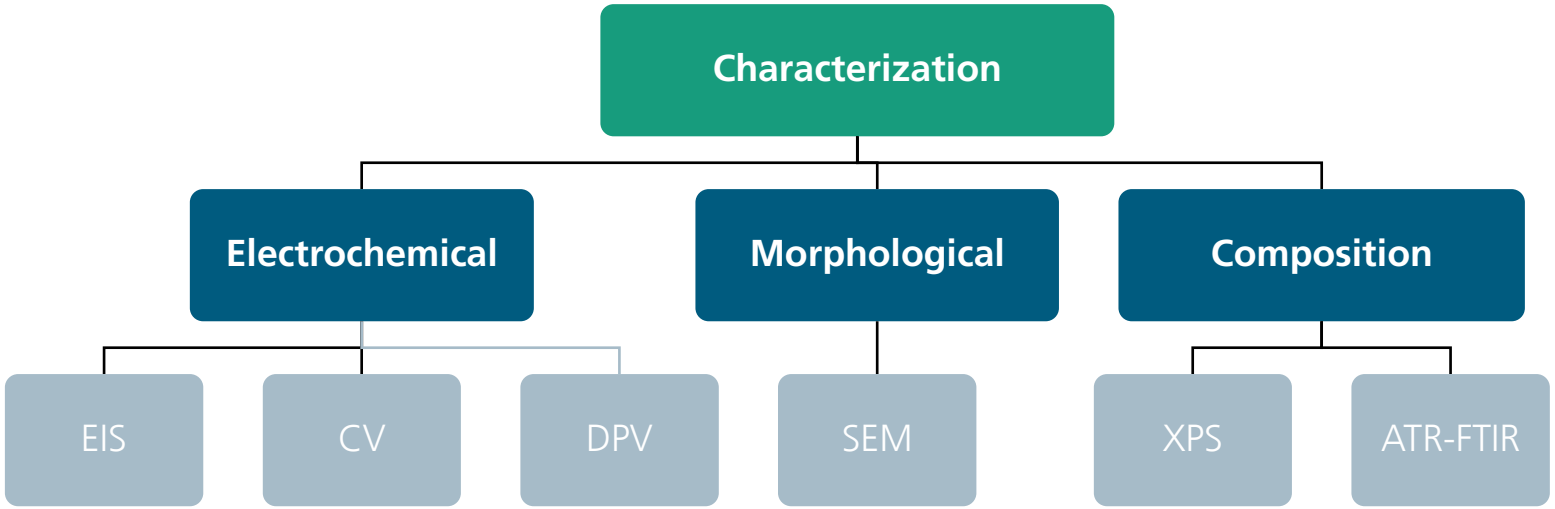
Development of Aptamer-based sensor for cardiac troponin I

Cleaning
- Characterization
- Morophological
- Electrochemical
- Composition

Immobilization
- Protocol thiolated-aptamer
- Characterization

Storage
- Set of parameters
- Characterization

Target detection
- Different target concentration
- Exposure time
- EC Characterization



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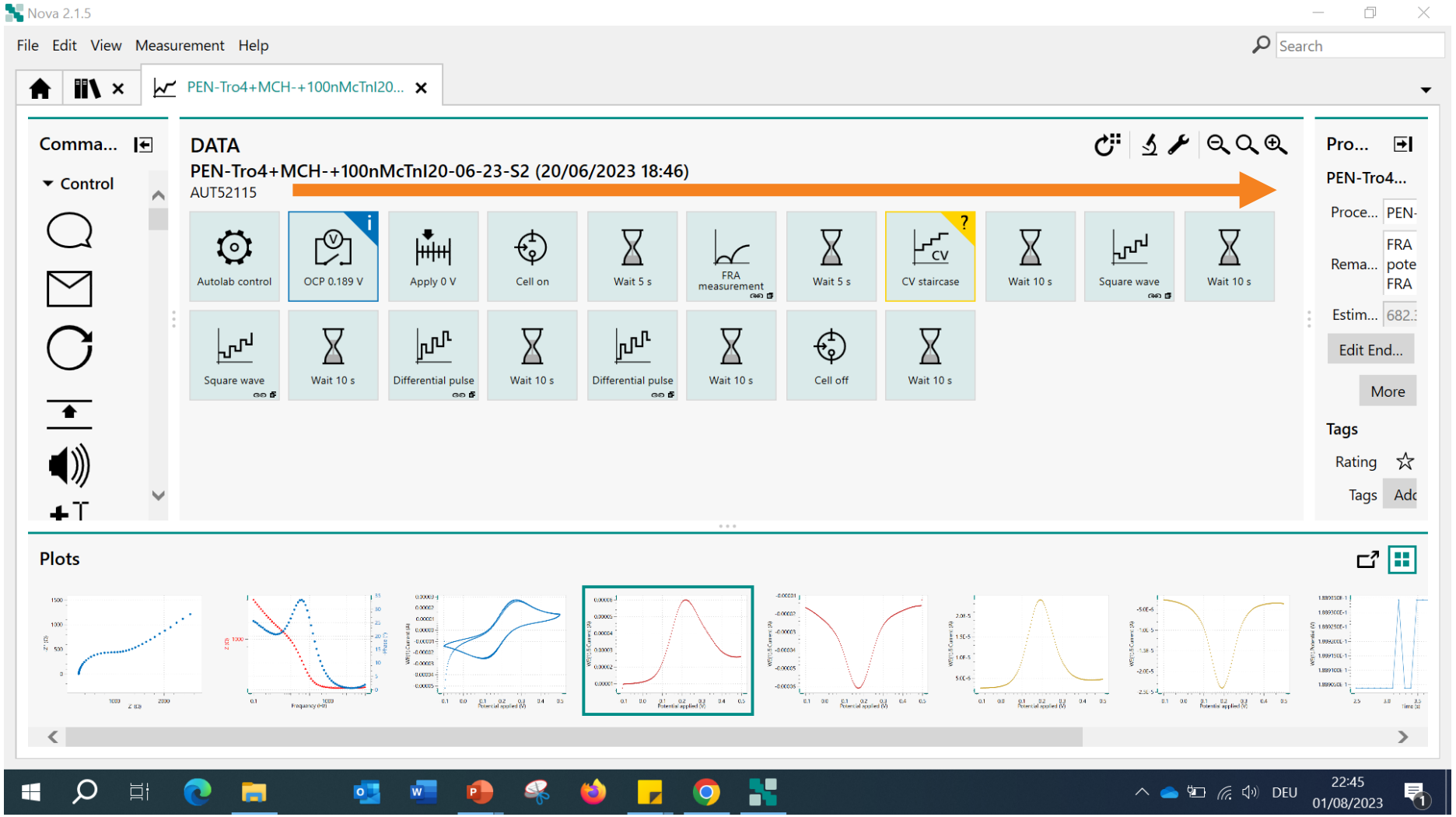
Procedure follow for electrochemical characterization



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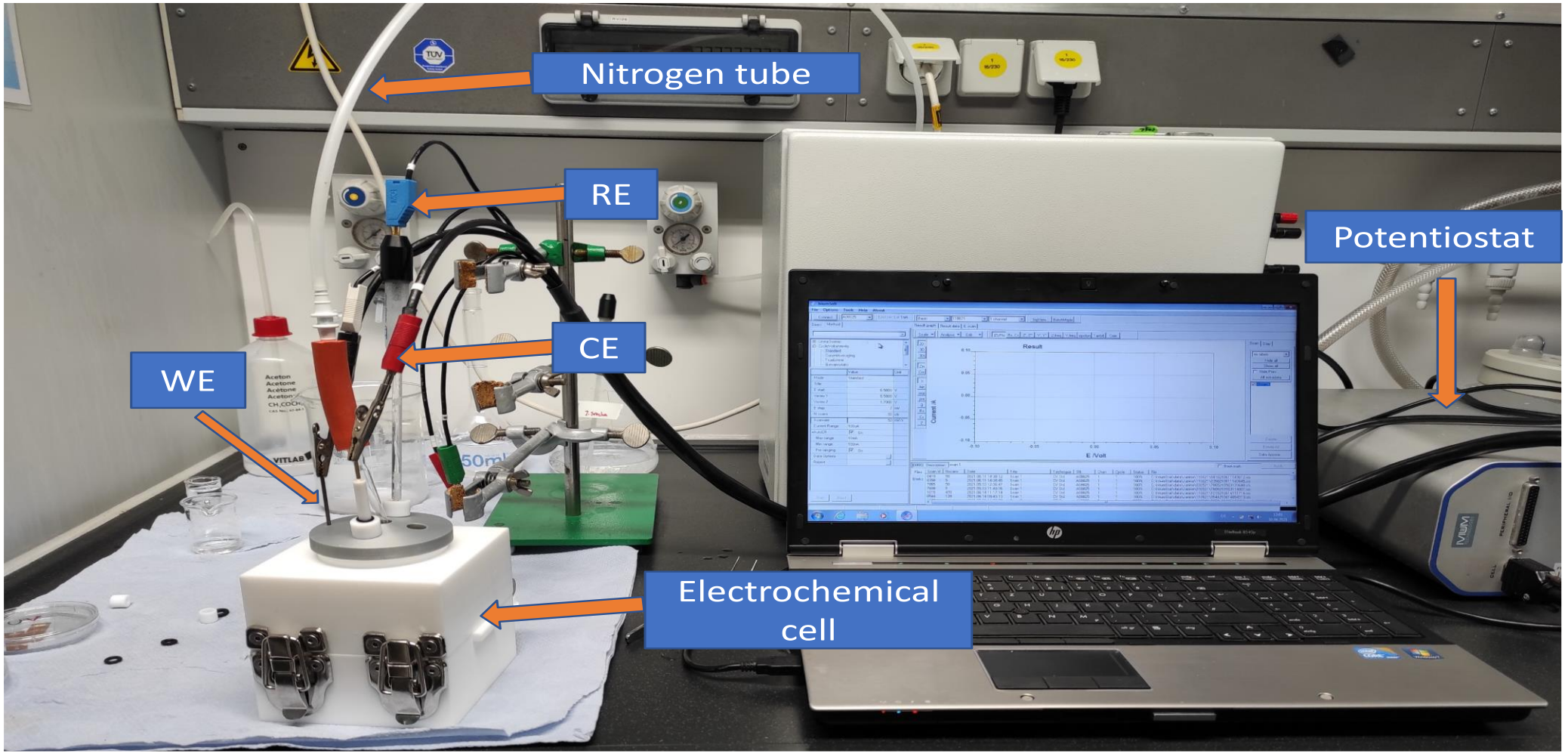
Experimental setup for electrochemical characterization



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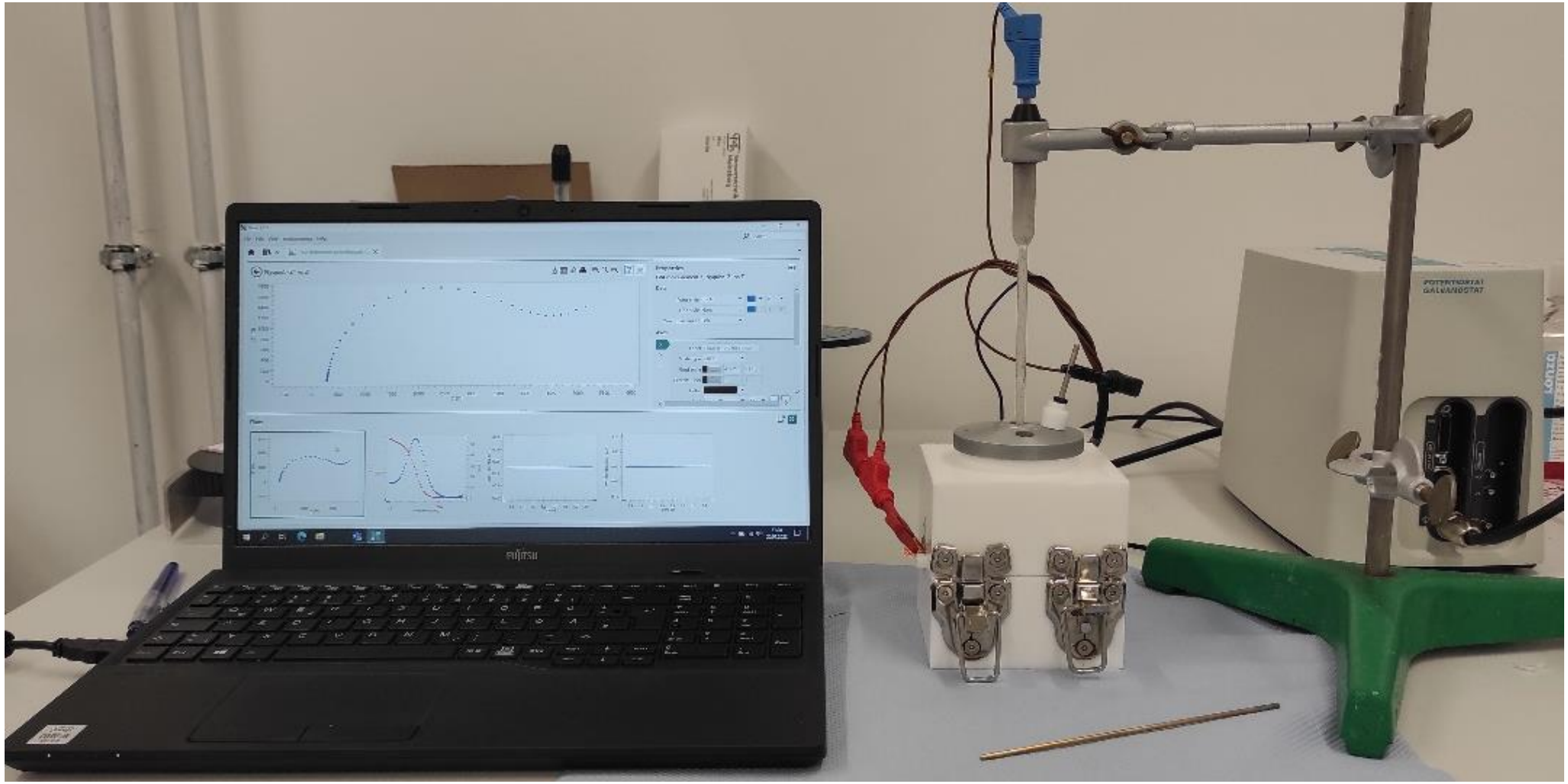
Experimental setup for electrochemical characterization



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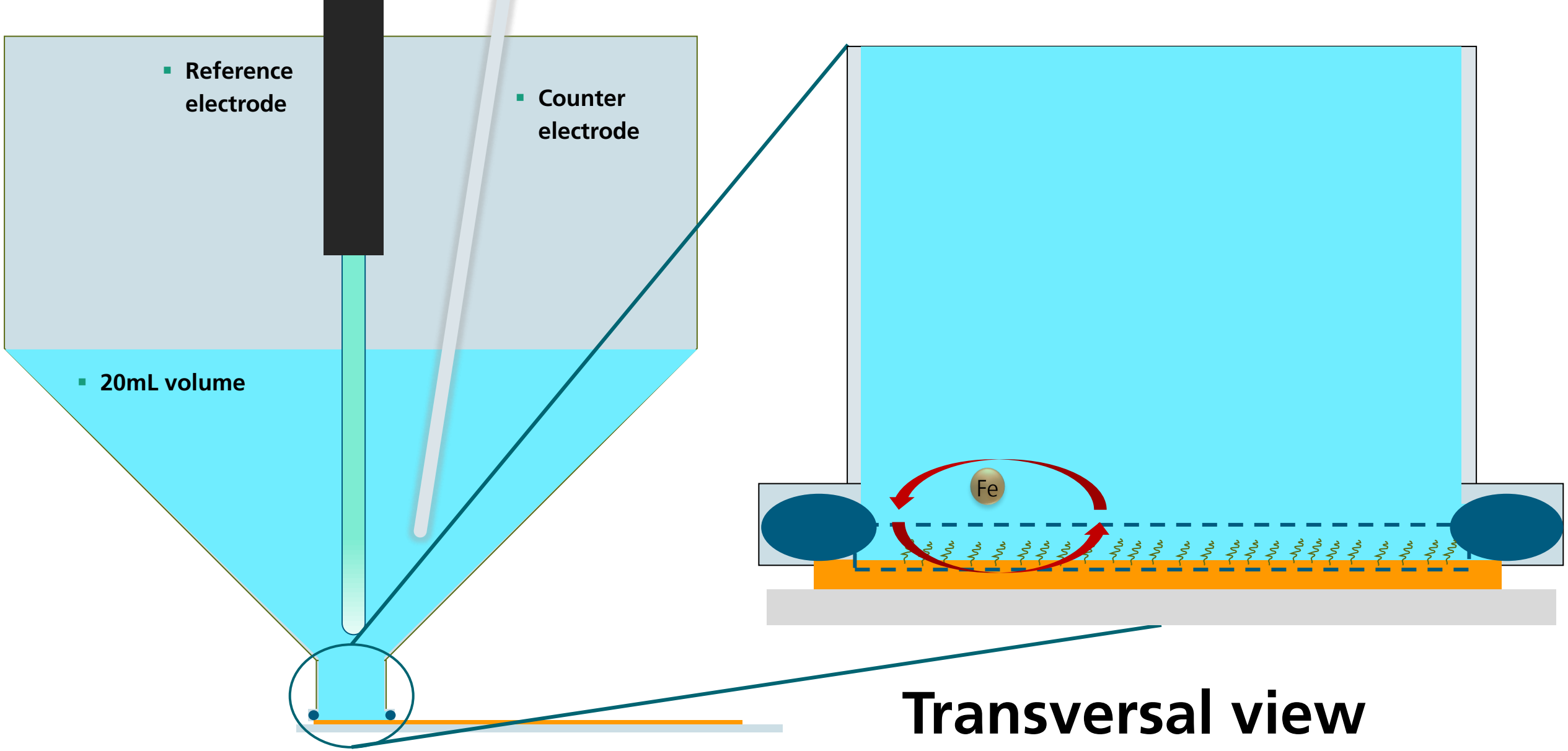

Transversal view

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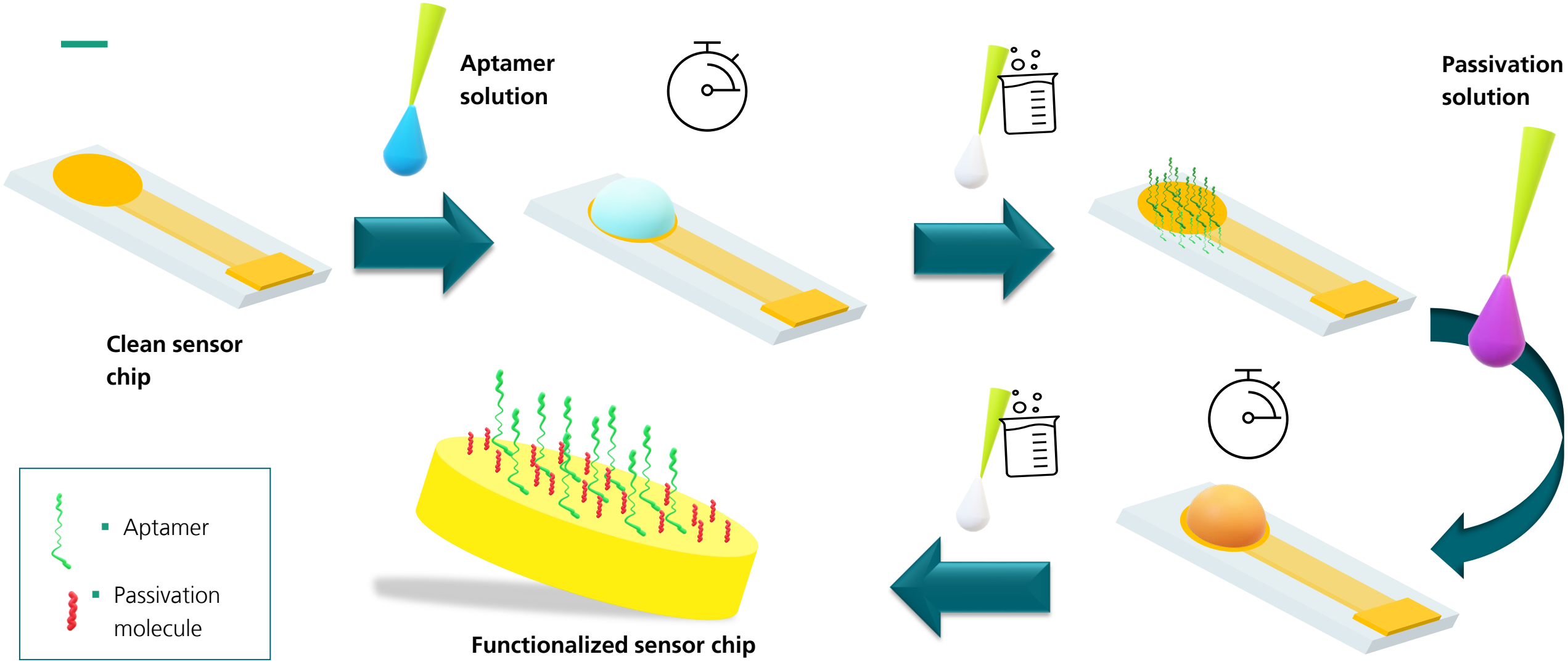
Parameter that are control in immobilization step

Code	Temperature	Time	Aptamer concentration (µM)	Co-immobilization	pH
Medium value 0	RT	10 hrs	15	50%	7.5
Low value -	4°C	20min	5	0	7
High Value +	46 °C	20 hrs	25	100%	8

Functionalization procedure



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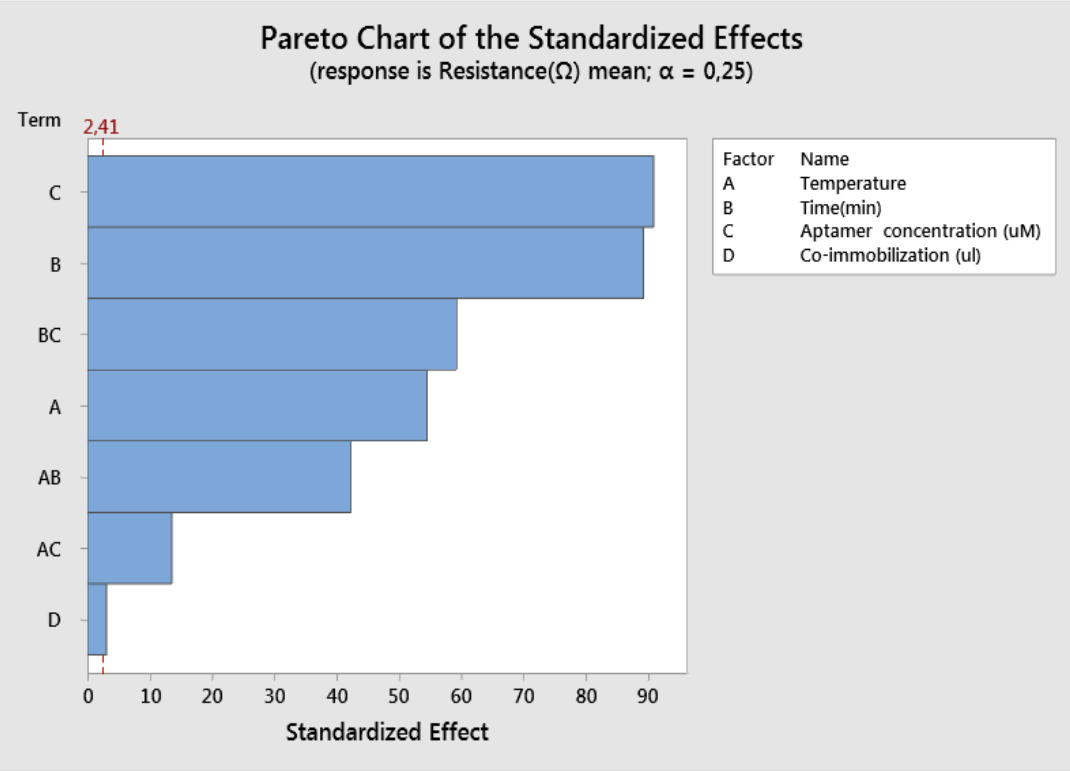
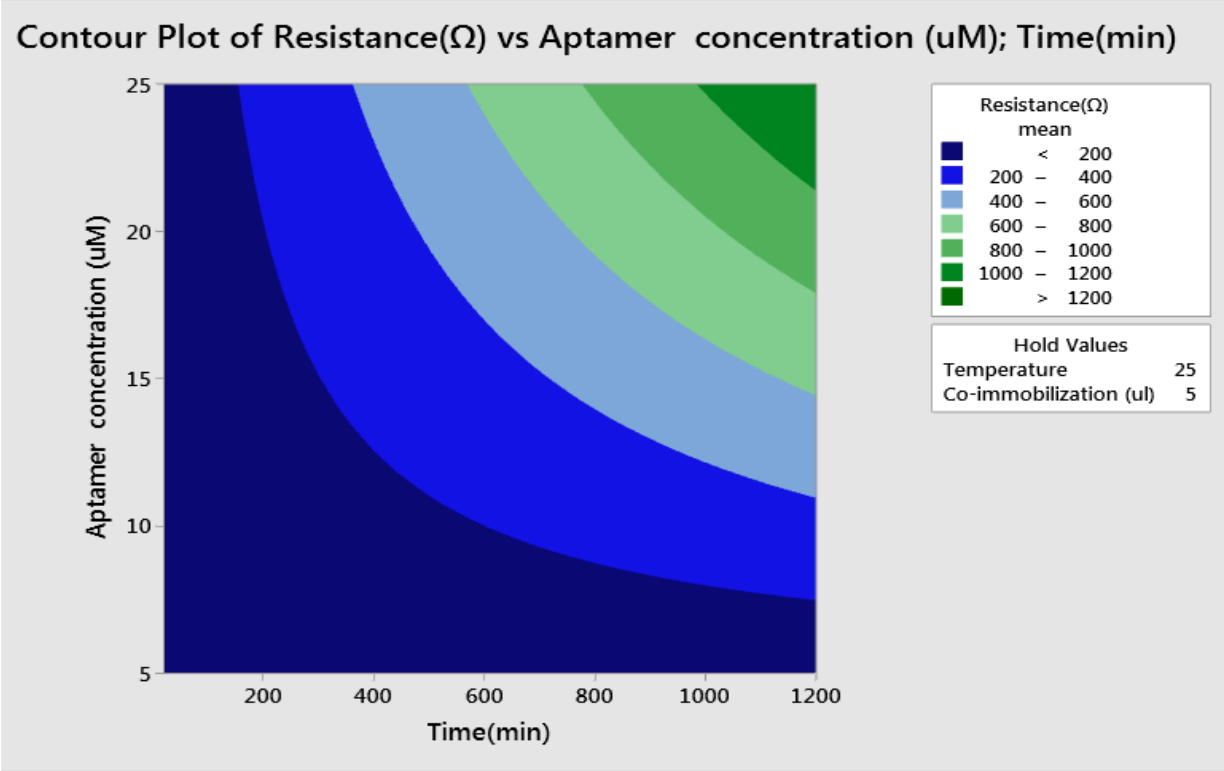
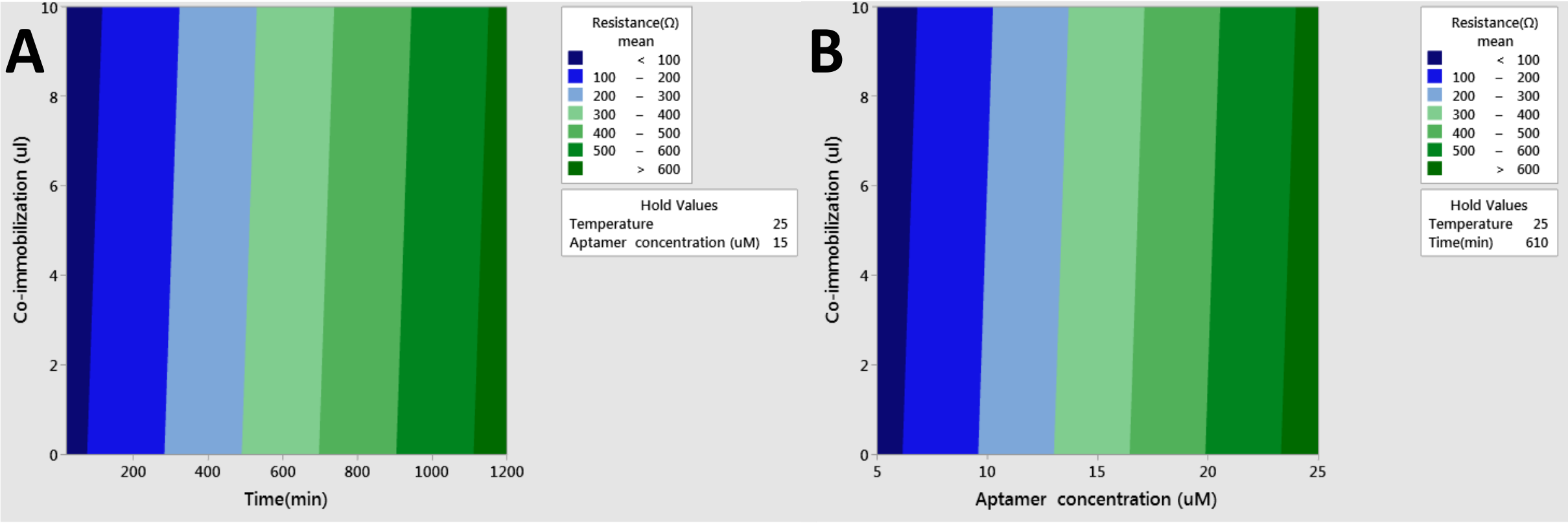
Pareto charts of the controlled parameters

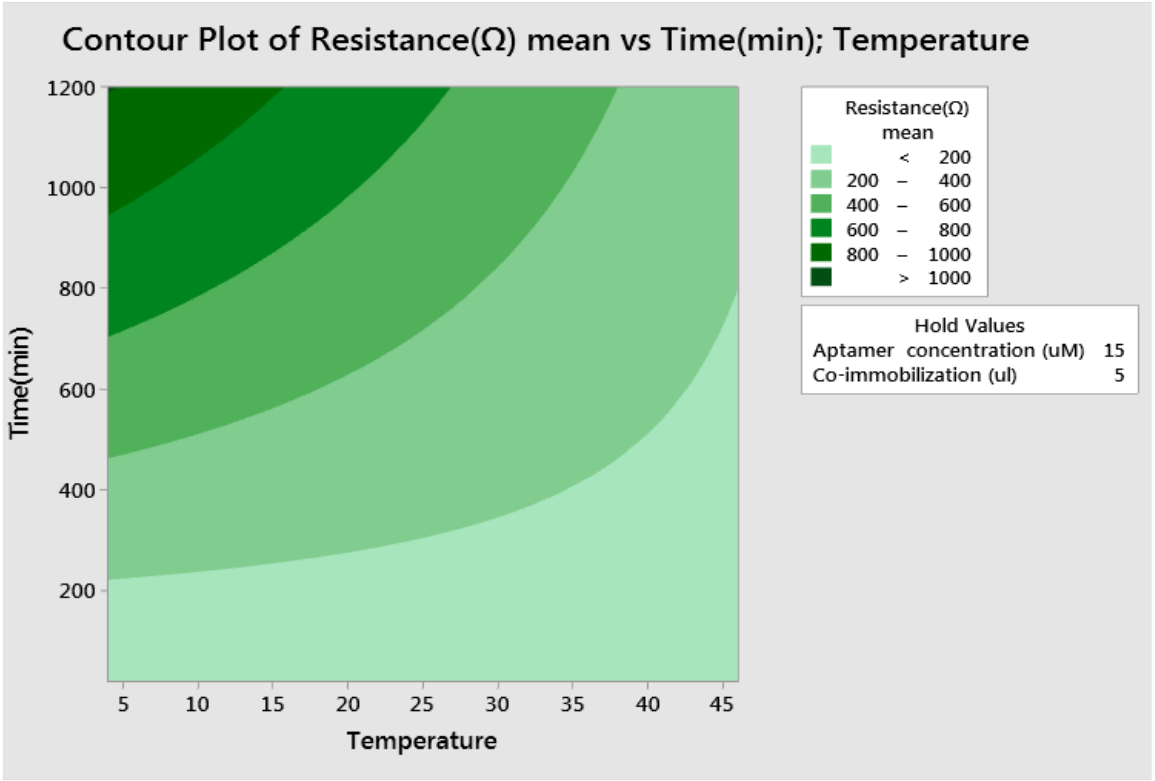


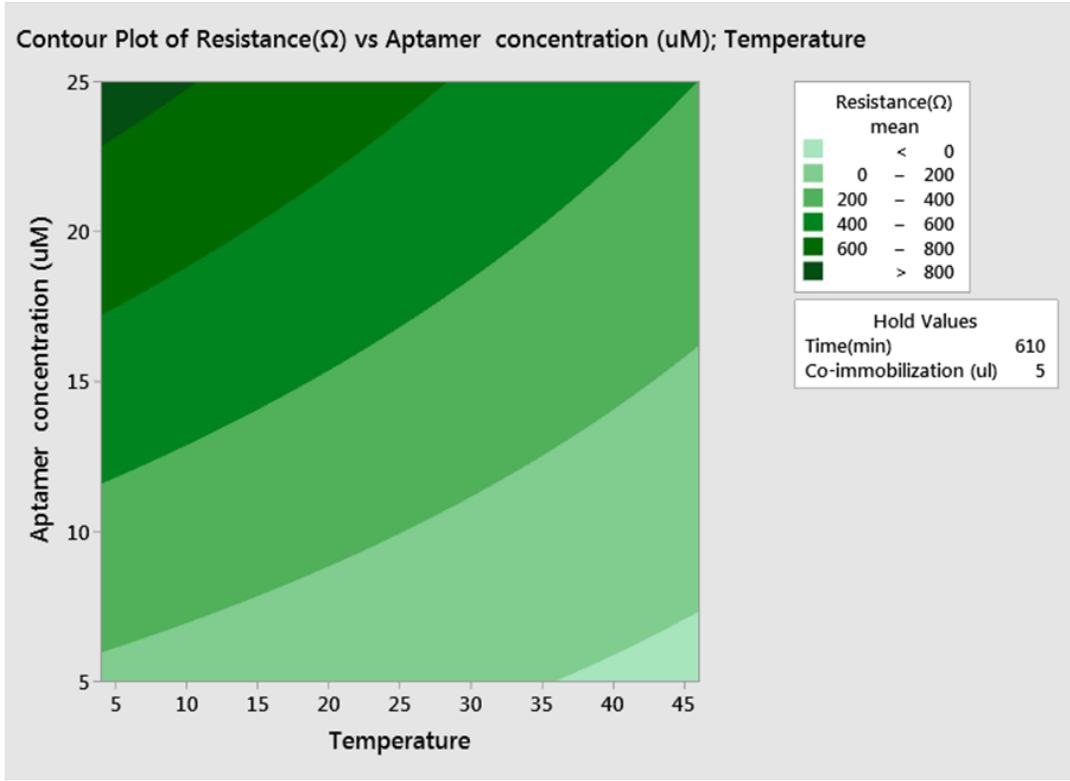


Co-immobilization vs the two main parameters



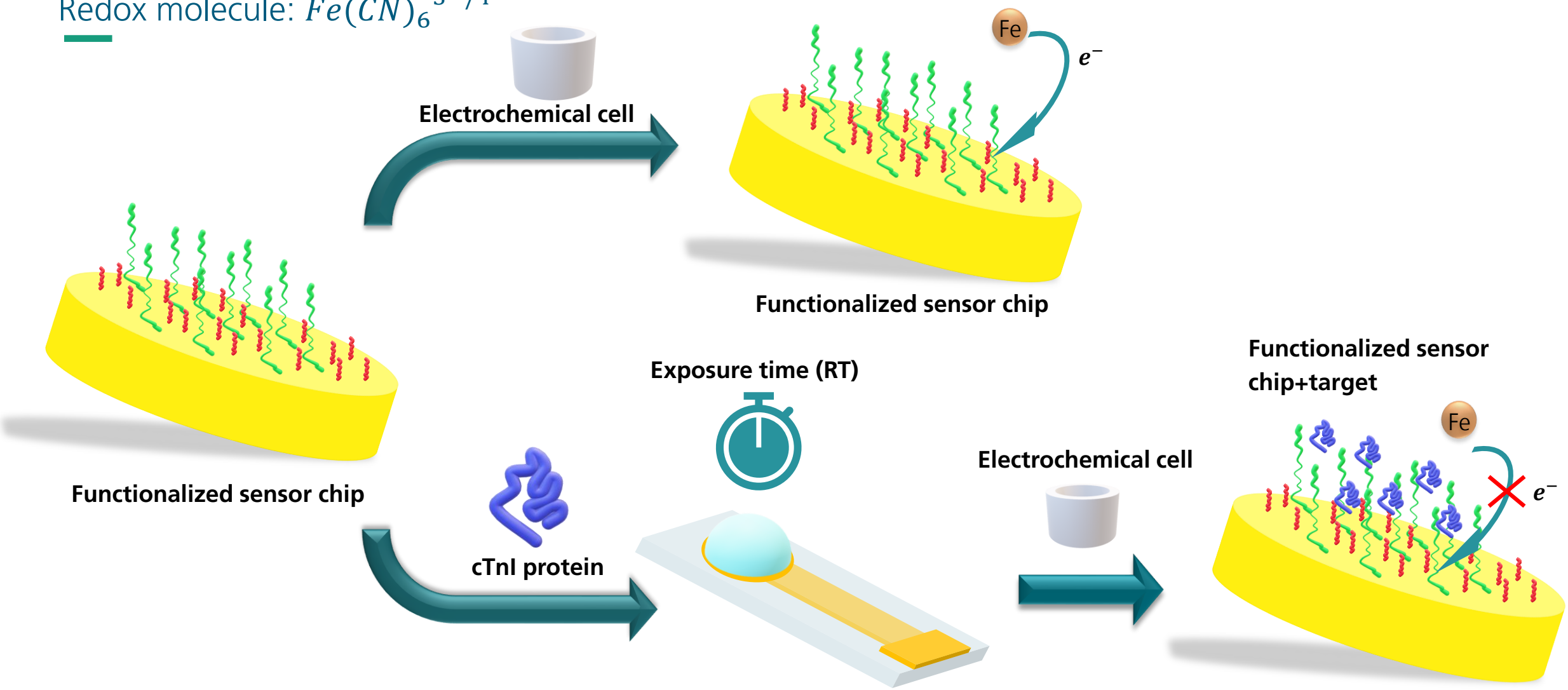
Contour plots for aptamer concentration and time





Detection methodology and electrochemical characterization

Redox molecule: $Fe(CN)_6^{3-/4-}$



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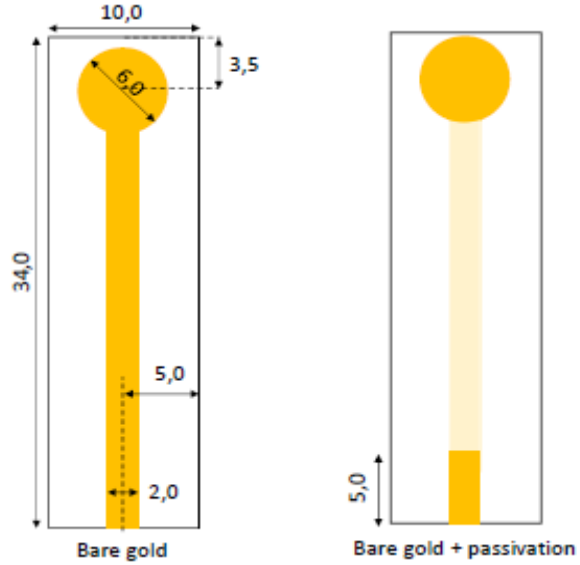
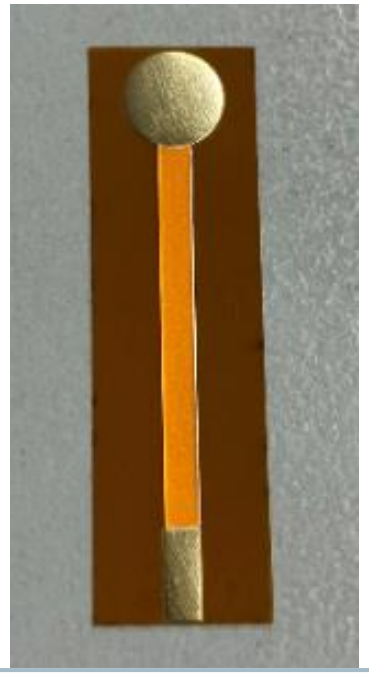
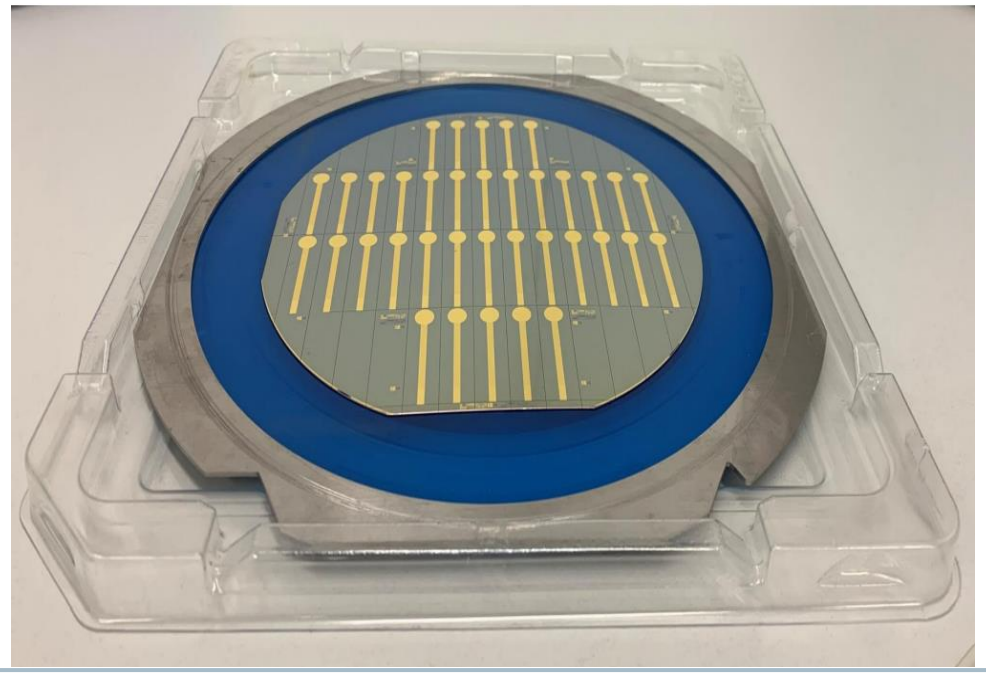
Sensor chip initial options

- PCB electrode with a chemical AuNi and with galvanic soft gold(with not Nickel)-add technology
- Silicon-base electrodes with a gold layer
- PEN-base gold electrodes







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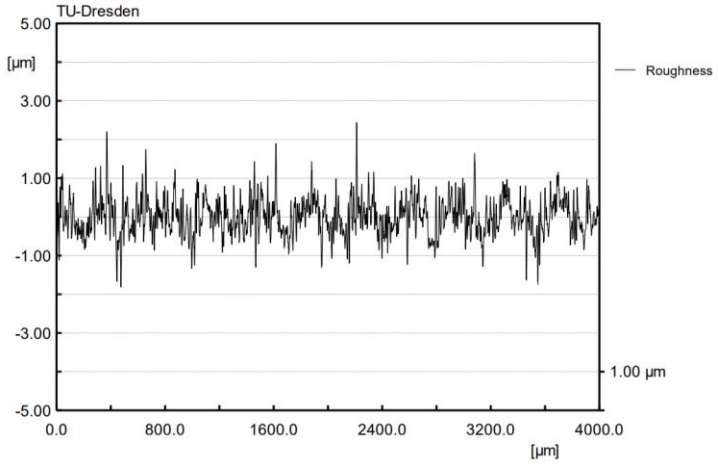
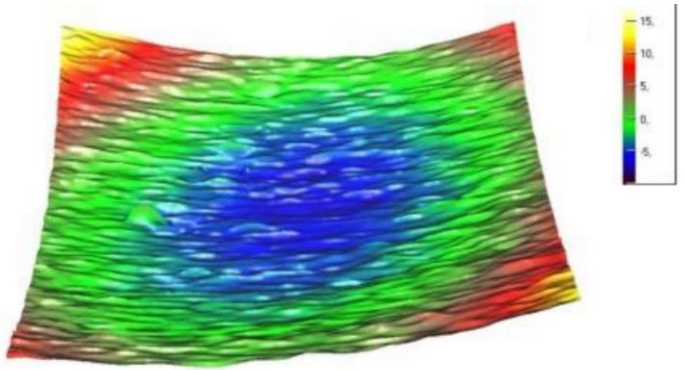
PEN-gold electrodes

Polyethylene naphthalene, pure gold , inkjet-printing

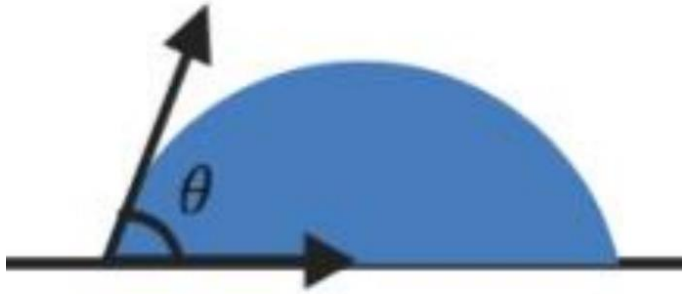
Laser profilometry measurements

- Roughness average 0.3710 ± 0.04



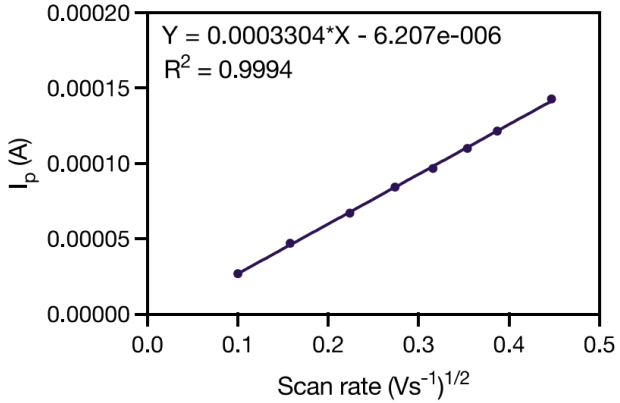


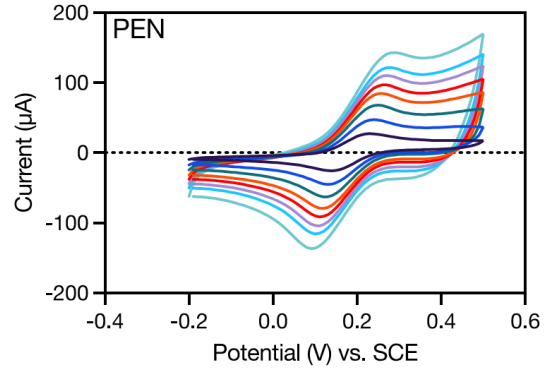
Contact angle	Water	DMSO	DIM
PEN	60.8 ± 2.6	16.7 ± 0.3	11.8 ± 0.3



Electrochemical Surface area

- $A_{effective} = 0{,}4558\ cm\text{^}2$
- $A_{geometric} = 0{,}2826\ cm\text{^}2$





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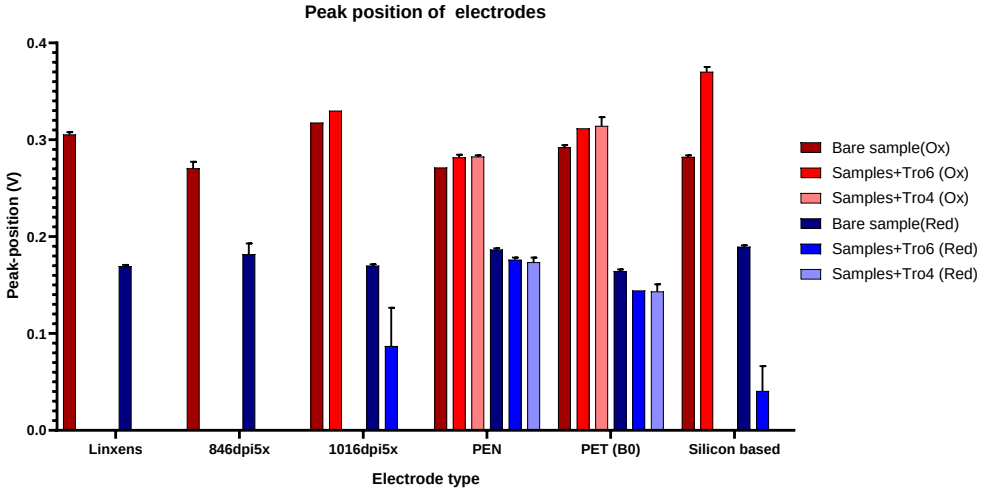
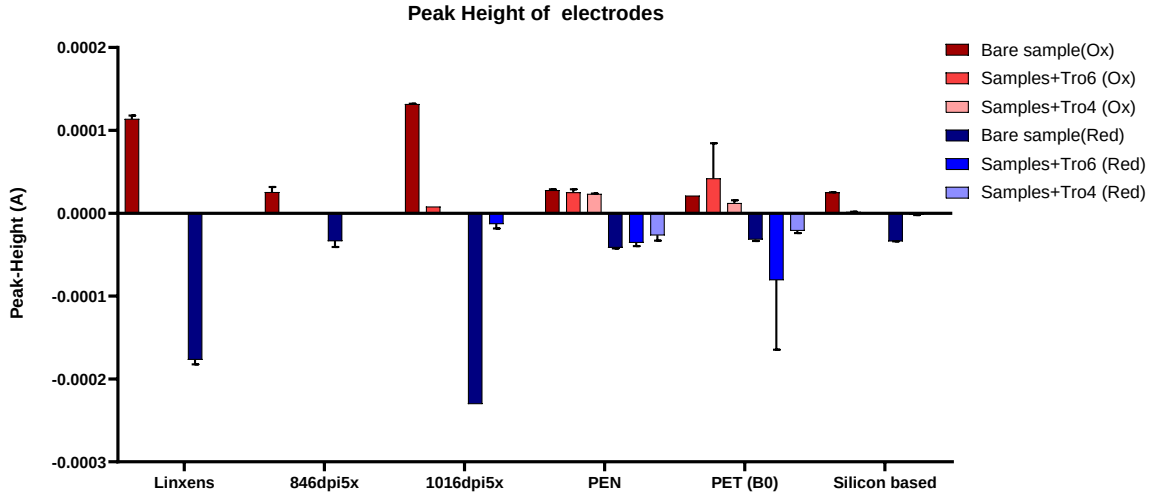
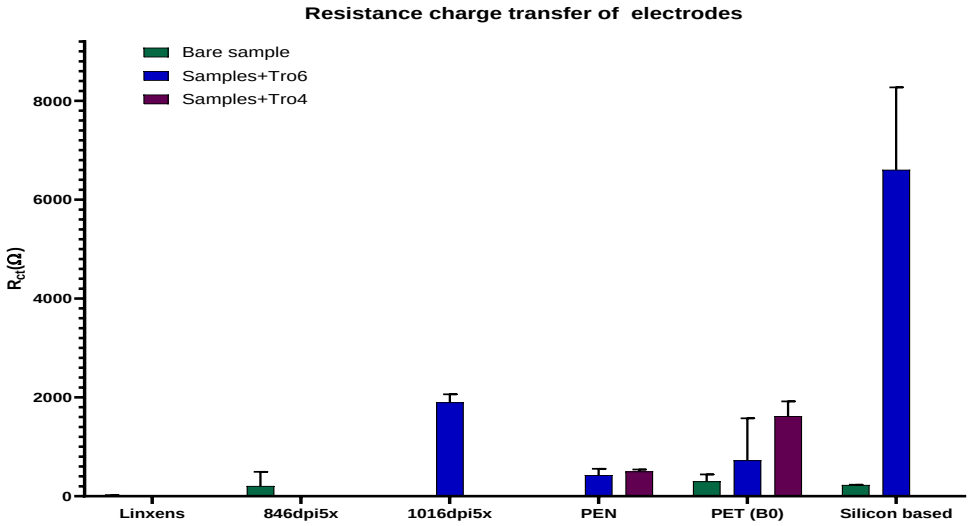
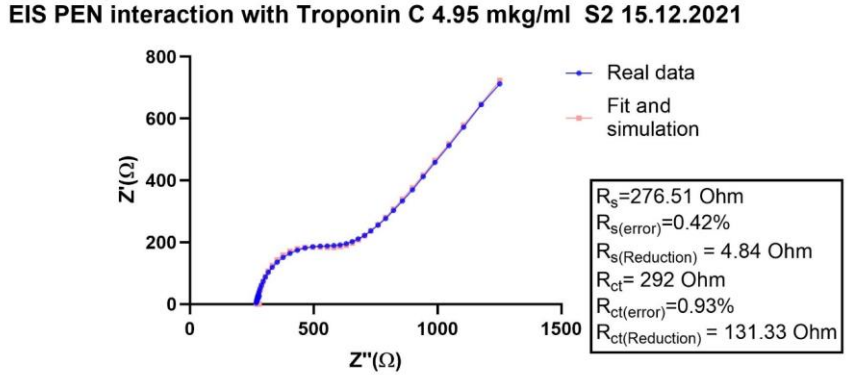
Summary of results of immobilization on different manufacturing electrode technologies

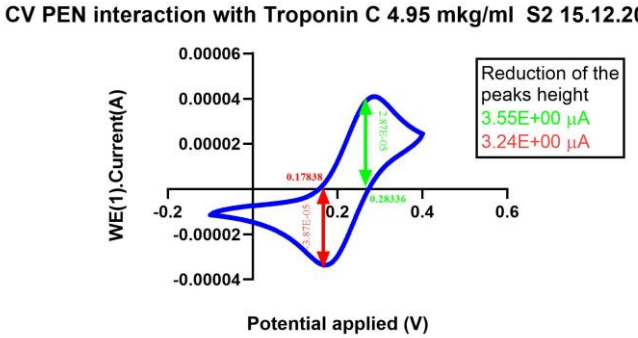
Results use in a publication











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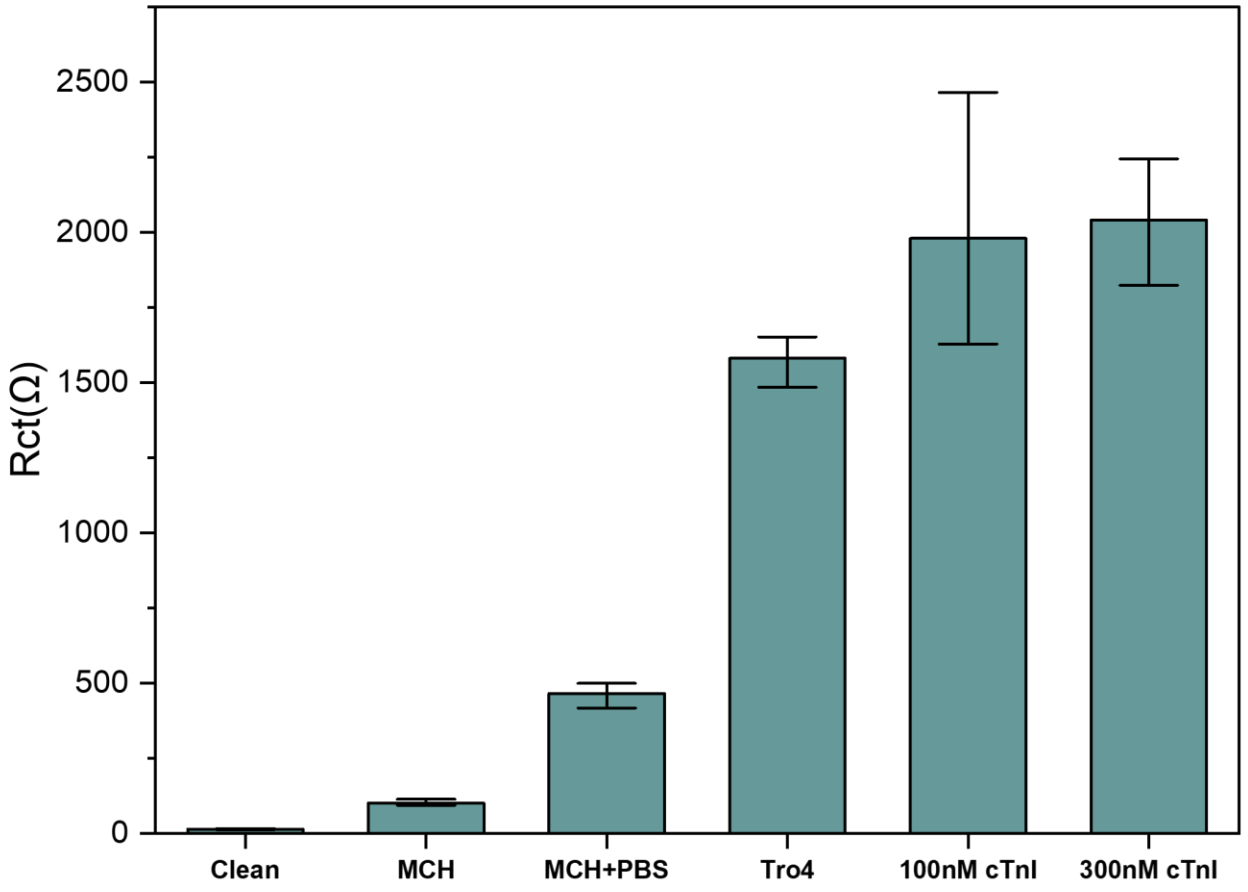
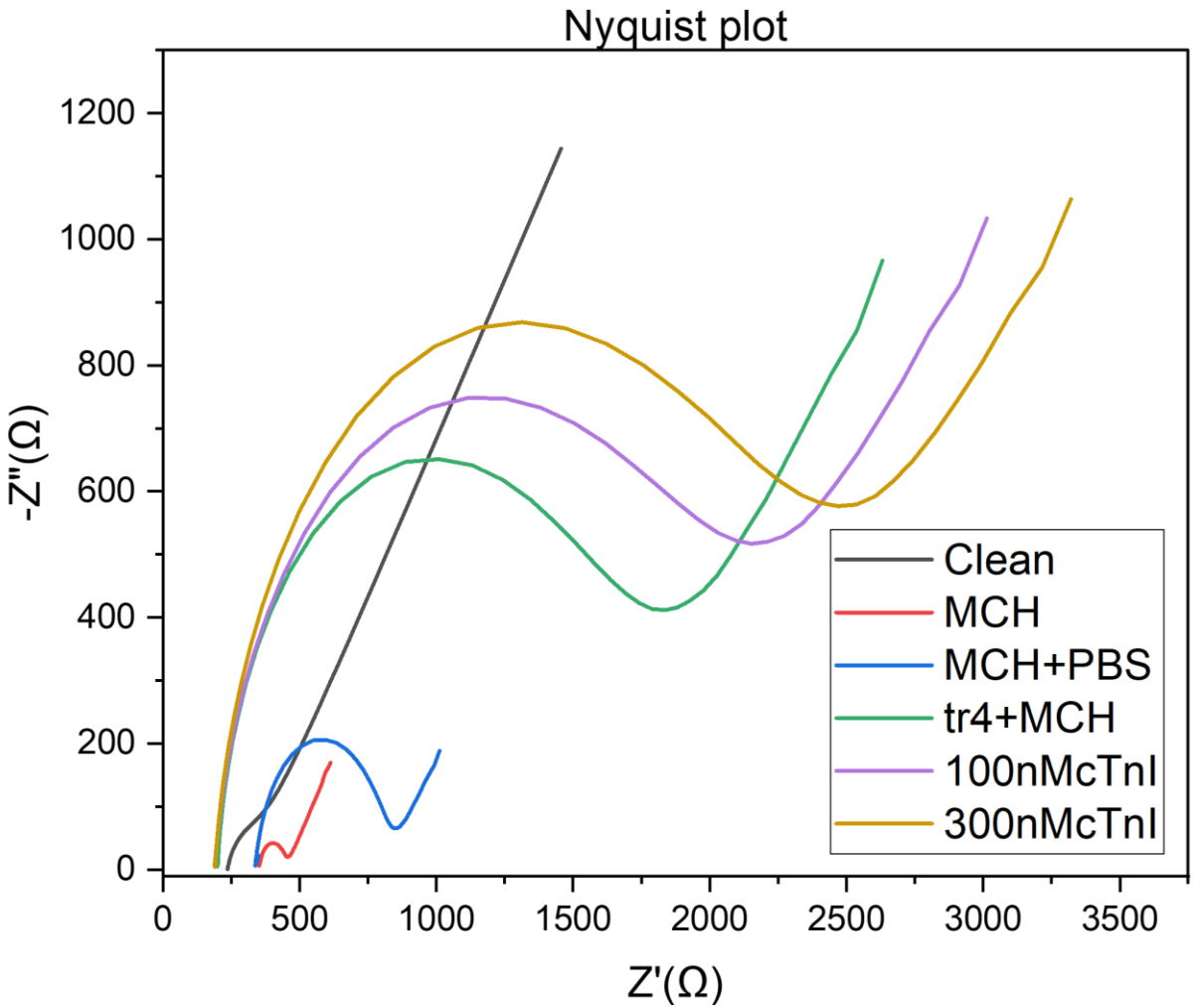
Results of immobilization steps and and binding events obtain with EIS

PEN substrate, 1mM $Fe(CN)_6^{3-/4-}$





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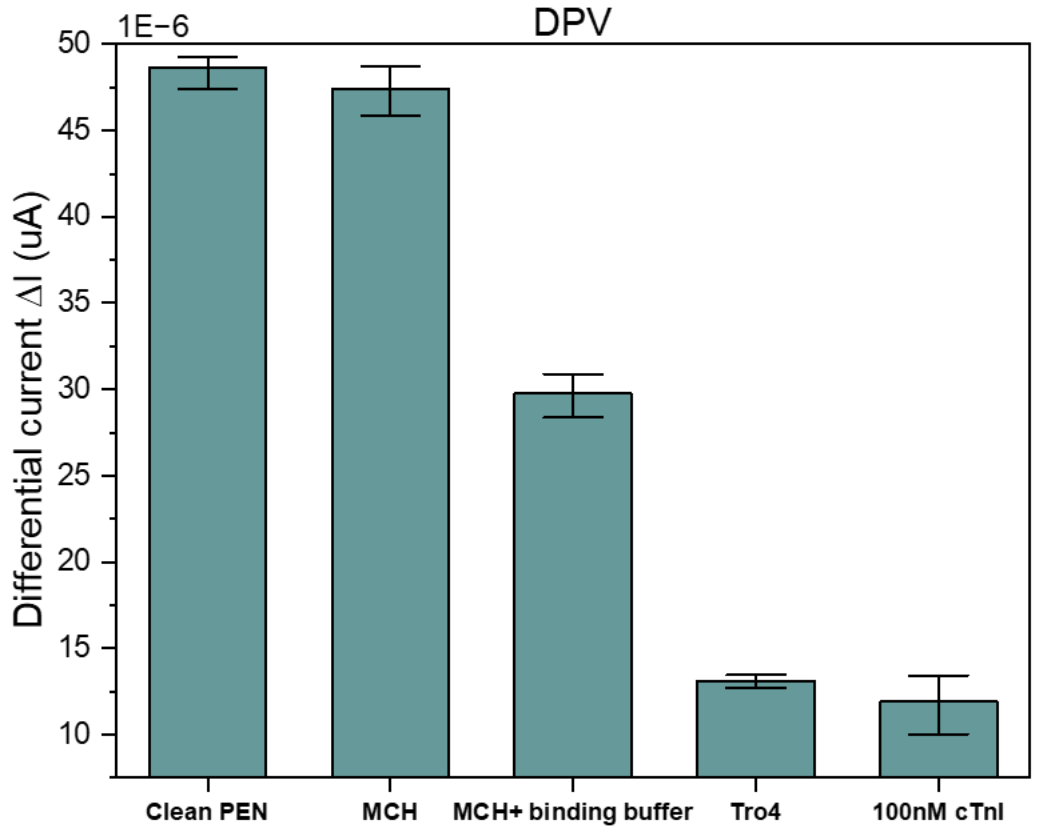
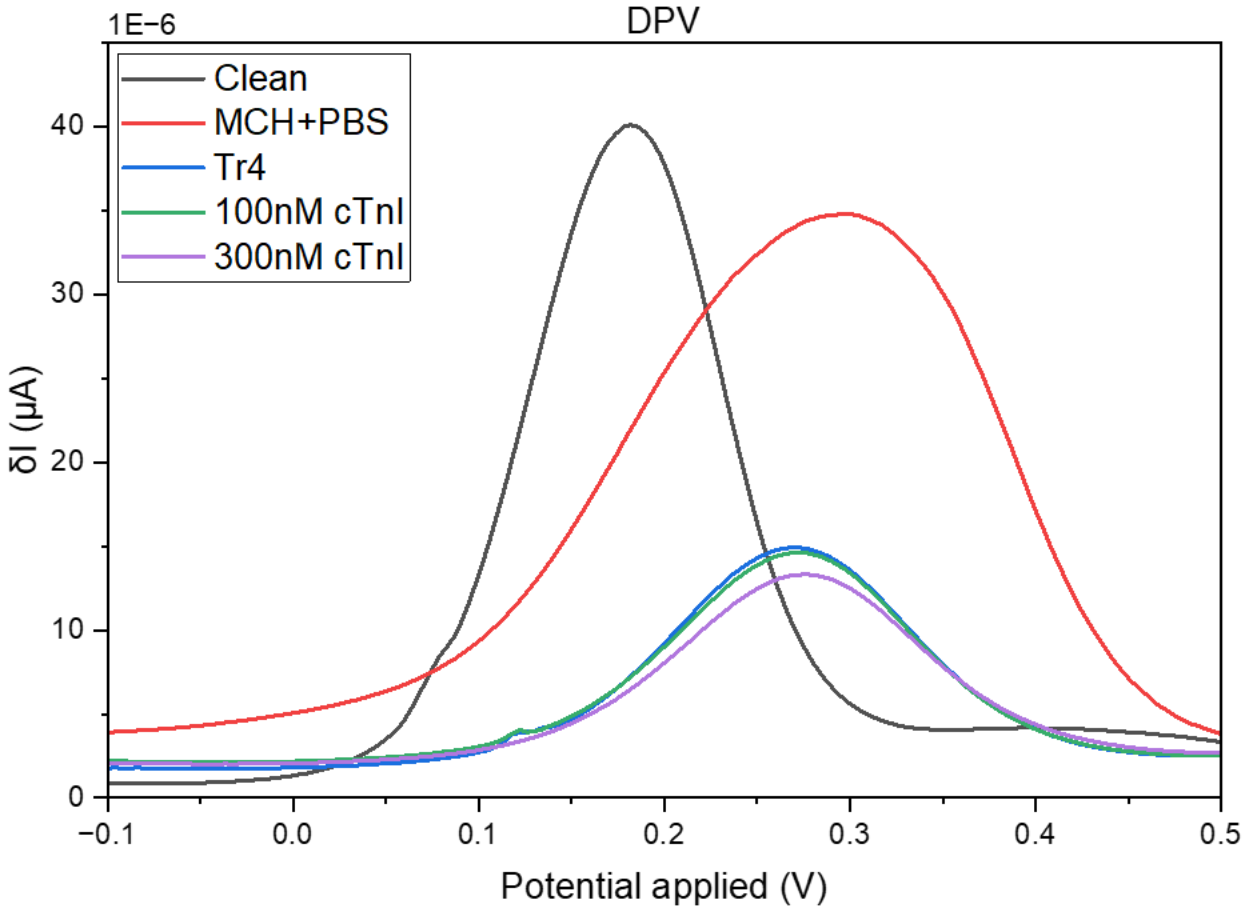
Results of immobilization steps and binding events obtain with DPV

PEN substrate, 1mM $Fe(CN)_6^{3-/4-}$





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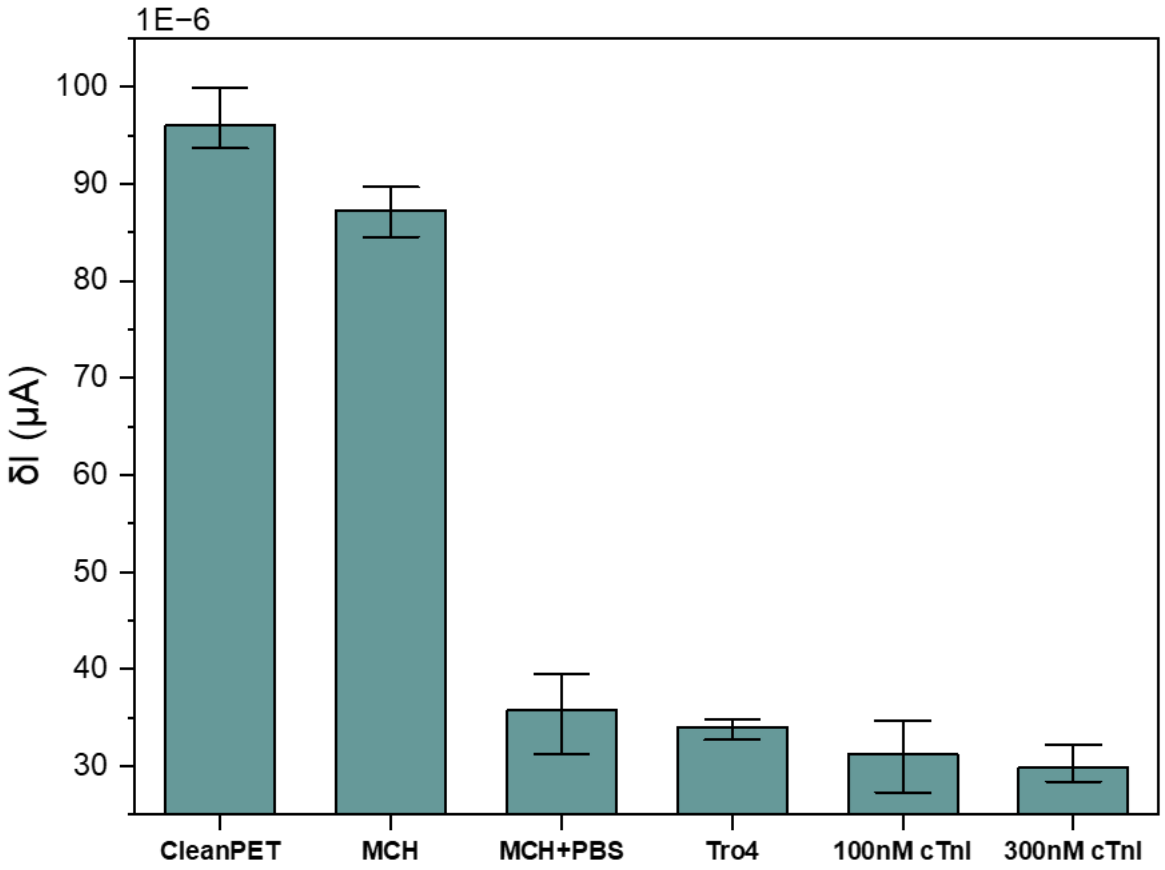
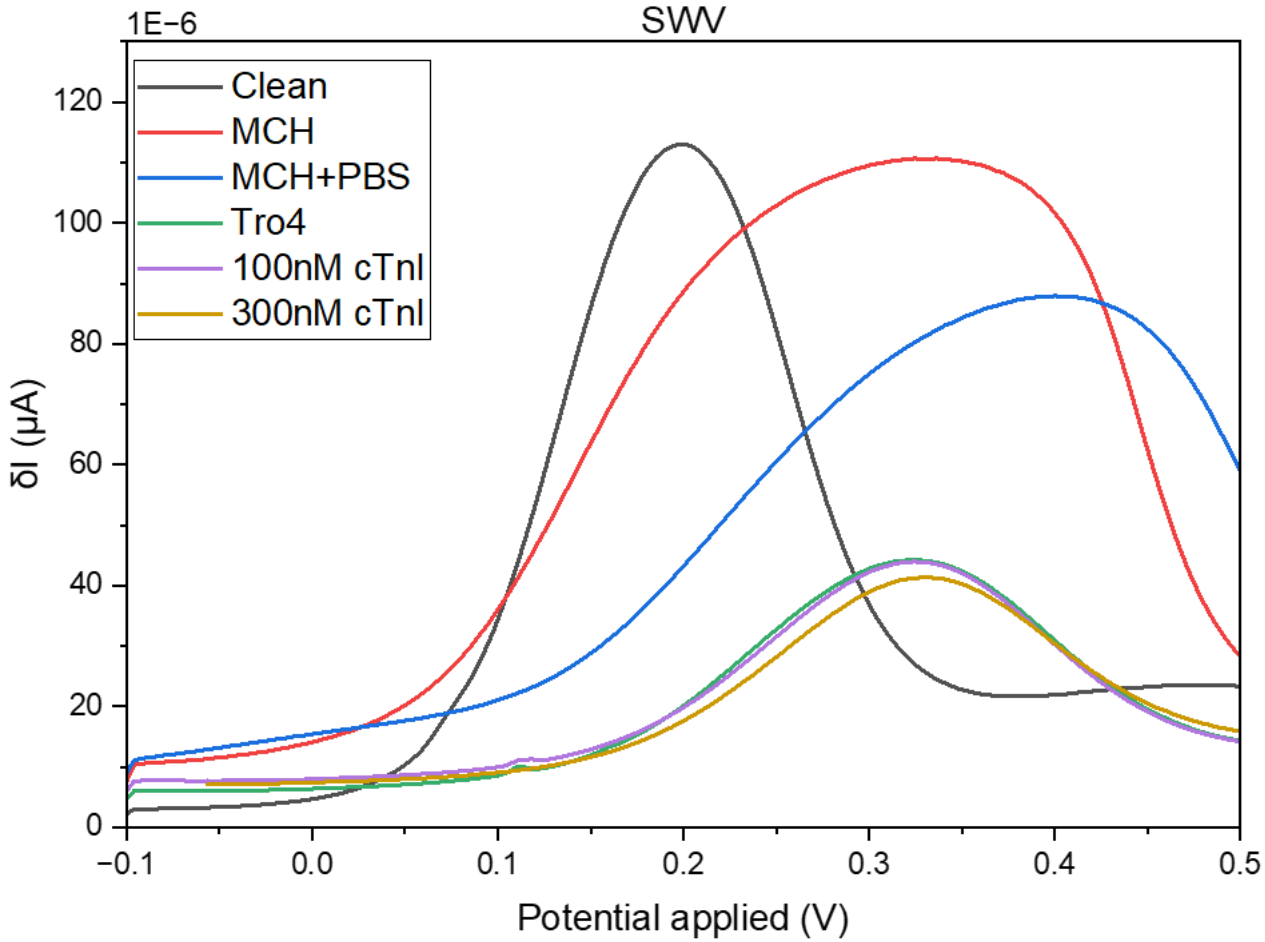
Results of immobilization steps and binding events obtain with SWV

PEN substrate, 1mM $Fe(CN)_6^{3-/4-}$





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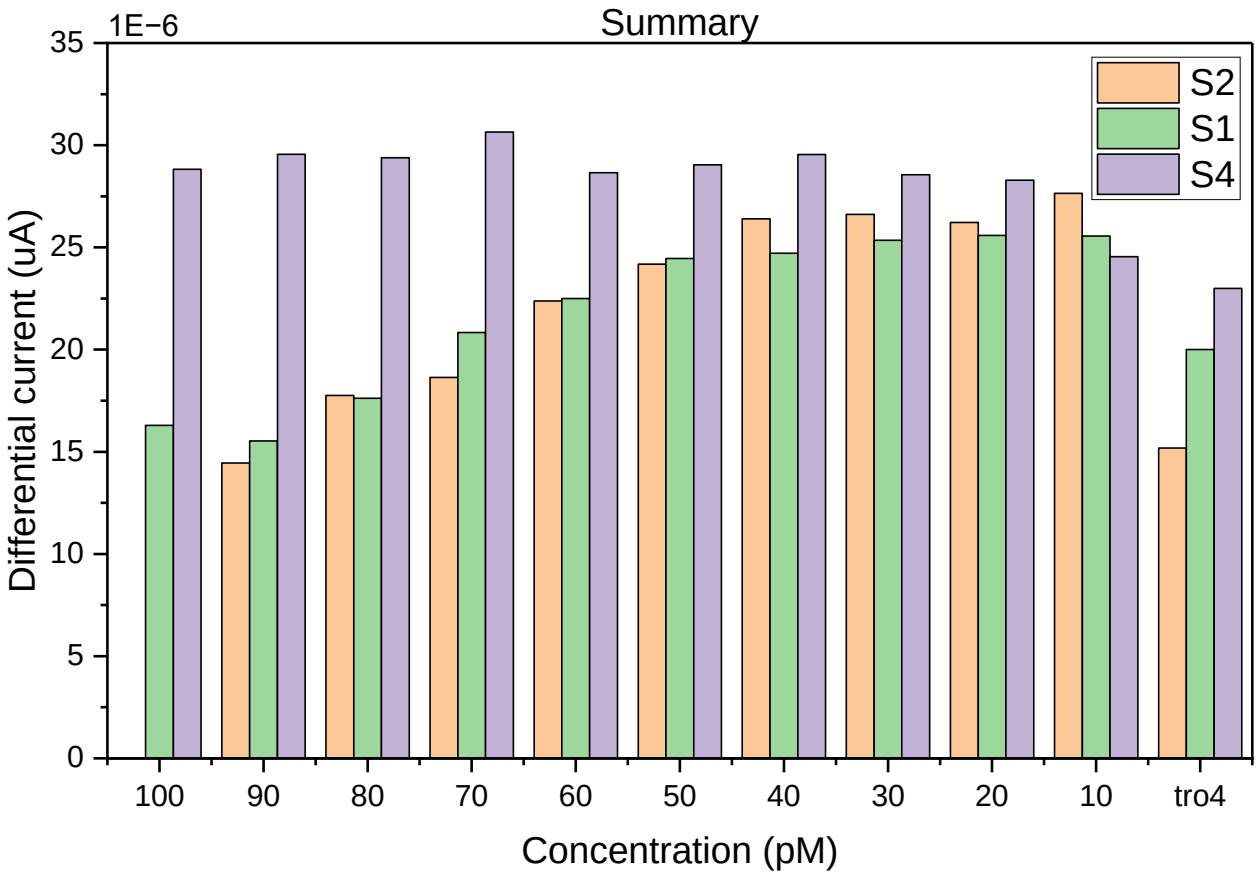
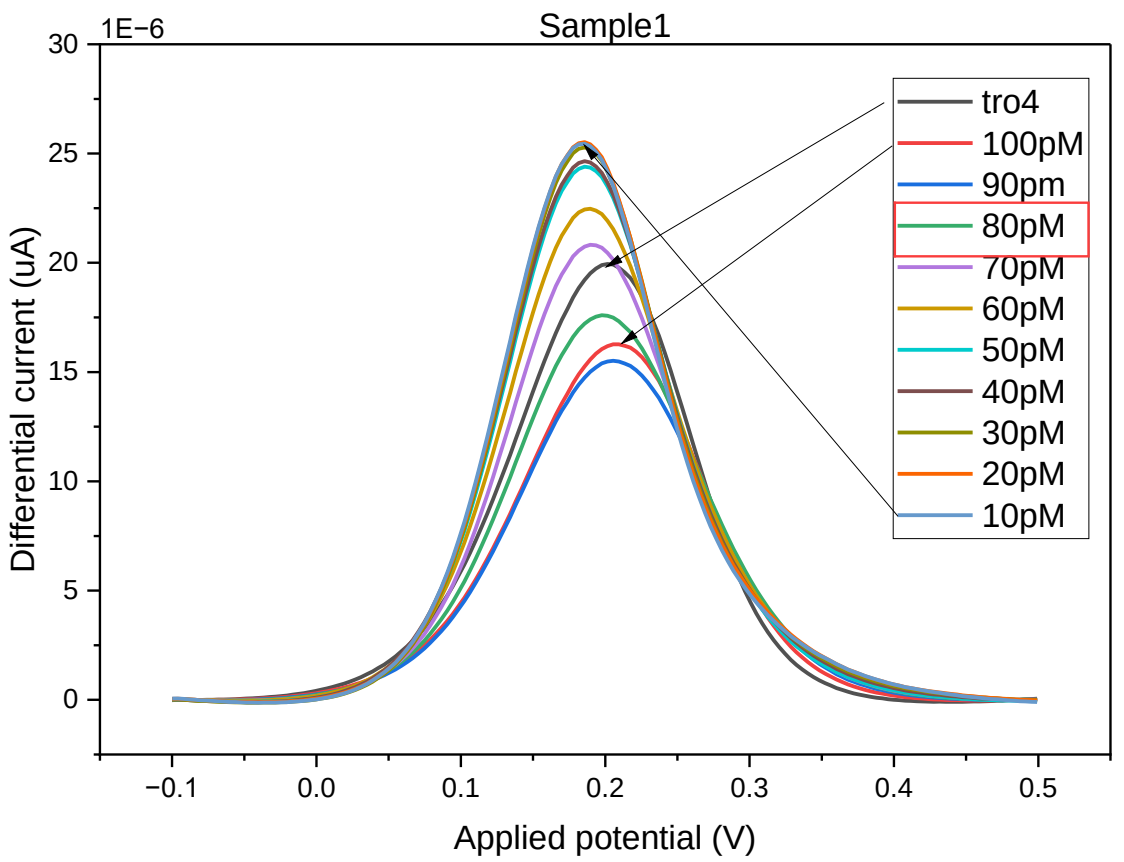
Results of the tests done with functionalized PEN-based electrodes in binding experiments at different protein concentrations





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Identification of behaviour for functionalized samples

1. Cleaning step
2. Electrochemical buffer
3. MCH concentration
4. Electrochemical characterization
5. Aptamer

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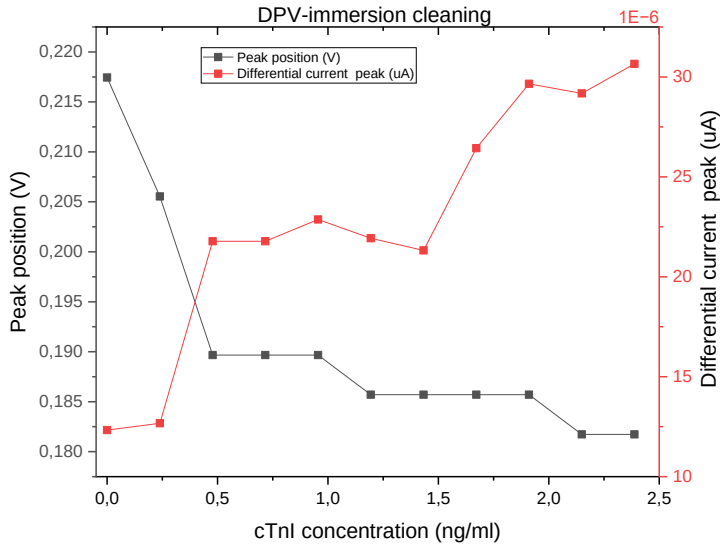
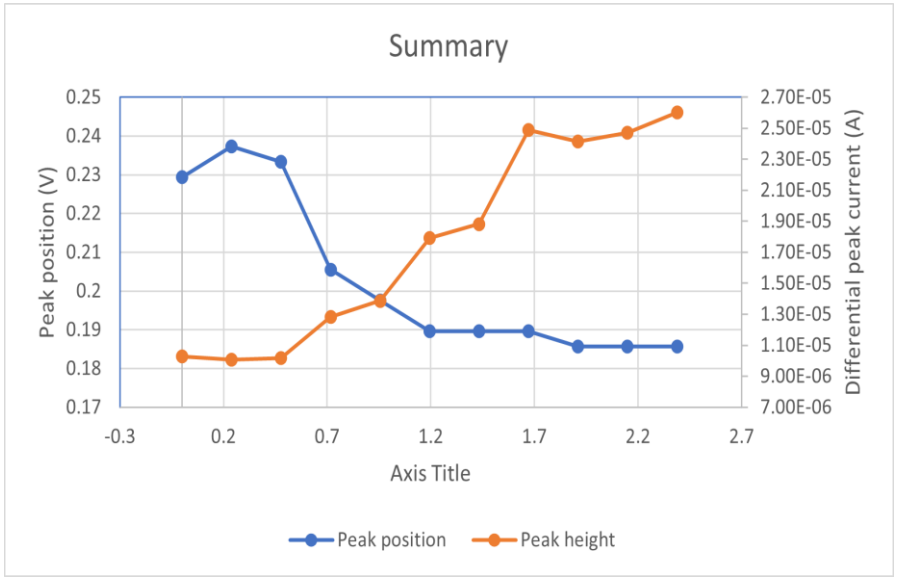
Summary of results for the behaviour of functionalized samples against different concentrations of cTnI protein

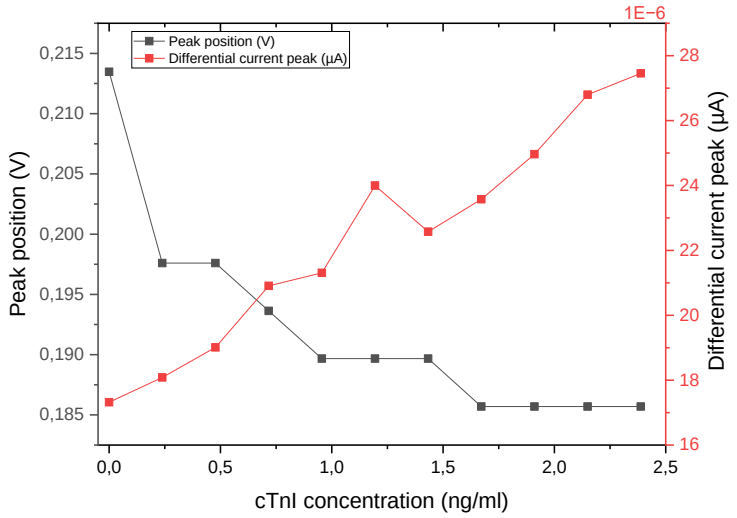
Cleaning after exposure



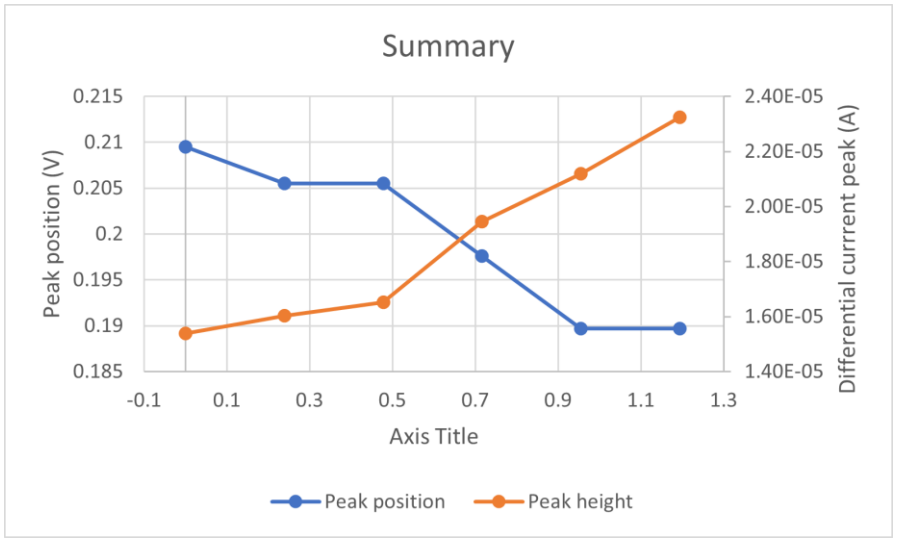
Change of electrochemical buffer



Change of MCH concentration



Change of aptamer



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Single technique approach

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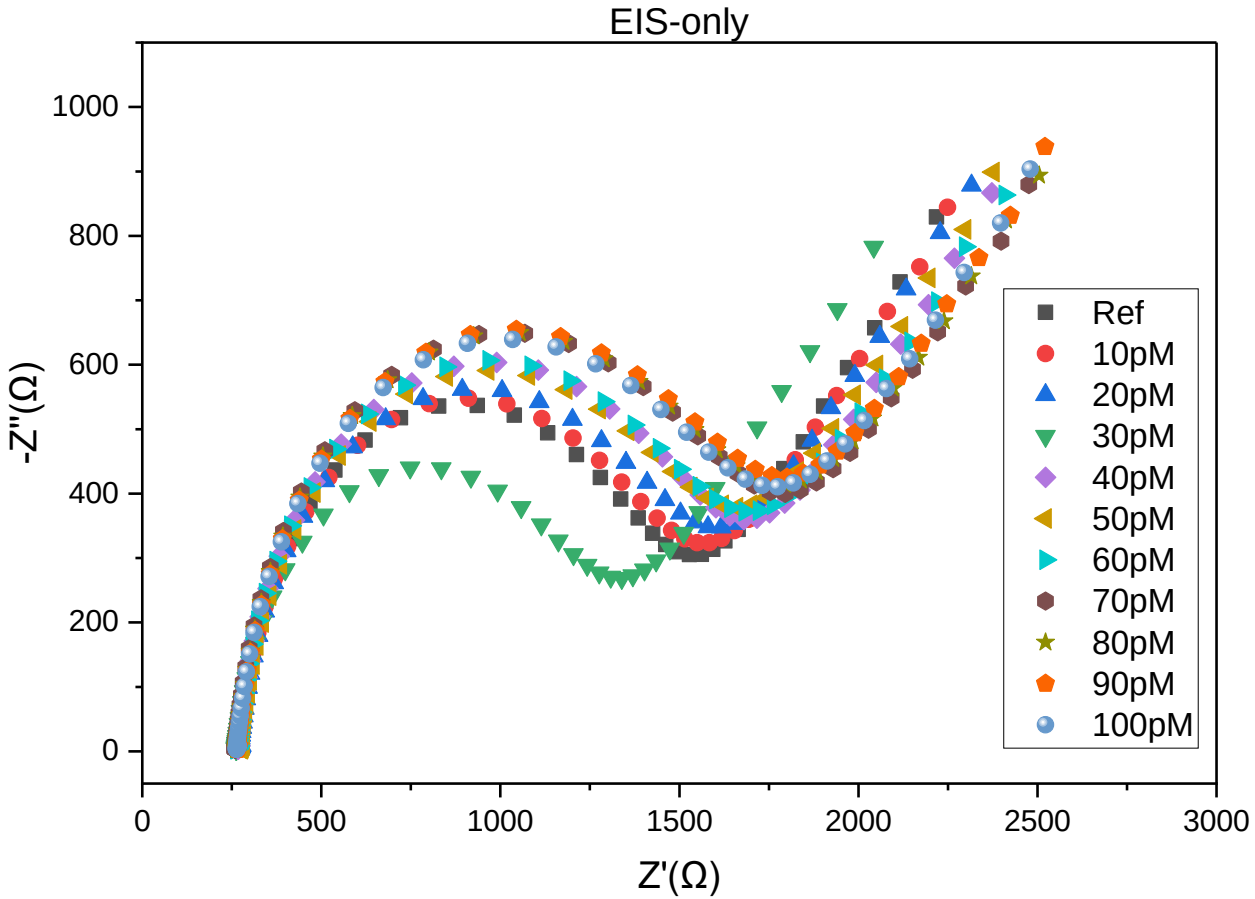
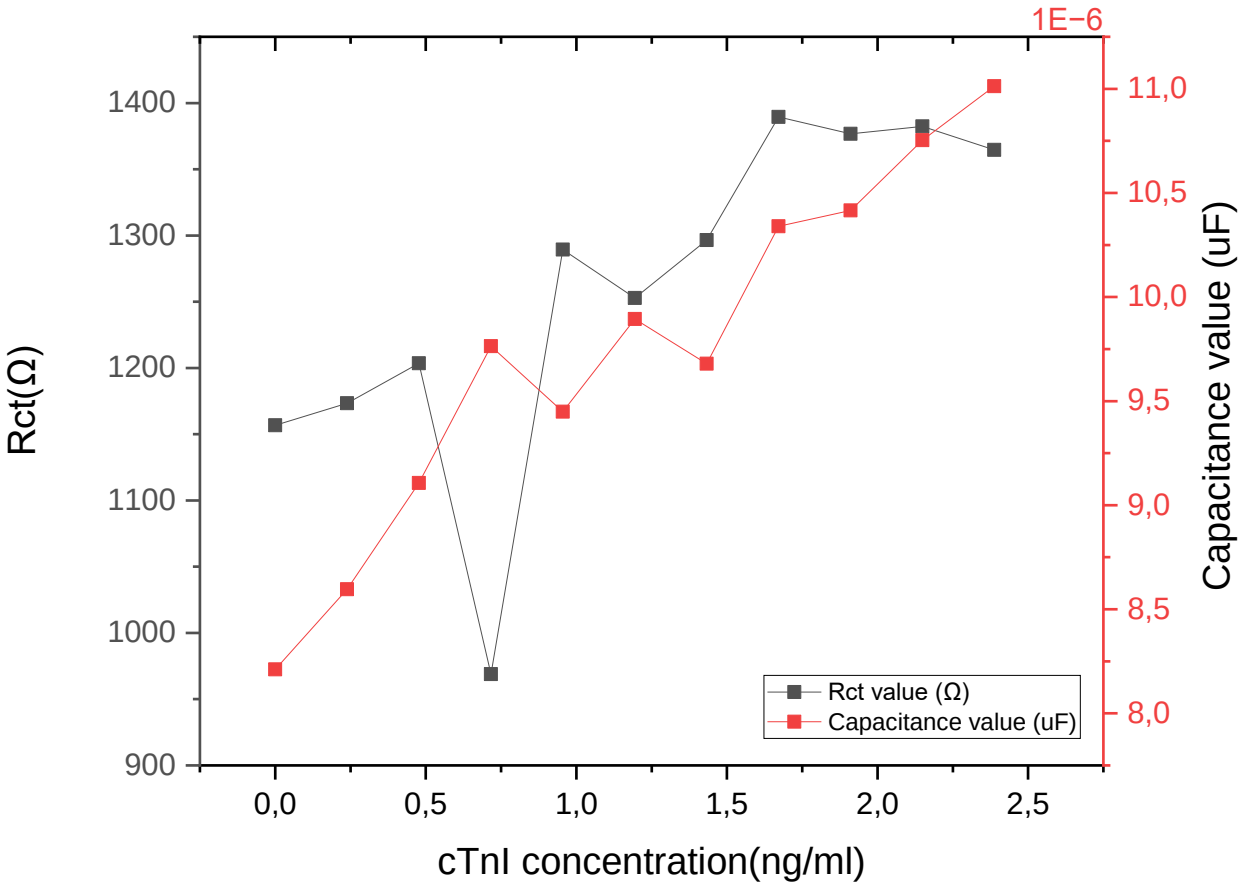
Results obtained with EIS technique (single technique approach)





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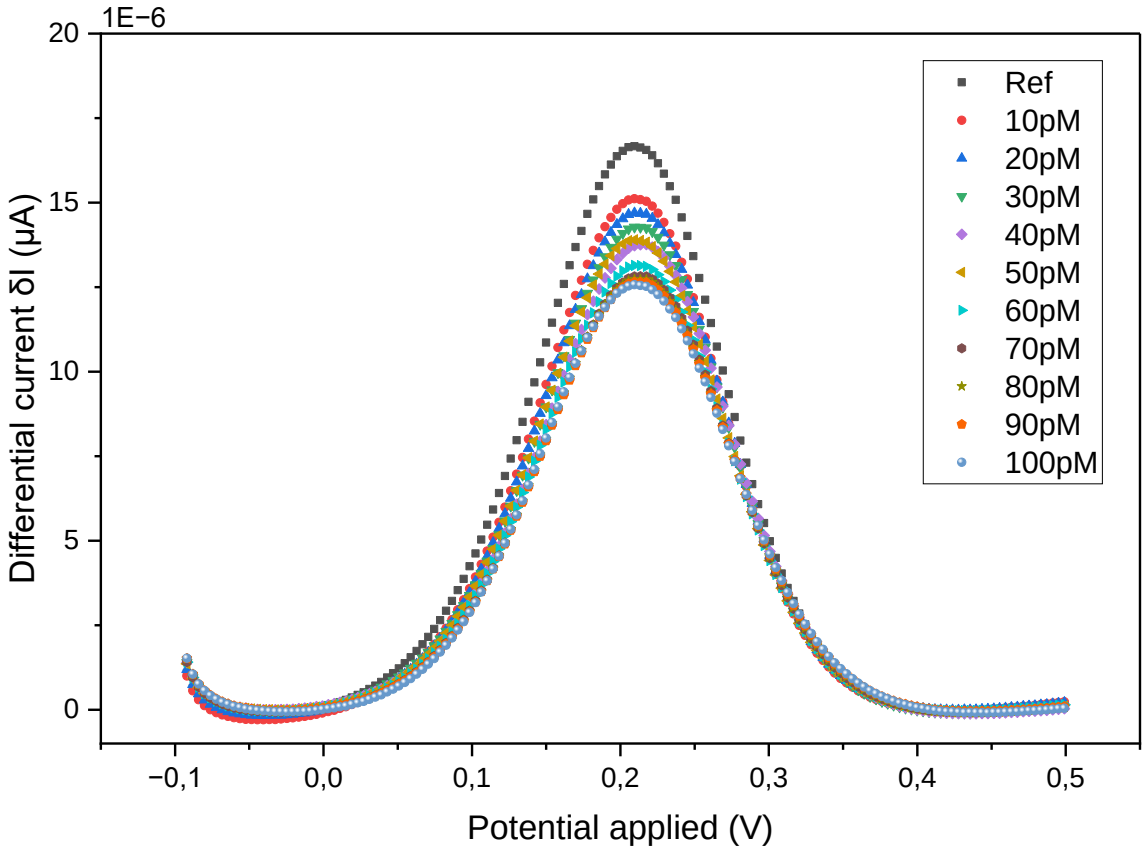
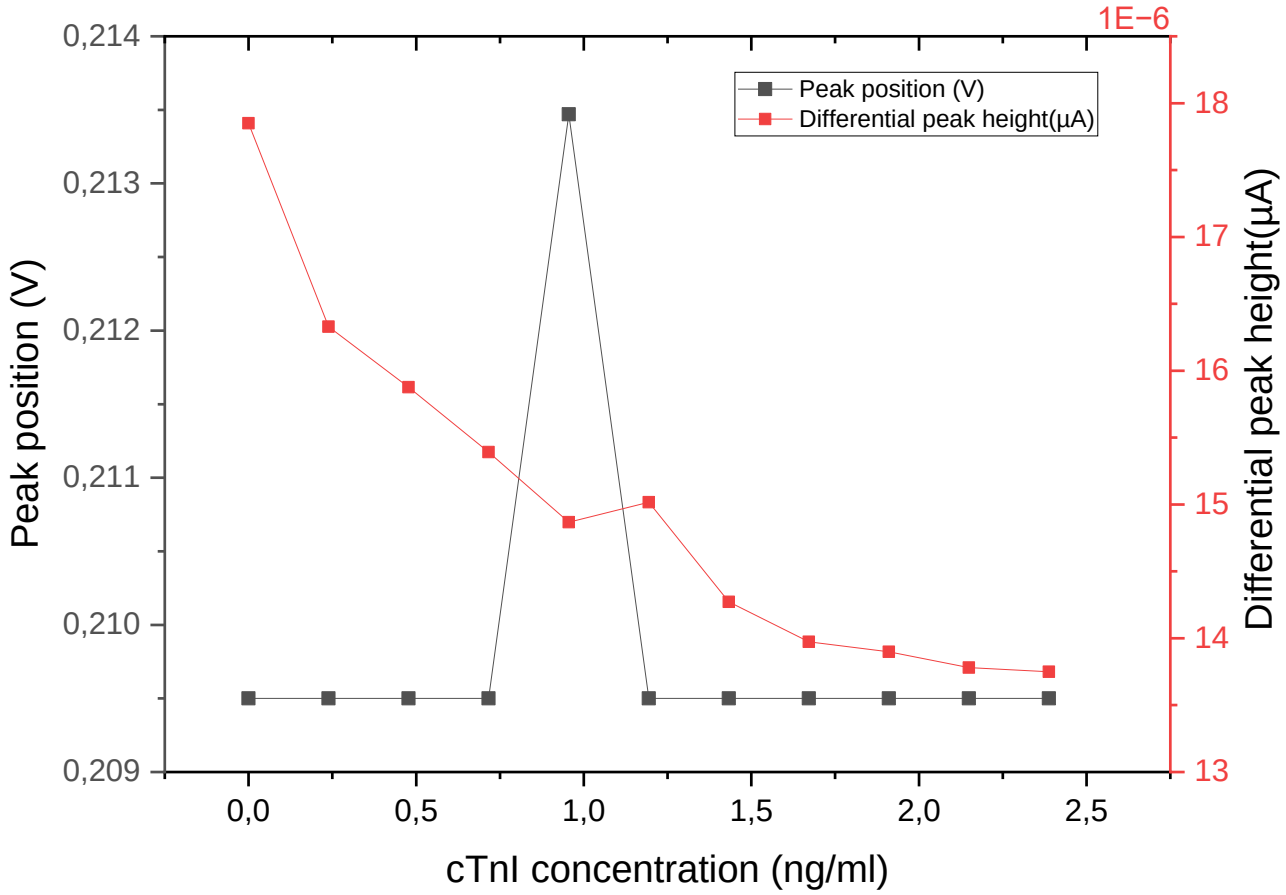
Results obtained with DPV forward (single technique approach)





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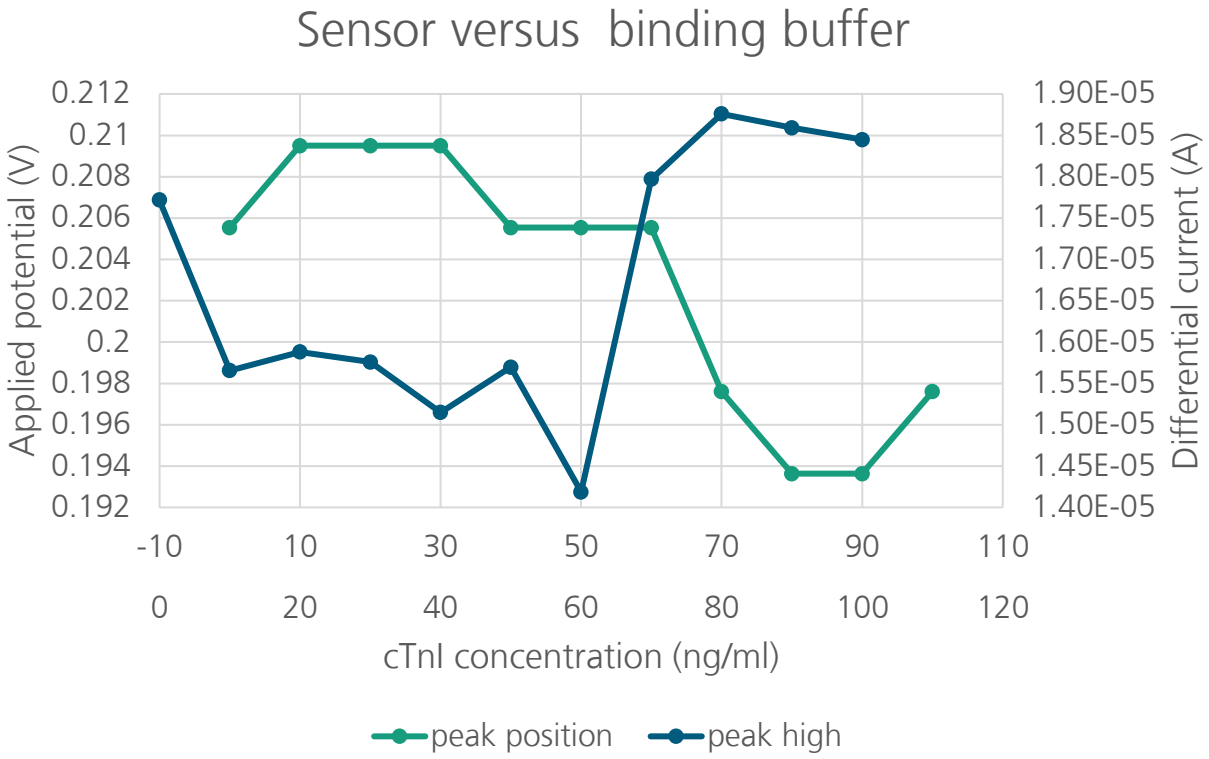
Next step in the research

- Test of several sample to have a statistical analysis
- Test more complex solutions in the detection experiments
- Enhance response signal of the system
- Miniaturization of de system



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Publications status

- Immobilization of thiolate-aptamer on different manufactured electrodes (main author)
- Influence in electrochemical response of PEN-based gold electrodes treated with Laser-induced periodic surface structure for its use as biosensor of cardiac biomarkers(main author)
- Cleaning of LTCC, PEN, and PCB Au electrodes towards reliable electrochemical measurements (co-author)
- Advanced Hydrogel-based Wearable Electrochemical Biosensors with integrated Microfluidics(review, co-author)

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Thank you for your attention

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