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Development of a Photothermally-Activated Hybrid Sol-Gel Platform for Enzymatic Biosensing Applications

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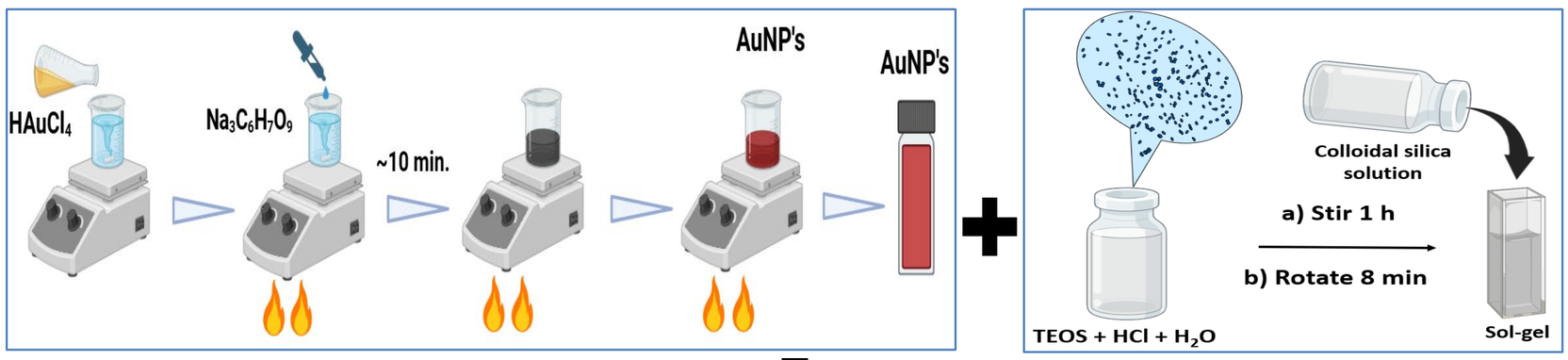
INTRODUCTION & AIM

Enzyme-based biosensors are promising for pollutant detection due to their specificity and eco-friendly nature. However, their practical application is often limited by challenges such as enzyme stability, reusability, and the need for optimal operating conditions.

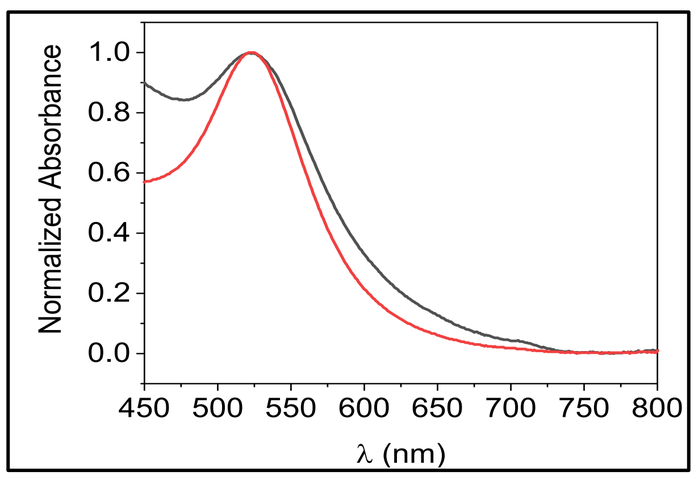
To address these limitations, we developed a hybrid sol-gel platform co-immobilizing laccase and gold nanoparticles (AuNPs) in a silica matrix. This system combines biocatalytic activity with photothermal properties, enabling localized heating through AuNPs under laser irradiation to enhance enzyme performance.

This work aims to design and characterize a photothermally responsive biosensor that improves enzymatic activity and stability through thermal modulation, enabling faster and more efficient pollutant detection.

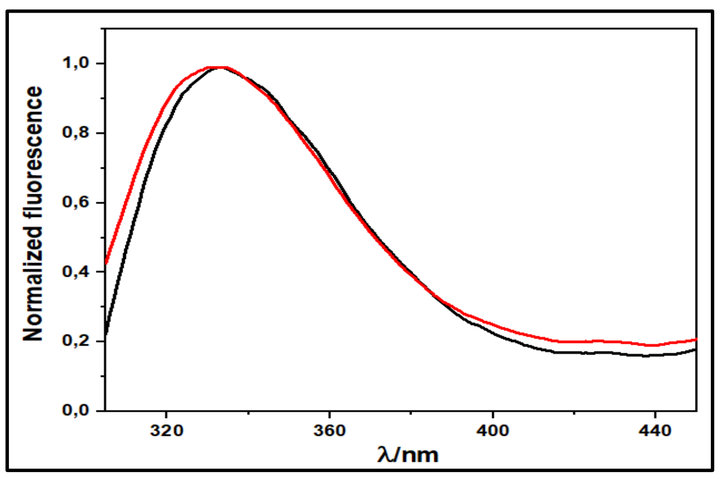
METHOD & OBJECTIVE



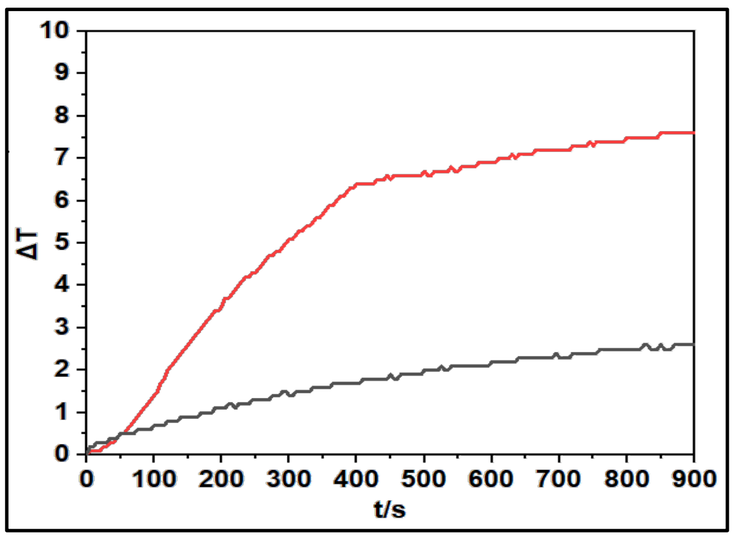
RESULTS AND DISCUSSION



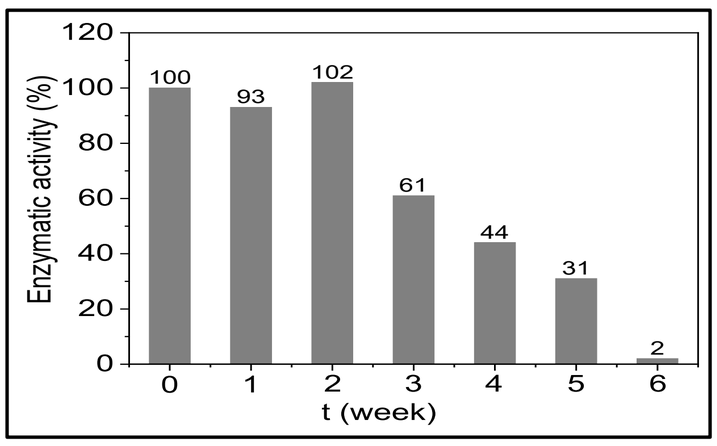
Normalized absorption spectra of AuNPs in solution (red) and immobilized in the silica matrix (black).



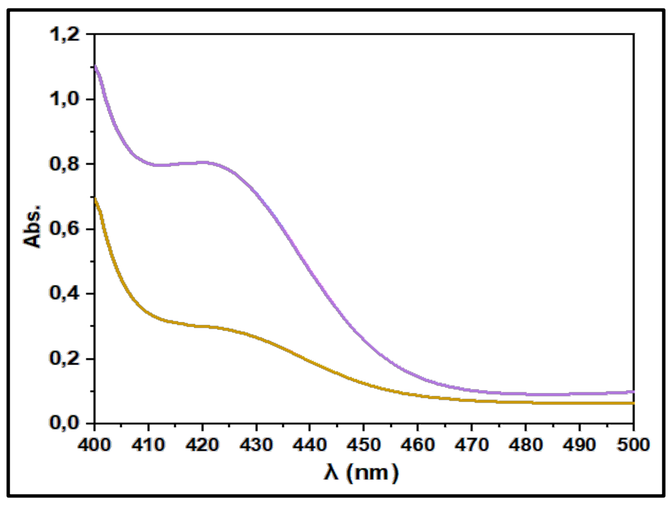
Normalized fluorescence emission spectra of laccase in solution (red) and immobilized (black) in sol-gel matrices.



Heating of the environment induced by 520 nm laser irradiation of AuNPs, showing heated gold in red and control in gray.



Stability of the enzymatic activity over multiple weeks, showing the retained activity of the immobilized laccase across time.



Enhanced ABTS oxidation by laccase upon 520 nm irradiation of AuNPs (purple), compared to the non-irradiated sample (yellow).

CONCLUSION

- The hybrid sol-gel matrix effectively co-immobilizes laccase and AuNPs without compromising enzyme activity.
- Localized photothermal heating from AuNPs under 520 nm laser irradiation significantly enhances laccase catalytic activity, as shown by higher substrate conversion rates.
- Immobilized laccase maintains high stability and enzymatic activity over several weeks, demonstrating the durability of the sol-gel platform.
- Photothermal modulation via AuNPs offers a controllable method to improve enzyme performance, potentially addressing key limitations in biosensor applications.

Acknowledgements

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