Biomimetic Synthesis of Lepidocrocite on Marine Spongin Scaffolds: Mechanistic Insights and Multifunctional Potential

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INTRODUCTION & AIM

In 1968, the initial discovery of crystalline mineral phases of **lepidocrocite (γ-FeOOH)** forming on the proteinaceos spongin fibres of marine sponges was a groundbreaking observation[1]. This research on iron-based biominerals from marine sponges is compatible with the biomimetics field[2]. The fascinating inquiry that arises is whether the marine sponges could provide a sustainable source of distinct **3D scaffolds**, that are apt for the biomineralization of iron ions on their microporous surface.

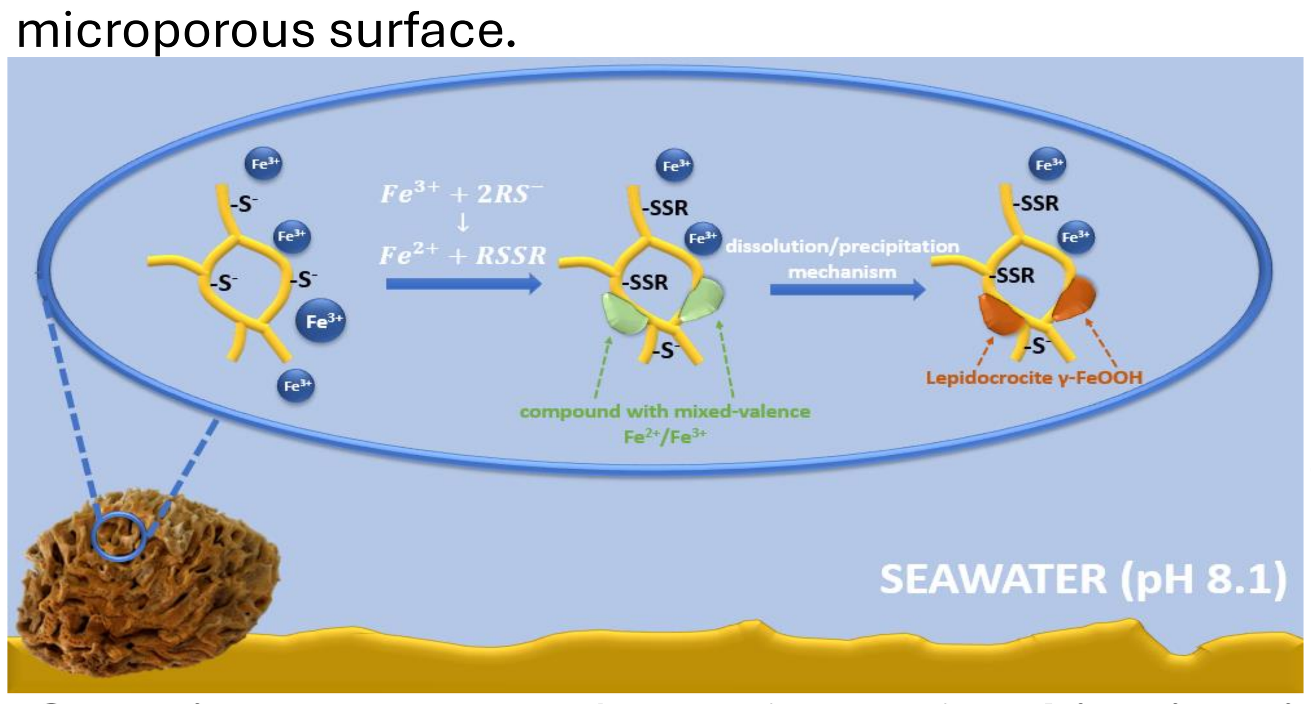
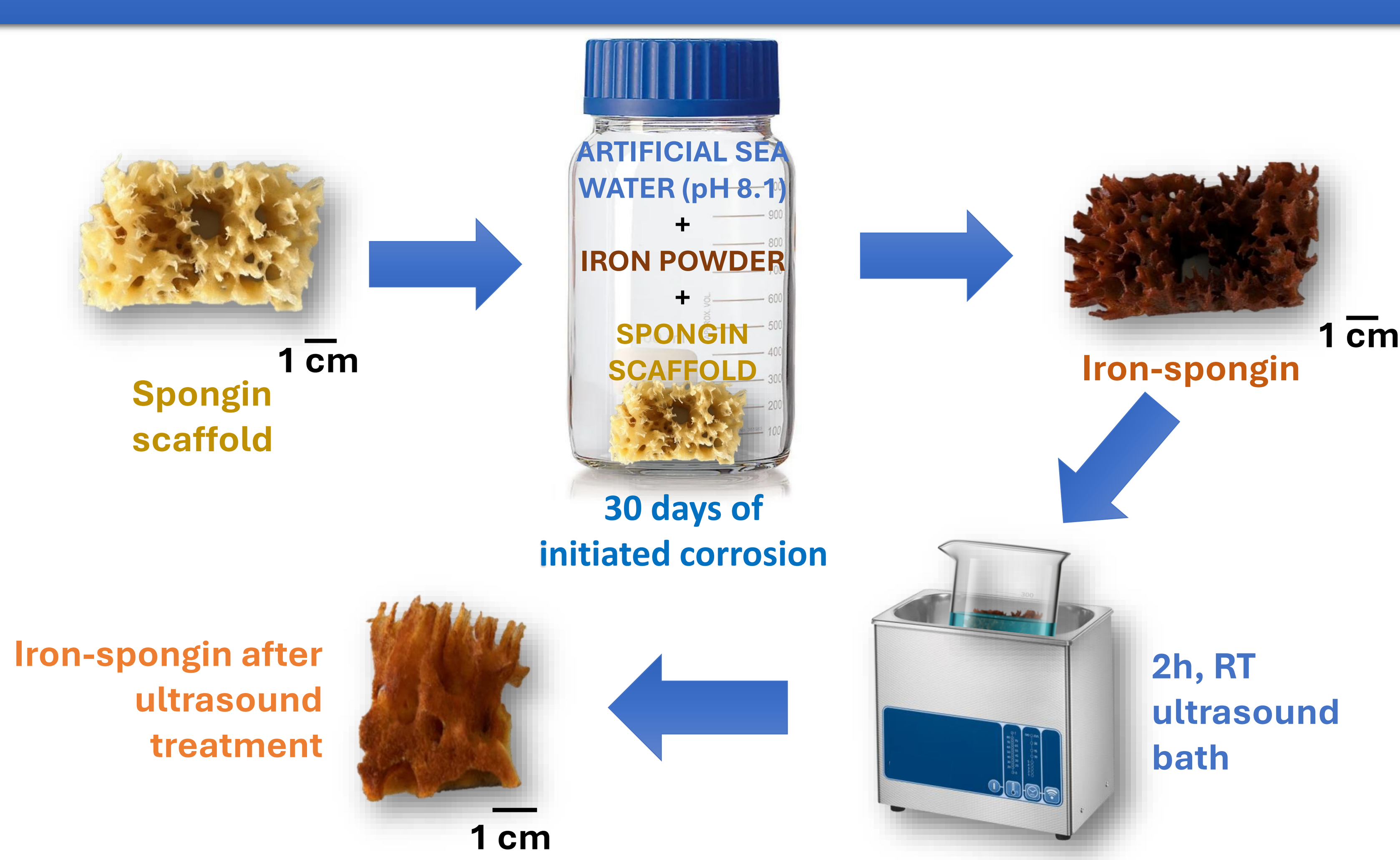


Figure 1. Schematic representation of the possible mechanism of lepidocrocite formation on spongin fibers[3].

Our aim was to apply an innovative **biomimetic** methodology to synthesize lepidocrocite on a spongin scaffold in vitro[3]. This research delved into the complex interaction between iron ions and the spongin scaffold in **the corrosive environment of artificial seawater**, which ultimately led to the pioneering creation of an iron oxide and spongin composite. Interestingly, our study is also a pioneering application of this 3D composite as a **dopamine sensor**.

METHODOLOGY



Spongin was placed in pH 8.1 artificial seawater containing powdered iron and left to initiate corrosion. The resulting material became entirely coated with brick-like sediment. An ultrasonic bath removed excess unattached precipitate after 2 hours at room temperature, yielding the final material.

RESULTS & DISCUSSION

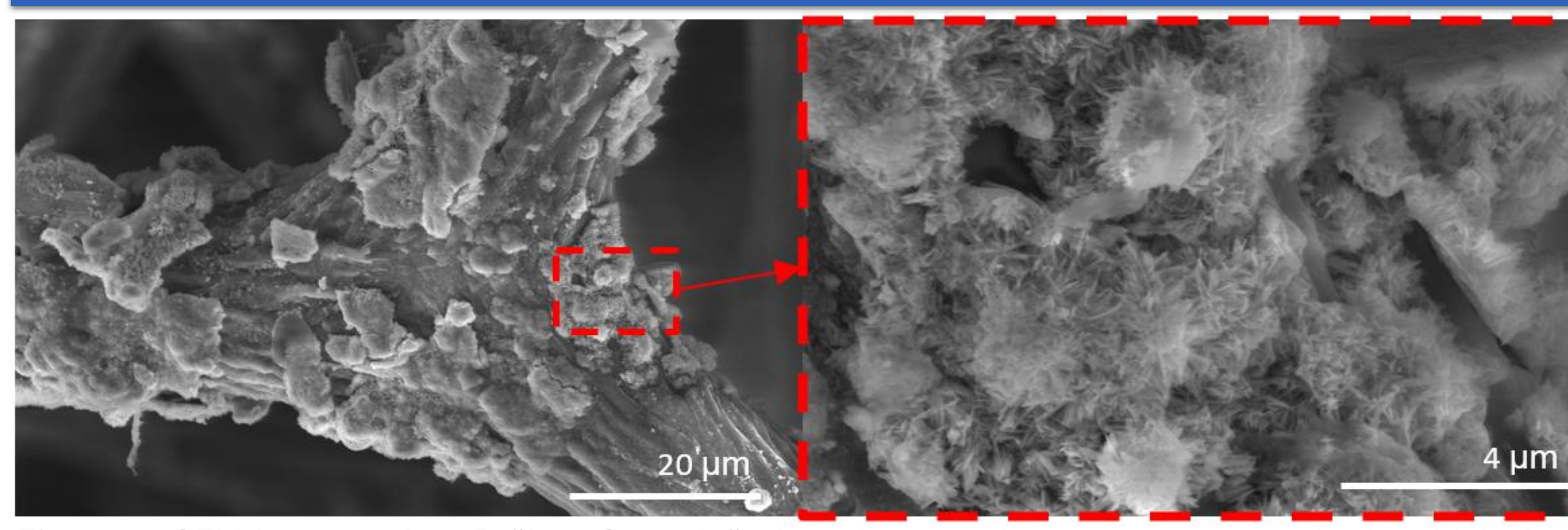


Figure 2. SEM images of a 3D "Iron-Spongin" after ultrasound treatment composite in which the formation of **the crystalline phase** remains clearly visible even after ultrasonic treatment.

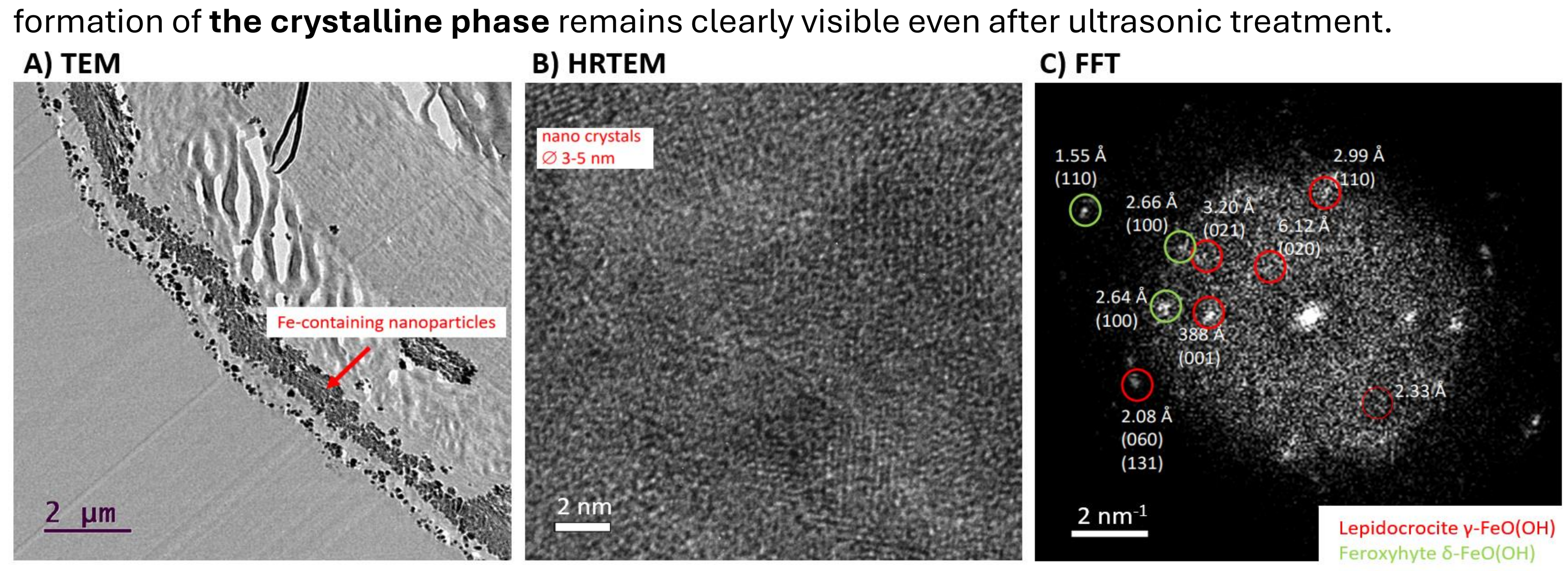


Figure 3. TEM overview (**A**) and high-resolution TEM (**B**) of Fe-containing nanoparticles on a selected nanofiber of "Iron-Spongin" composite investigated after ultrasound treatment. Calculated fast Fourier transform (FFT) with measurement of interplane separations indicating the **occurrence of lepidocrocite** and possible minor phase of feroxyhyte (**C**).

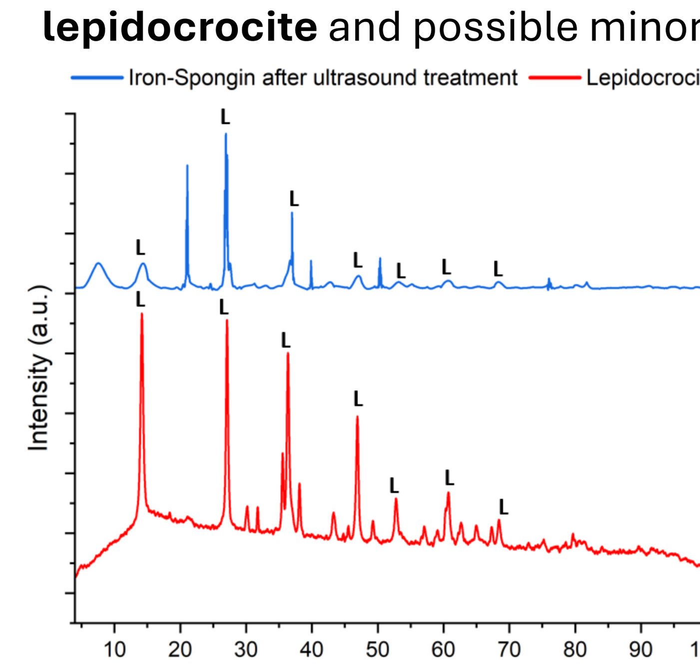


Figure 4. XRD patterns of "Iron-Spongin" after ultrasound treatment and lepidocrocite standard.

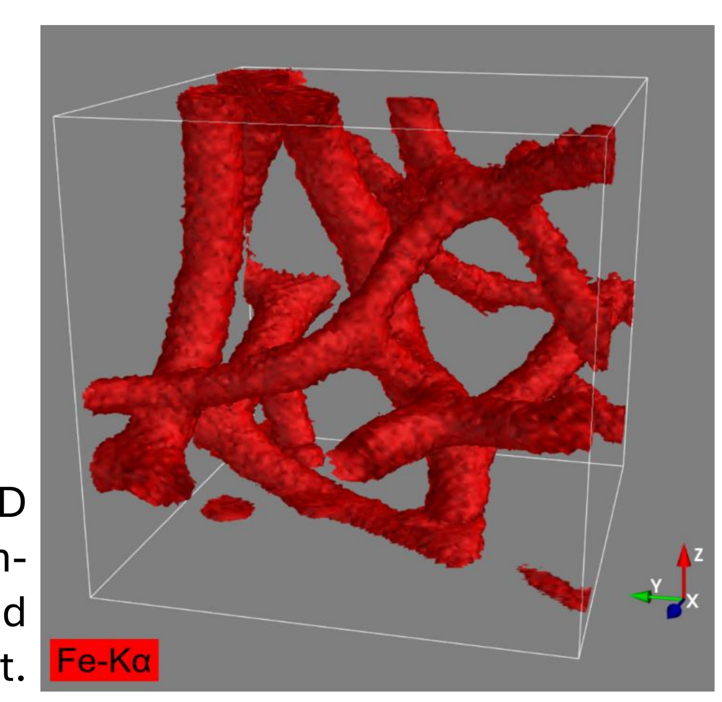


Figure 5. Image of 3D distribution Fe (Kα) in "Iron-Spongin" after ultrasound treatment.

Application – dopamine detection

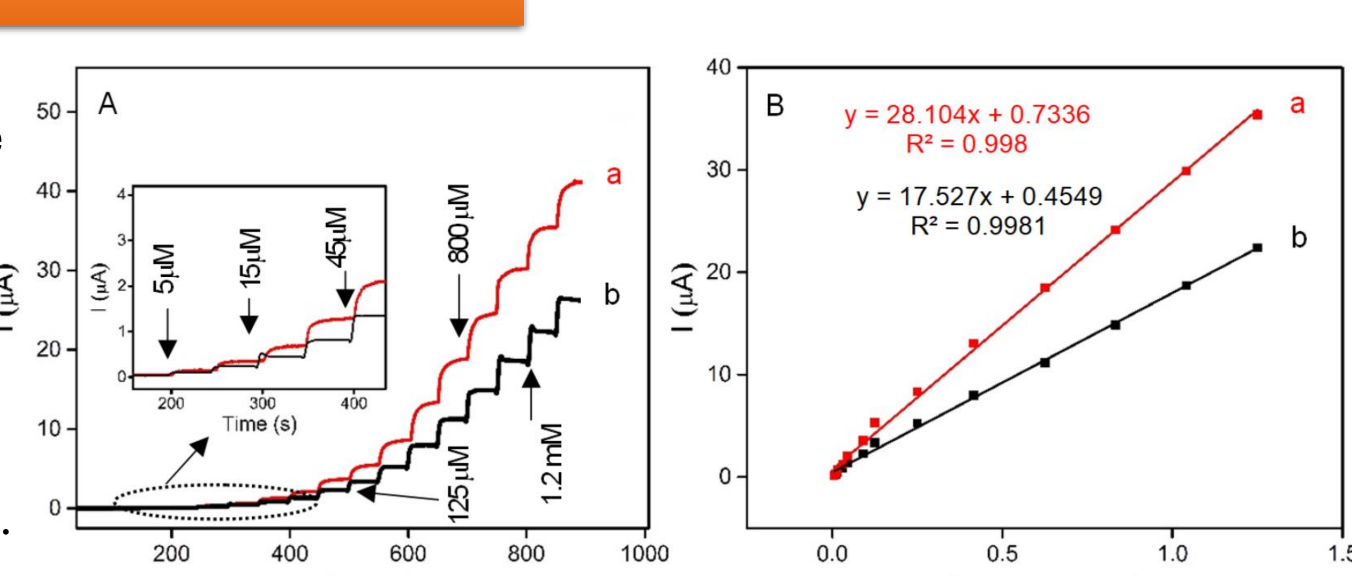


Figure 6. (**A**) Amperograms recorded in 0.1 M phosphate buffer pH 6.5 with the successive addition of dopamine (5 μM to 1.3 mM) at (a) Natural-Spongin/CPE, and (b) Iron-Spongin/CPE. (**B**) Calibration curve for the linear response of current vs. dopamine concentration.

CONCLUSIONS

Innovative Biomimetics Synthesis Method

Based on the biomineralization process, we developed a method for the in vitro synthesis of a **lepidocrocite-spongin** composite characterized by a **porous, macroscopic 3D structure**. The resulting material exhibited stability even after a sonication period of 2 hours.

Creative Application in Applied Sciences

This innovative material demonstrates significant potential as a novel **dopamine sensor.** Its capabilities include high electrocatalytic activity, fast response time (2s) and high sensitivity. This is an example of the successful translation of a biological process into a practical engineering application.

Future Research Perspectives

The findings open up new possibilities for future research into the biomineralisation and applications of marine sponge-derived composites in areas such as **environmental remediation, biomedical engineering and electrochemical devices.**

References

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3. Kubiak, A.; Pajewska-Szmyt, M.; Kotula, M.; et al. (2023) Spongin as a Unique 3D Template for the Development of Functional Iron-Based Composites Using Biomimetic Approach In Vitro. *Mar. Drugs*, 21, 460.

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