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(BIO)MIMETIC SENSORS FOR HEALTH AND FOOD MONITORING

Dr. Parvaneh Rahimi
TU Bergakademie Freiberg
40. Chemnitzer Seminar; Sensor Systems for One Health, 03.-04. December 2024

INBM
Institute of Nanoscale and Biobased Materials

BIOSENSORS-GROUP

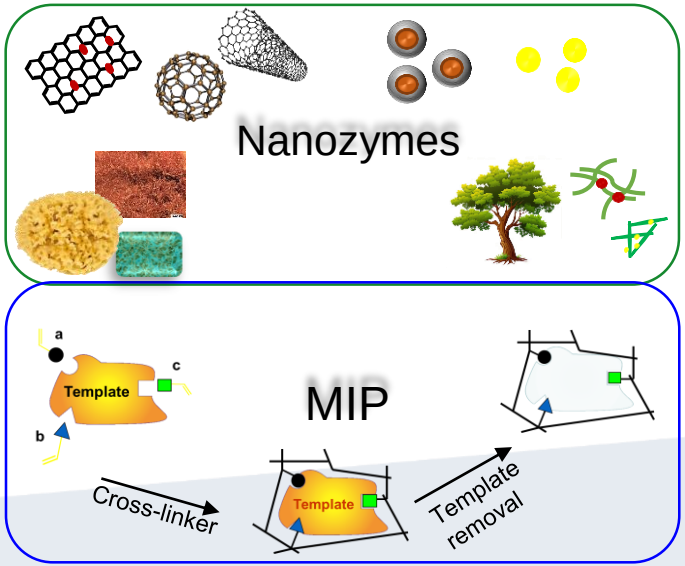
Main research interests:

- Sensor substrate (Bio-)functionalization
- Development of sensing materials and electrocatalysts
- Development of protein-based biosensors (enzyme, antibody)
- Development of nucleic acid-based biosensors (DNA, aptamer)
- Development of (bio)mimetic Sensors
- Biosensor/ mimetic Sensor applications

(Bio)-Mimetic Sensors

Development of sensor materials mimicking the activity of biological recognition

- Functional nano-/micromaterials with enzyme-mimicking activities (Nanozymes)
- Molecularly imprinted polymer (MIP); artificial antibody



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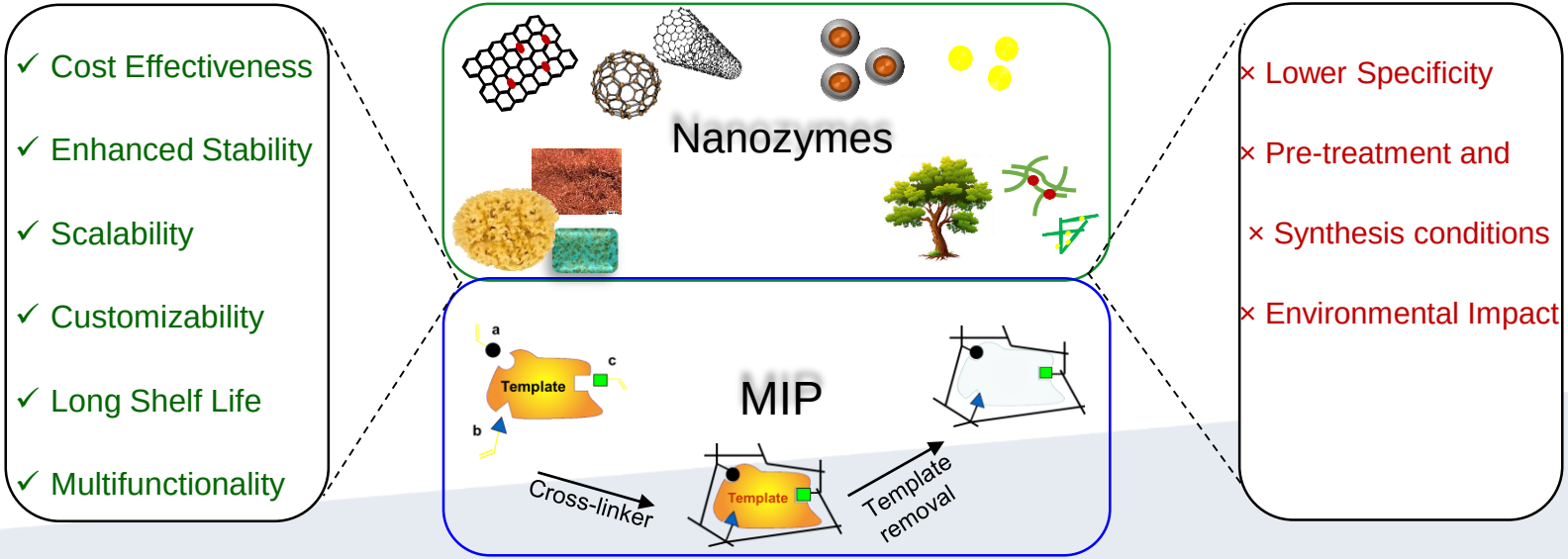
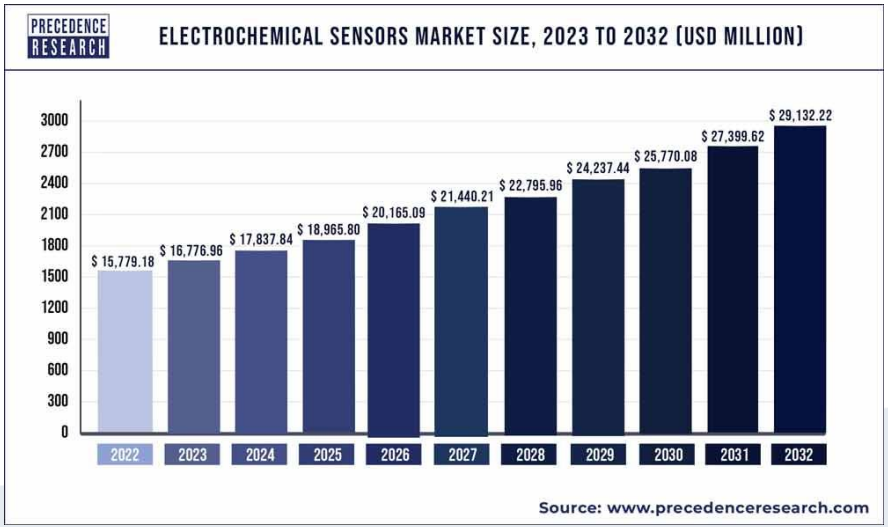


Electrochemical (Bio)Mimetic Sensors

Integration of mimetic sensing materials with electrochemical systems

→ Development of portable, cost-effective, sensitive and stable sensors for various applications.

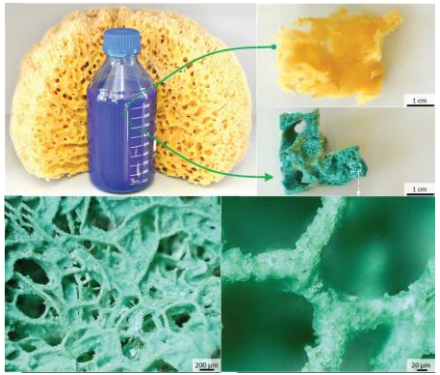


Portable
User friendly
Easy fabrication
Low cost

(Bio)Mimetic Sensors

Development of Enzyme-free Sensor for Glucose Detection

3D natural Spongin-based composites from Prof. Hermann Ehrlich group



Spongin-atacamite ($Cu_2Cl(OH)_3$)

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(Bio)Mimetic Sensors

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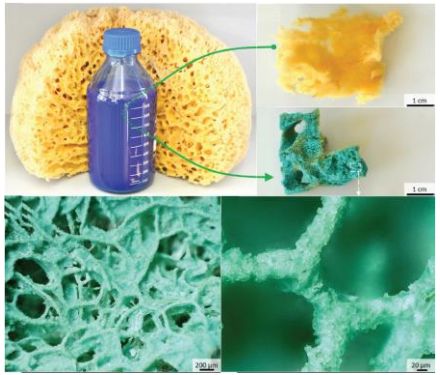

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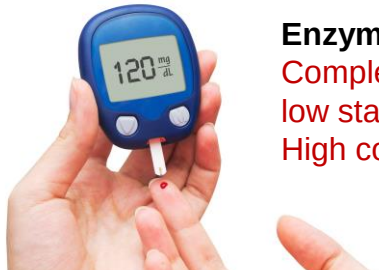

https://www.vorhofflimmern.de/vorhofflimmern-und-diabetes

Enzymatic glucose biosensors

Complex enzyme purification

low stability

High cost

(Bio)Mimetic Sensors

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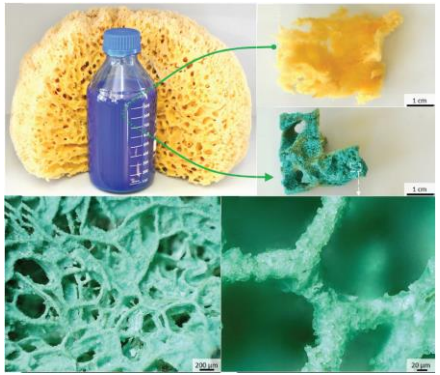

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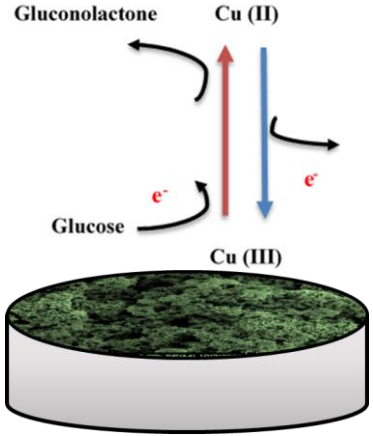
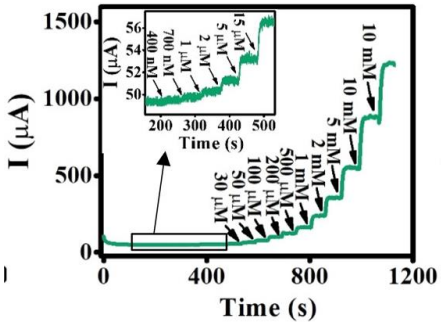
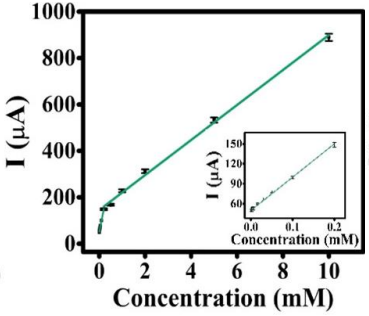
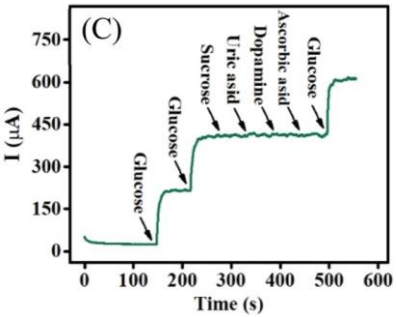






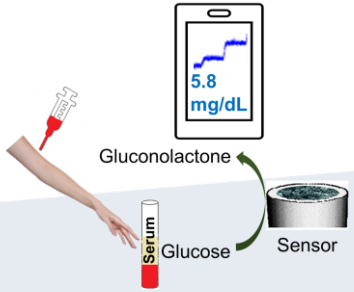


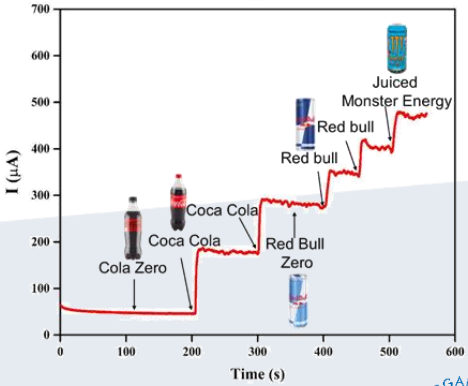
$$Cu(II) + (OH)^- \rightarrow Cu(III) + e^- \quad (1)$$

$$Cu(III) + Glucose + e^- \rightarrow Gluconolactone + Cu(II) \quad (2)$$

$$Gluconolactone \rightarrow Gluconic\ acid \quad (3)$$

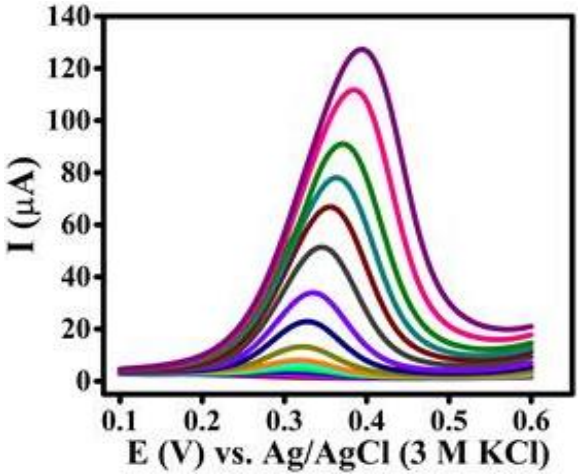
Real Sample



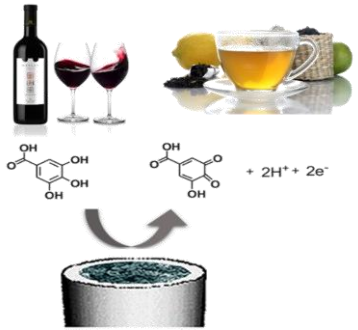


Falahi et al., ACS Appl. Bio Mater, 2022, https://doi.org/10.1021/acsabm.1c01248

Electrochemical Sensing of Gallic Acid in Beverages Using Carbon Nanotubes/Spongin-Atacamite



DPV responses of sensor to successive additions of different concentrations of Gallic acid from 500 nM to 1 mM



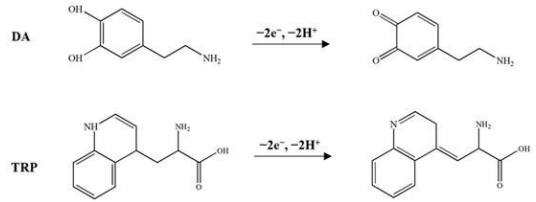
Sample	Spiked (μM)	Detected GA (μM)	Recovery (%)	RSD (%)
Black tea	-	30.7	-	3.2
	10	40.6	98.2	2.3
	30	59.9	97	2.6
Green tea	-	31.2	-	3.6
	10	41	98	2.9
	30	62	102	3.5
Red wine	-	18.2	-	4
	10	27.8	95.2	3.3
	30	47.4	97.1	3.5

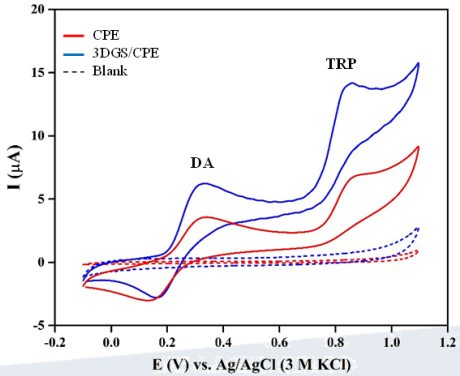
Falahi et al., Biosensors, 2023, https://doi.org/10.3390/bios13020262

(Bio)Mimetic Sensors

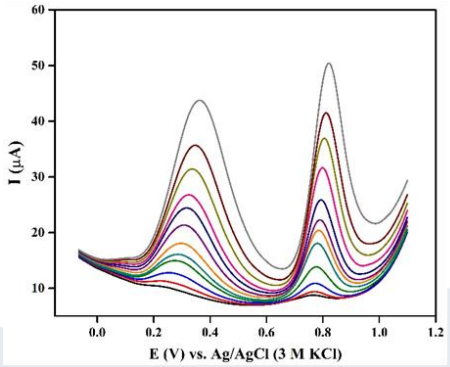
Simultaneous Detection of Dopamine and Tryptophan using 3D Goethite-Spongin

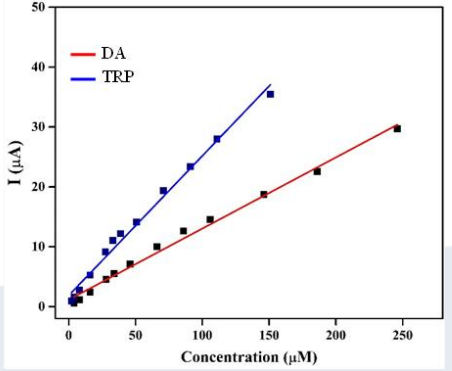
Goethite-Spongin (α-FeO(OH)-Spongin)





CVs of CPE, and 3DGS/CPE recorded in the presence of 80 μM DA and TRP





DPV responses for simultaneous addition of different concentrations of DA (4-520 μM) and TRP (2-230 μM) and corresponding calibration curves

Falahi et al., Biomimetics, 2024, https://doi.org/10.3390/biomimetics9060357

MIP based Electrochemical Sensor for Progesterone Detection

(Erasmus +, YEMAYA Project: African Women in Science)

- Progesterone is a 21-Carbon hydrophobic Steroid Hormone; produced by Adrenal cortex, Gonads (ovaries in women, testes in men), Ovarian corpus luteum (first 10 weeks of pregnancy), Placenta (later phase of pregnancy)
- Synthetic progesterone: utilized in both human and veterinary medicine for various purposes, e.g. as growth promoters in cattle and as contraceptive pills.

× Steroids are among the most potent endocrine disrupting compounds.

× They reach aquatic ecosystems from natural excretion by humans and livestock.

× Progesterone's EDC effects can lead to various health issues

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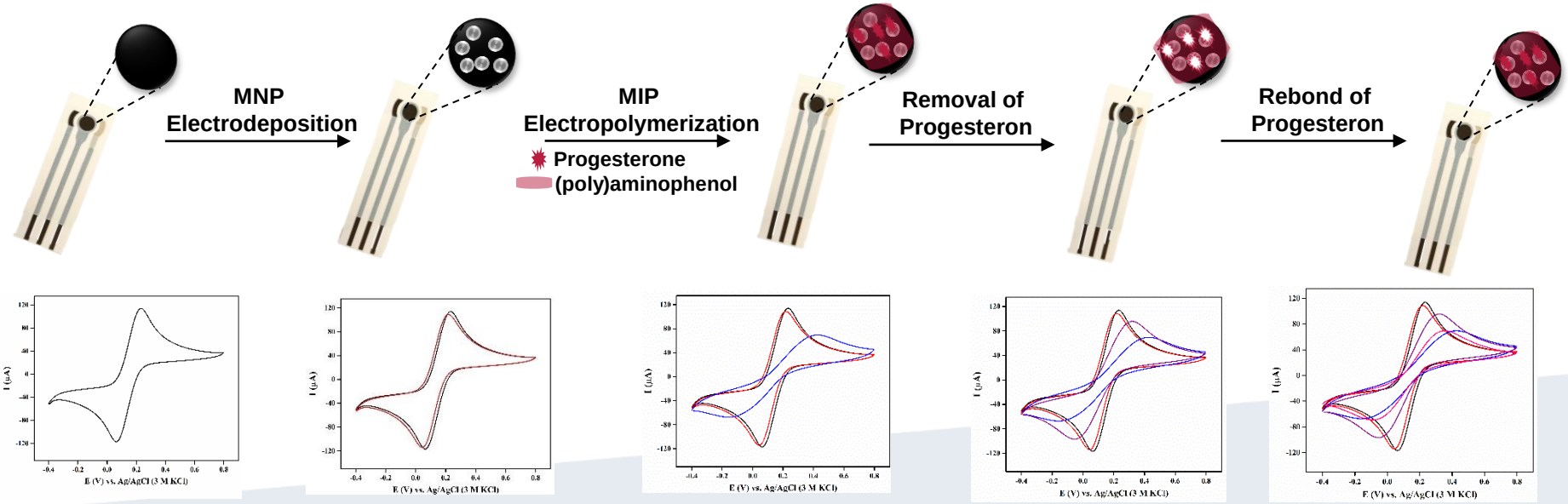

MIP based Electrochemical Sensor for Progesterone Detection

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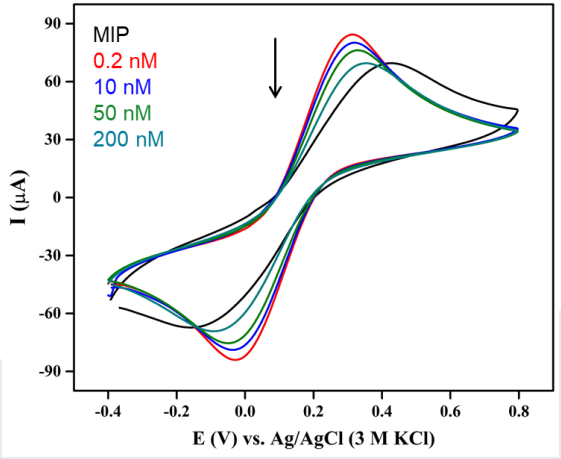
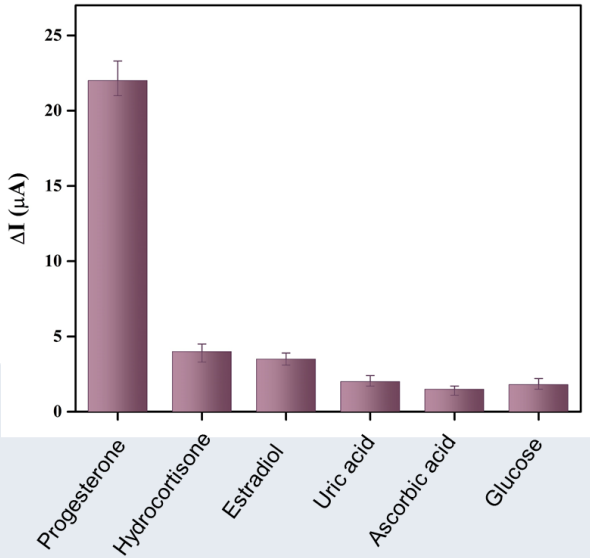
Optimization

- Electropolymerization Parameters, Template to monomer ratio and polymerization cycles
- Number of cycles for removal of progesterone
- Buffer solution for removal of progesterone
- Rebonding time





Future Outlook of (bio)Mimetic Sensors

- Advancements in Material Design
  - Renewable and Sustainable Materials like carbon quantum dots
  - Molecular Engineering
- Multi-Analyte Detection in medical diagnosis and food safety
- Integration with Emerging Technologies
  - Wearable and Portable Devices
  - Internet of Things (IoT)
- Overcoming Current Challenges
  - Development of scalable and cost-effective manufacturing methods
  - Enhance the specificity and selectivity

https://tu-freiberg.de/esm/ag-biosensoren

https://www.linkedin.com/in/parvaneh-rahimi-71671983/

parvaneh.rahimi@esm.tu-freiberg.de

Thank you!