IOCE 2026 Conference

The 1st International Online Conference on Environments

02–04 March 2026 | Online

Chaired by Prof. Dr. Sergio Ulgiati

environments MDPI

Electrochemical Detection of Thallium as a Tool for Environmental Impact and Risk Assessment

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INTRODUCTION & AIM

Thallium is one of the most toxic heavy metals, posing a serious threat to ecosystems and human health even at trace concentrations. Its reliable determination in environmental samples is challenging due to low concentration levels and complex sample matrices. Therefore, there is a need for sensitive, selective, and mercury-free analytical tools for environmental monitoring.

To develop a mercury-free electrochemical sensor based on a glassy carbon electrode modified with silver nanostructures synthesized using biopolymers.

METHOD

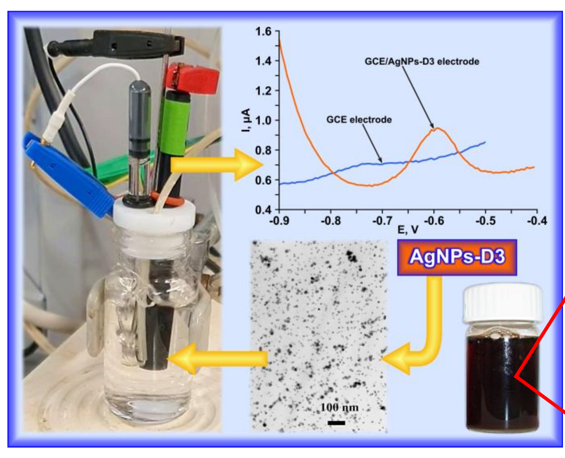
- Glassy carbon electrodes were modified with starch-stabilized silver nanostructures.
- Silver nanostructures were synthesized via a controlled chemical reduction process.
- Biopolymers acted as stabilizing and structure-directing agents.
- Electrochemical characterization of modified electrodes was performed.
- Thallium was determined using anodic stripping voltammetry (ASV).
- Measurements were carried out in model electrolyte solutions and real environmental samples.

CONCLUSION

- Surface modification significantly improved electrode performance.
- Increased sensitivity and improved detection limit were achieved.
- Good repeatability and operational stability were observed.
- The sensor performed well in complex sample matrices.
- The developed platform represents a promising mercury-free approach for trace-level thallium monitoring.

RESULTS & DISCUSSION

Electrode material with silver nanoparticles stabilized with potato starch derivative dextrin - GCE/AgNPs-D3



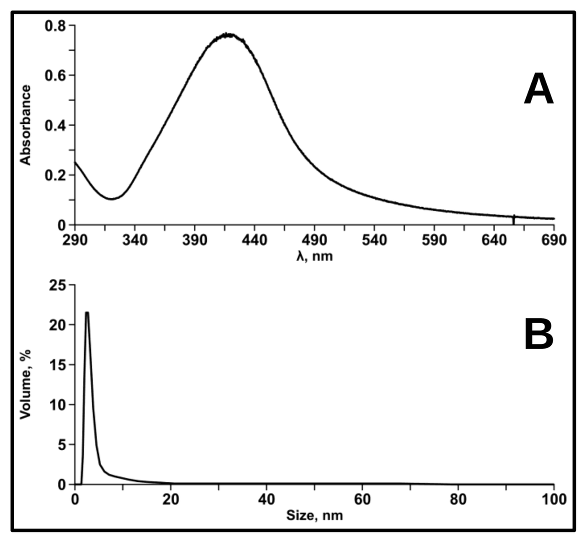


Fig. 1. *Characteristics of the AgNPs-D3 modifier: (A) UV–vis spectrum (40xdilution), (B) particle size distribution*

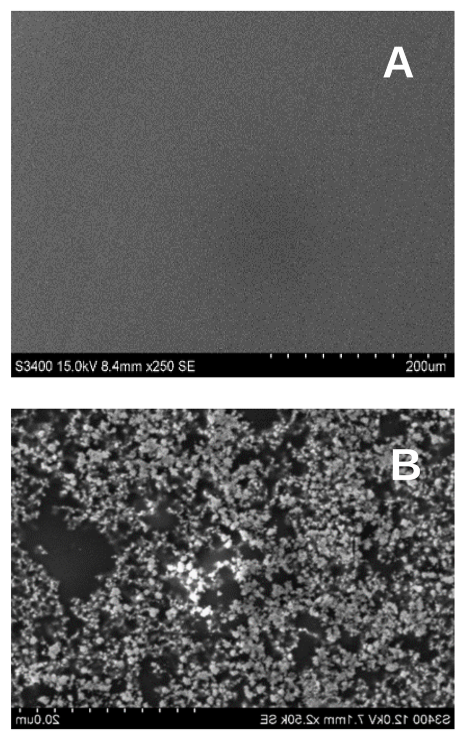


Fig. 2. *SEM image of the electrode surface: A) GCE before modification, B) GCE/AgNPs-D3*

Detection limit (LOD): $3.5\cdot10^{-8}$ mol·L^{-1}

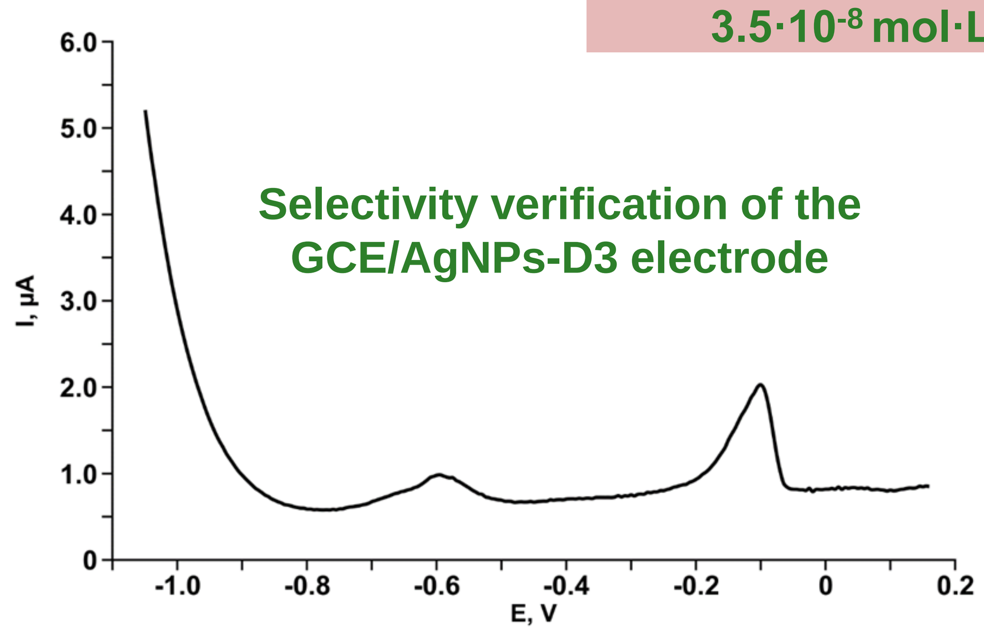


Fig. 3. *Differential pulse voltamperogram for the GCE/AgNPs-D3 modified electrode recorded in 0.2 M EDTA in the presence of 30 ppb Tl^{+}, 400 ppb Zn^{2+}, 80 ppb Cd^{2+}, 20 ppb Pb^{2+} and 200 ppb Cu^{2+}*

Electrode material with silver nanoparticles stabilized by cross-linked starch derivative - GCE/AgNPs-E1414

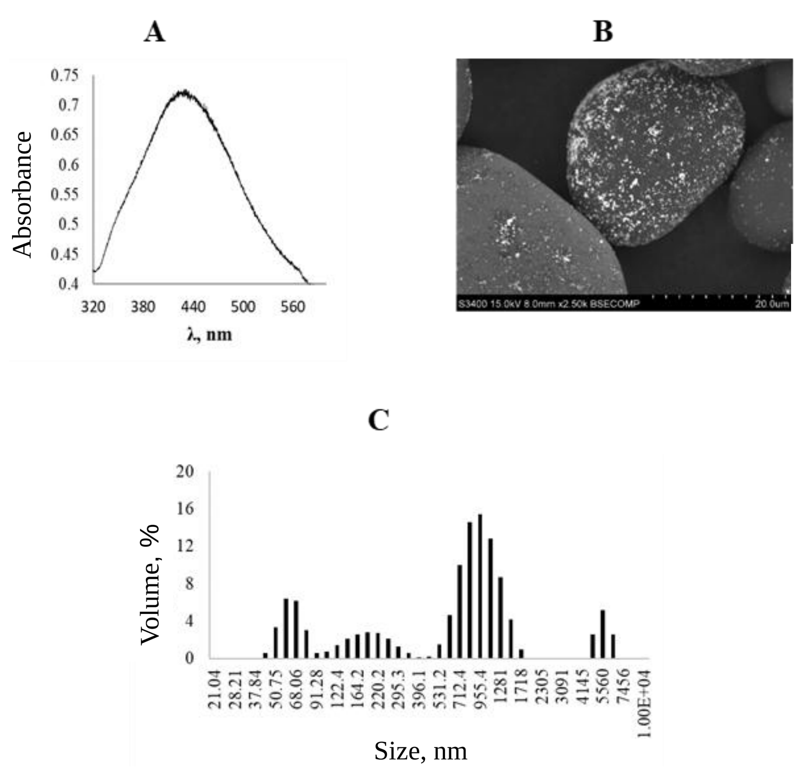


Fig. 4. *Characteristics of the AgNPs-E1414 modifier, A) UV-Vis spectrum (100×dilution); B) SEM image (magnification 2500×), C) particle size distribution*

Detection limit (LOD): $2.07\cdot10^{-8}$ mol·L^{-1}

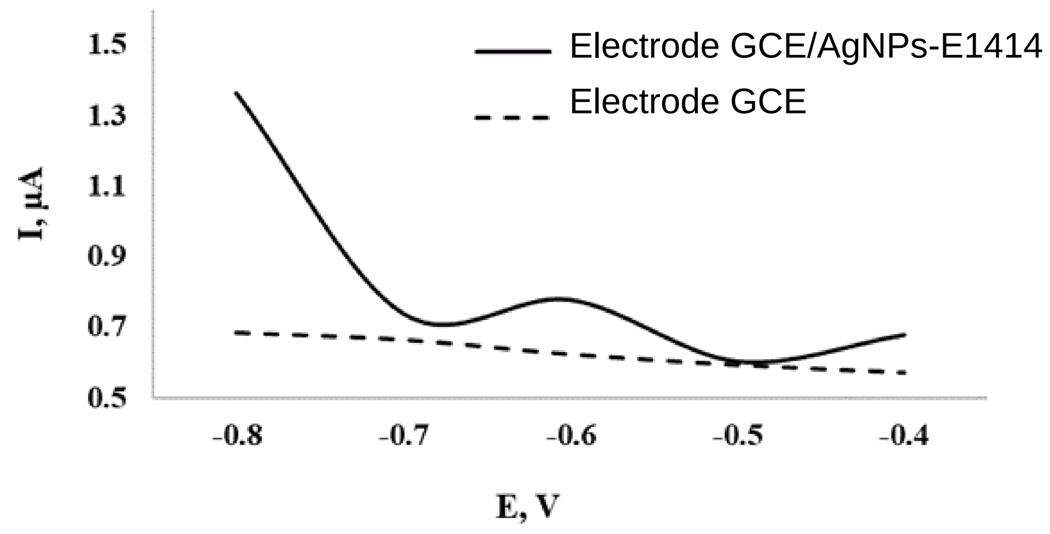


Fig. 5. *Differential pulse voltammetry for GCE electrode and GCE/AgNPs-E1414 electrode*

FUTURE WORK / REFERENCES

[1] DOI: 10.1002/elan.202200281
[2] DOI: 10.15199/62.2023.9.6
[3] DOI: 10.3390/ijms26199658
[4] DOI: 10.24425/aep.2025.157233