Novel Sensitive Electrochemical Immunosensor Development for the Selective Detection of HopQ *H.pylori* Bacteria Biomarker

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Presented by : Farid Shirmardi
Supervisor : Dr Poursina

Department of Medical Microbiology, Faculty of Medicine, Esfahan University of Medical Sciences

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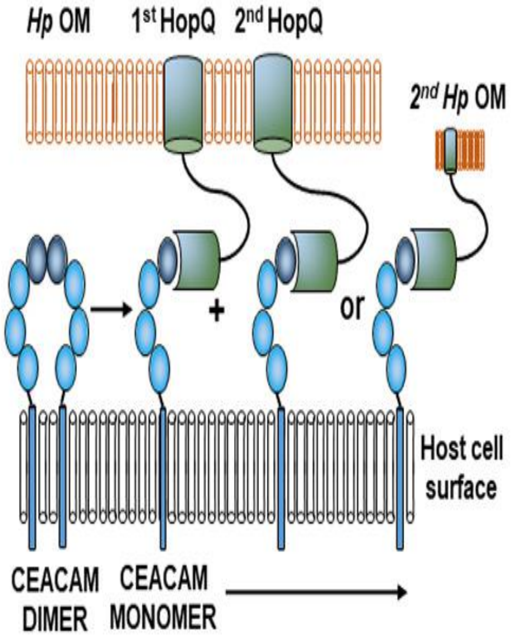
Introduction

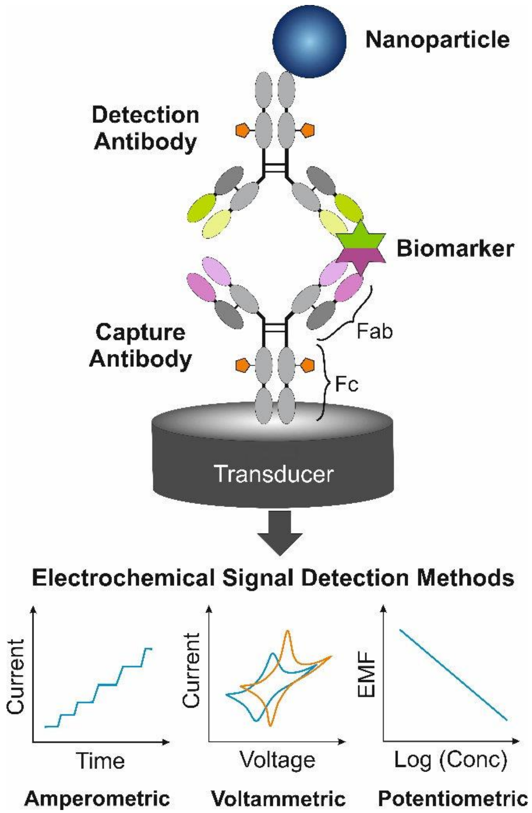
- *Helicobacter pylori* (H. pylori)
- HopQ
- *H. pylori* utilizes its outer membrane HopQ proteins to facilitate the mechanism of trans fer of its pathogenic factor, such as CagA, to the host cells at early stages of *H. pylori* infection
- HopQ is considered an excellent biomarker for reliable, selective, and specific non-inva sive direct detection of *H. pylori* bacteria



Introduction

biosensor platform

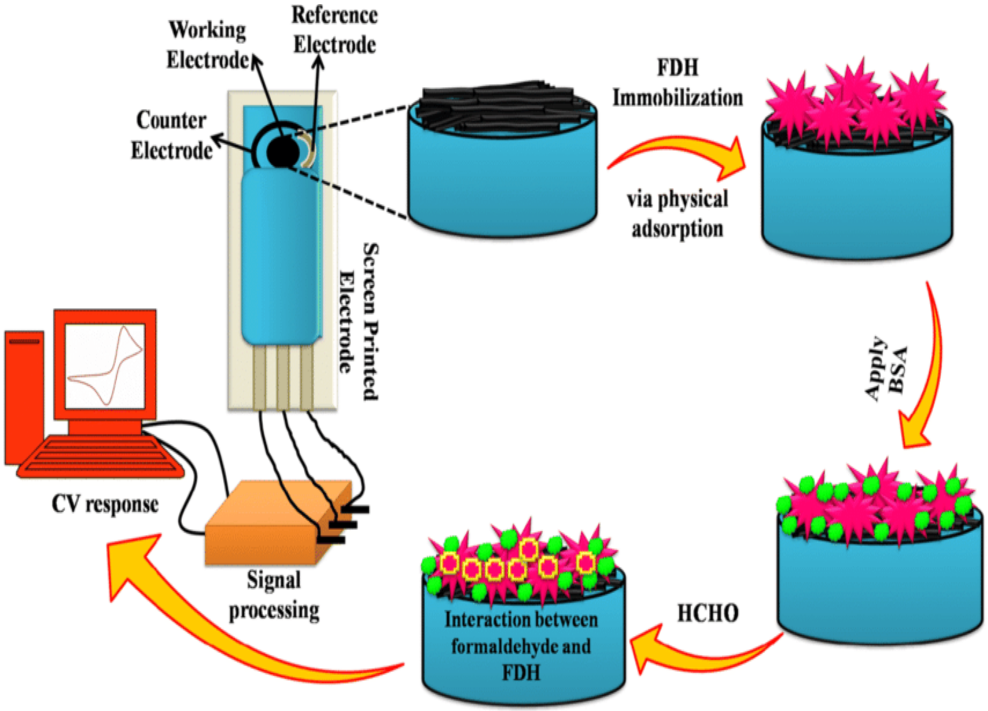
- ❖ Immunosensors based on electrochemical methods
- ❖ Biomarker-based biosensors need to be one-time use (disposable),cost-affordable, simple, accurate, reproducible and sensitive
- ❖ Nanomaterials used in electrochemical biosensors: carbon-based nanomaterials,metallic nanomaterials
- ❖ Multi-walled CNTs (MWCNT)
- ❖ AuNP



Introduction

Screen-printed carbon electrodes (SPCEs)

- ❖ working electrode (WE)
- ❖ counter electrode (CE)
- ❖ reference electrode (RE)



Materials and Methods

Immunosensor Preparation

- Activation and Pretreatment of SPCE
- Nanocomposite Preparation and Surface Modification
- WE Preparation and HopQ-Ab Immobilization

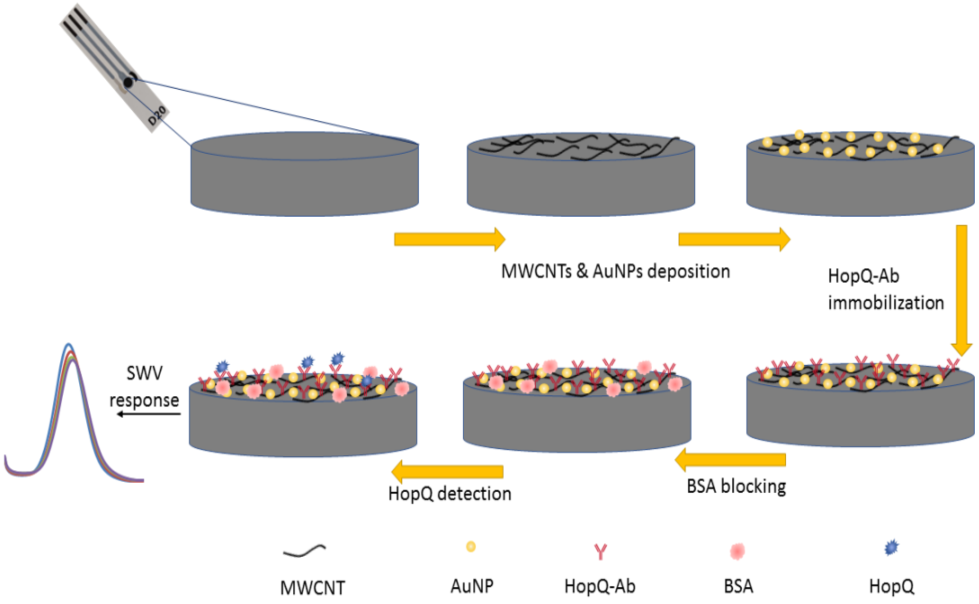
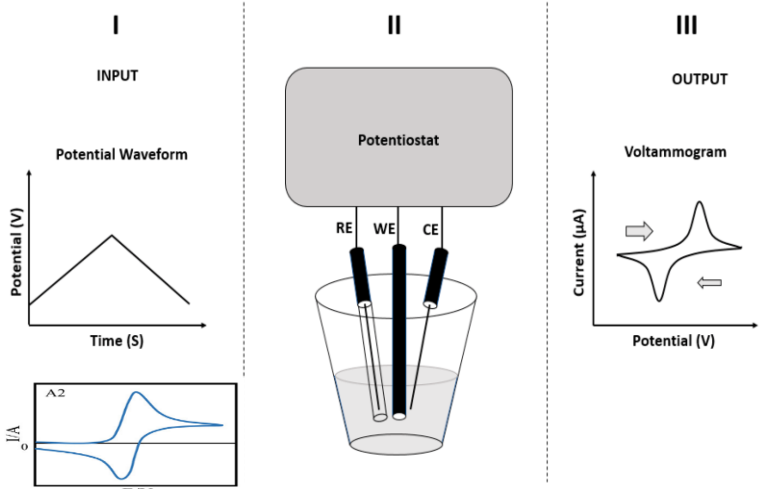


Figure 1. HopQ biosensor interface development process schematic diagram.

Materials and Methods

Electrode Characterization , Analytical Performance and Detection of HopQ

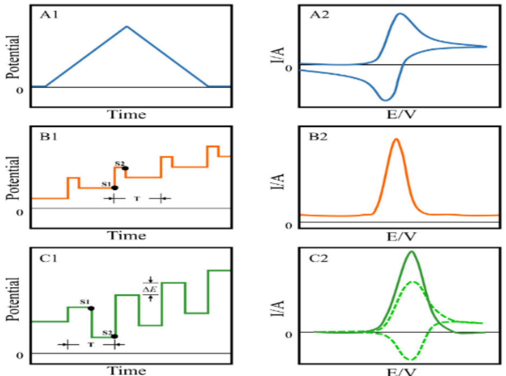
- Electrochemical Measurements
- Surface Characterization by Scanning Electron Microscopy
- Detection of HopQ and Calibra tion Curve
- Analytical Performance



CV

DPV

SWV

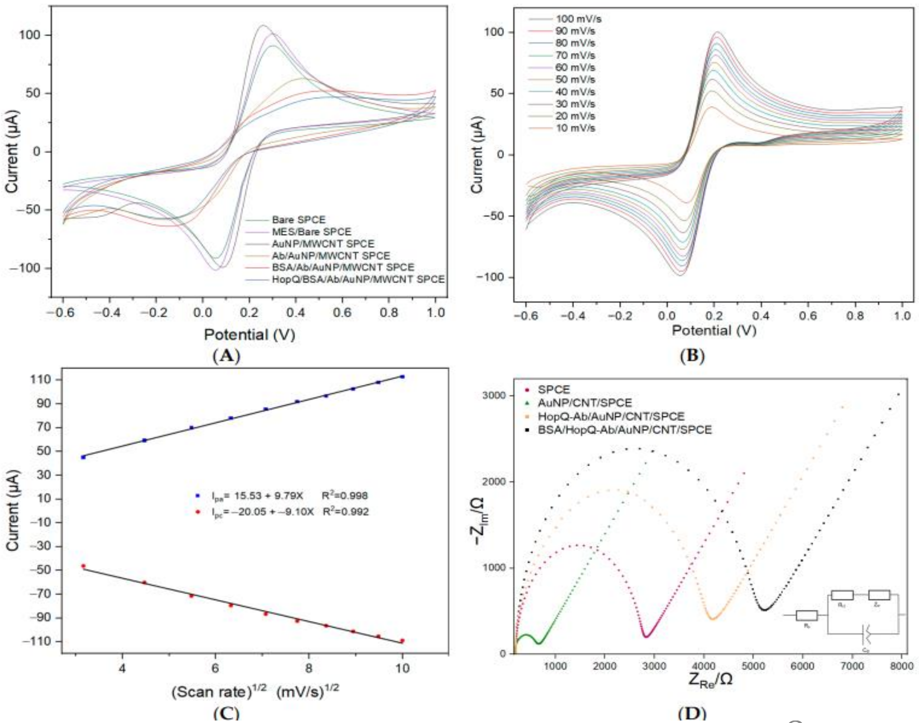


Results

Electrochemical Measurements and Detection of HopQ

- ❖ Electrochemical Measurements
- ❖ Electrochemical Impedance Studies
- ❖ Immunosensor Analytical Performance

y=4.79+11.7x



Results

LOD & LOQ

$$LOD = 10^{\frac{3.3\times\partial}{\alpha}}$$

$$LOQ = 10^{\frac{10\times\partial}{\alpha}}$$

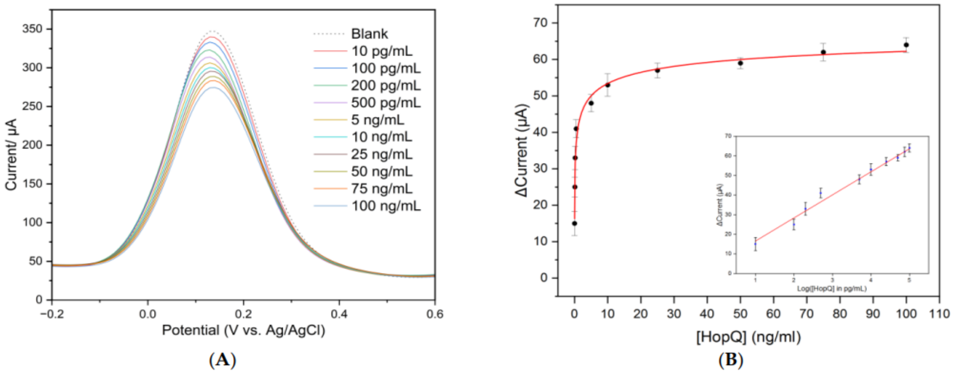


Figure 4. (**A**) SWV responses of BSA/HopQ-Ab/AuNP/MWCNT SPCE electrode with different HopQ concentrations, (**B**) variation in SWV peak current with respect to a blank solution vs. [HopQ] (and vs. Log[HopQ] for the inner plot). Error is the relative standard deviation for $n = 3$.

LOD = 2.0 pg/mL
LOQ = 8.6 pg/mL

Results

Comparison with other methods

Table 2. Limit of detection, detection range, and stability properties for different studies [61–65].

Ref.	Performance of Reported *H. pylori* Sensors						
	Interface	Detection Method	Biomarker	LOD (ng/mL)	Linear Range (ng/mL)	Stability at 4 °C (Weeks)	
[64]	CagA-Ab/ZnO*-T/SP-AuE	DPV	CagA	0.2	0.2–50	8–9	Up to 90%
[62]	CagA-Ab/TiO_2-NPs/c-MWNCT/Pin5COOH/AuE	SWV	CagA	0.1	0.1–8.0	~3 ~6	90% 50%
[61]	CagA-Ab/Pt_{nano}/PEDOT/rGO/AuE	EIS	CagA	0.1	0.1–30	~8	60–70%
[65]	BabA-Ab/Pd_{nano}/rGO/PEDOT/AuE	EIS	BabA	0.2	0.2–20	8–9	70%
[63]	VacA-Ab/g-C_3N_4/ZnO/AuE	DPV	VacA	0.1	0.1–12.8	~2	94%
This work	BSA/HopQ-Ab/AuNP/CNT/SPCE	SWV	HopQ	0.002	0.01–100	4 8	~85% ~60%

ZnO*-T: Irradiated Zinc Oxide Tetrapods, SP-AuE: screen printed gold electrode, AuE: gold electrode, TiO_2-NPs: Titanium oxide nanoparticles, c-MWCNT: carboxylated multi-walled carbon nanotubes, Pin5COOH: polyindole carboxylic acid, Pd/Pt_{nano}: palladium/platinum nanoparticles, PEDOT: poly(3,4-ethylenedioxythiophene), rGO: reduced graphene oxide, g-C_3N_4: graphitic carbon nitride.

Results

Accuracy and specificity

Table 1

Comparison of Analytical Parameters of Different Detection Methods with the Presented Immunosensor

H. pylori detection methods	accuracy	specificity	time consumption
histopathology	95.3%	77.8%	about 7 days
PCR	94.5%		24 h
serology	86%	60%	more than 3 h
stool antigen test	80.2%	86.7%	1–4 days
rapid urease test	73.6%	85%	40 min
presented immunosensor	96.2%	87.03%	10–15 min

Results

Selectivity and Cross-Reactivity

- ❖ Selectivity
- ❖ Cross-Reactivity

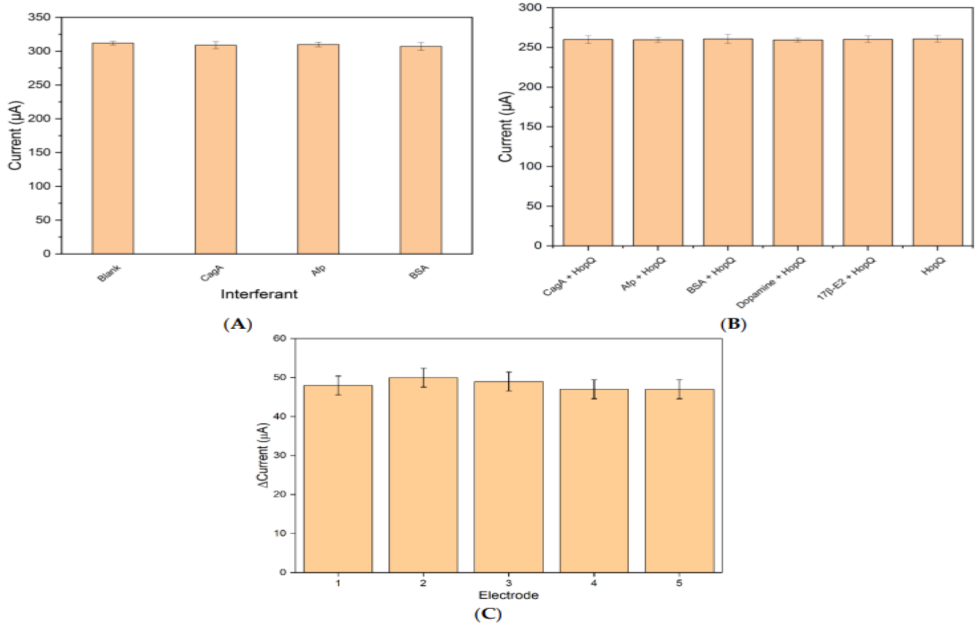


Figure 5. (**A**) Interferent study of BSA/HopQ-Ab/AuNP/MWCNT SPCE electrode with 5 ng/mL interferant concentration. (**B**) Interferent study of BSA/HopQ-Ab/AuNP/MWCNT SPCE electrode with 5 ng/mL HopQ antigen. (**C**) SWV peak current response of identically fabricated electrodes with the same criteria; the error bar is for $n = 5$.

Results

- ❖ Reproducibility

- ❖ Shelf-Life Studies and Comparison with Other Platforms

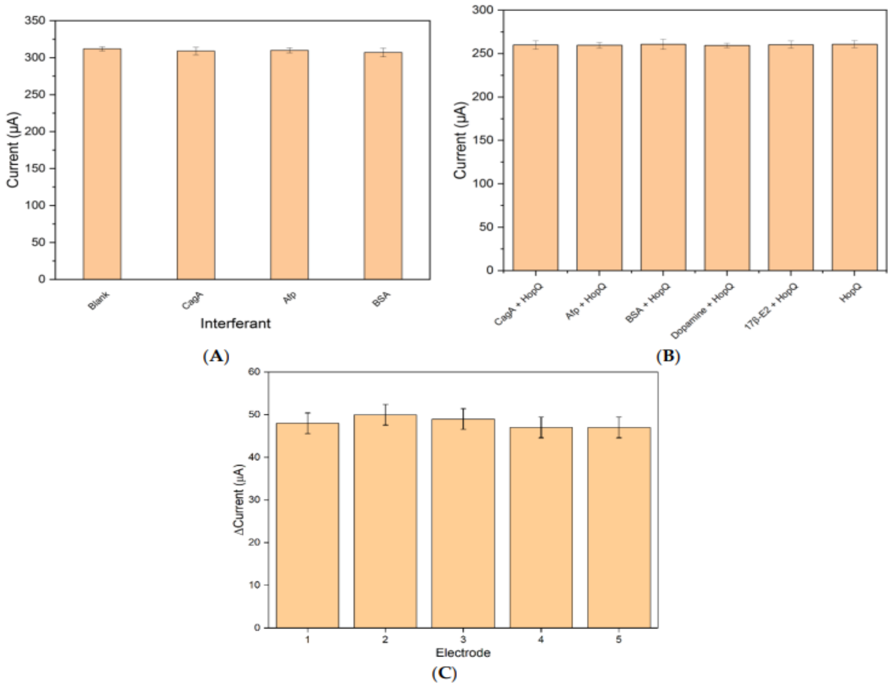


Figure 5. (**A**) Interferent study of BSA/HopQ-Ab/AuNP/MWCNT SPCE electrode with 5 ng/mL interferant concentration. (**B**) Interferent study of BSA/HopQ-Ab/AuNP/MWCNT SPCE electrode with 5 ng/mL HopQ antigen. (**C**) SWV peak current response of identically fabricated electrodes with the same criteria; the error bar is for $n = 5$.

advantages and disadvantages

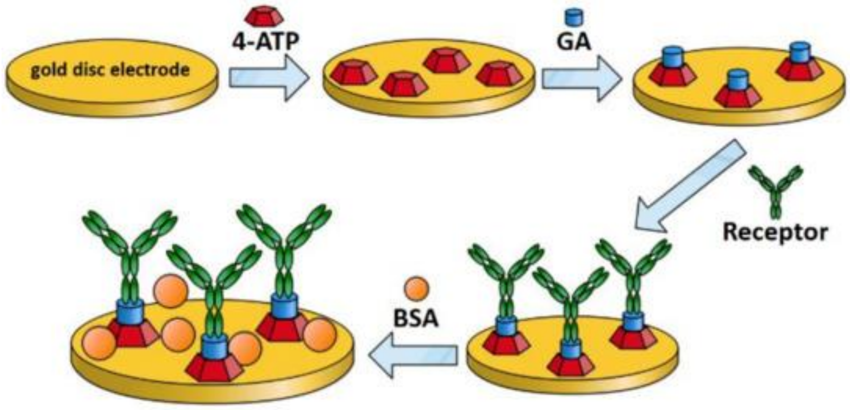
advantages

- highly enhanced sensitivity
- excellent selectivity
- lower detection limits
- Detection Ranges
- shelf-life
- simplified sample preparation
- cost affordability

disadvantages

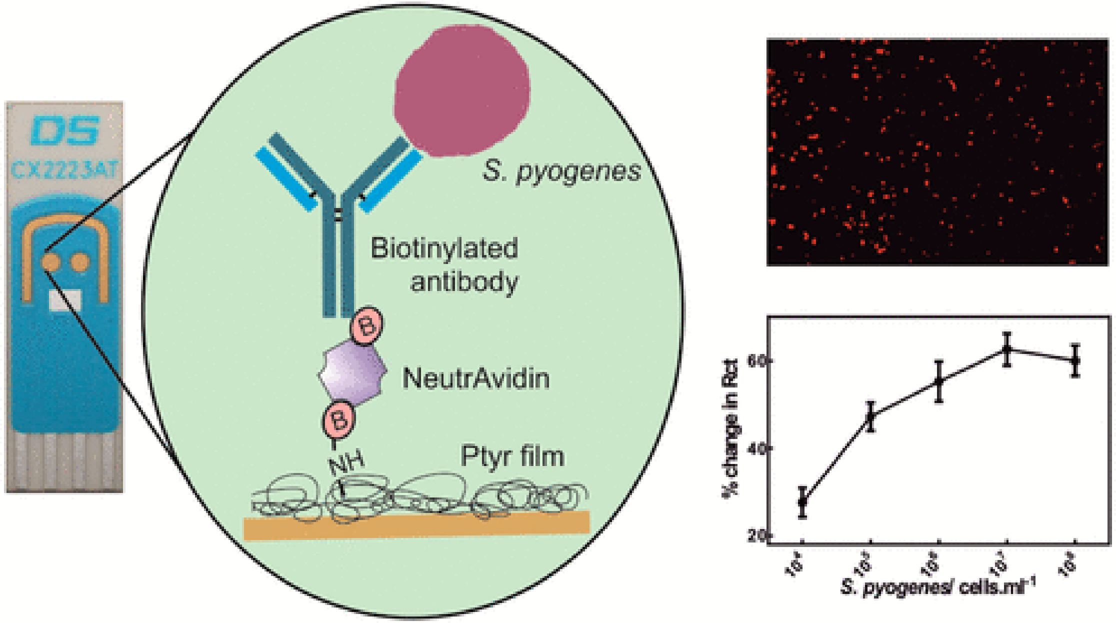
Other studies

Methodology of Selecting the Optimal Receptor to Create an Electrochemical Immunosensor for Equine Arteritis Virus Protein Detection



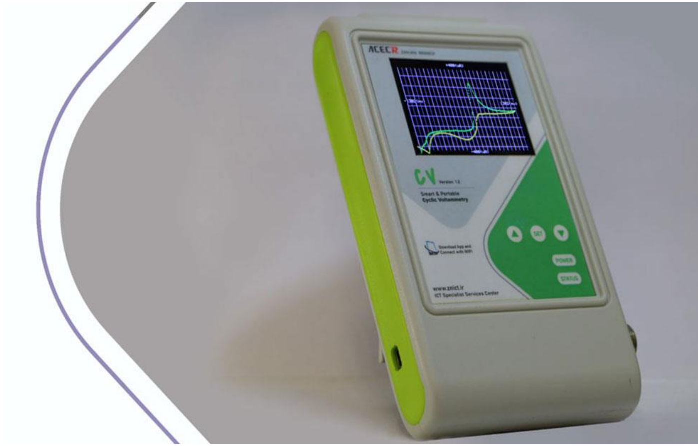
Other studies

Novel Impedimetric Immunosensor for Detection of Pathogenic Bacteria *Streptococcus pyogenes* in Human Saliva



Conclusions

Why should we use immunosensors?



MWCNT/AuNP

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Thank you
for your attention