# Remediation of Heavy Metal Ions Using Ferritin Immobilized in Swellable Organically Modified Silica

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## Background & Significance

The demand for clean and safe water has increased by 600% in the last 100 years. Sources of pollution are mainly caused by anthropogenic (human) activity like farming and mining. Heavy metals present a significant cause for concern in water sources due to their involvement in several health concerns. Current water treatment methods often involve the formation of by-products or require pretreatment before heavy metal removal. Protein immobilization presents a new method for water purification that is selective for metal ions and doesn't generate additional pollutants.

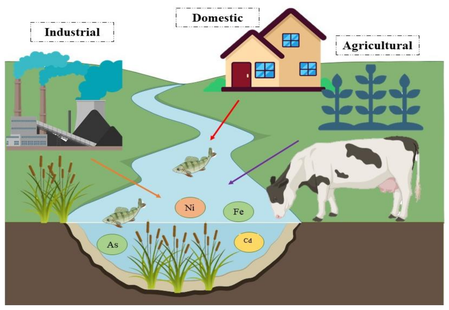



**Fig. 1**: Anthropogenic sources of metals.

## Swellable Organically Modified Silica (SOMS)

- SOMS is an organosilica material consisting of interconnected organosilicate nanoparticles
- SOMS expands upon adsorption of nonpolar solvents
- Can adsorb proteins and maintain their functional activity

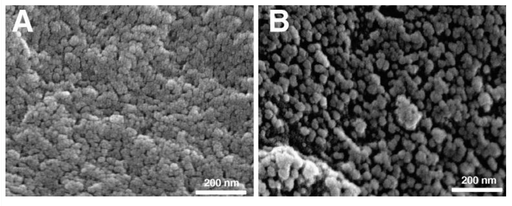



**Fig. 2**: A) Unswollen SOMS, B) Swollen SOMS

## Ferritin Structure & Function

- Ferritin is an iron storage protein
- Structure forms a dodecahedron cage
- Entry of $Fe^{2+}$ into ferritin is directed by facilitated diffusion; doesn't require a conformational change

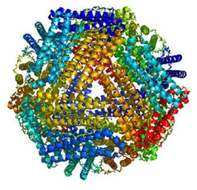


**Fig. 3**: Structure of ferritin.

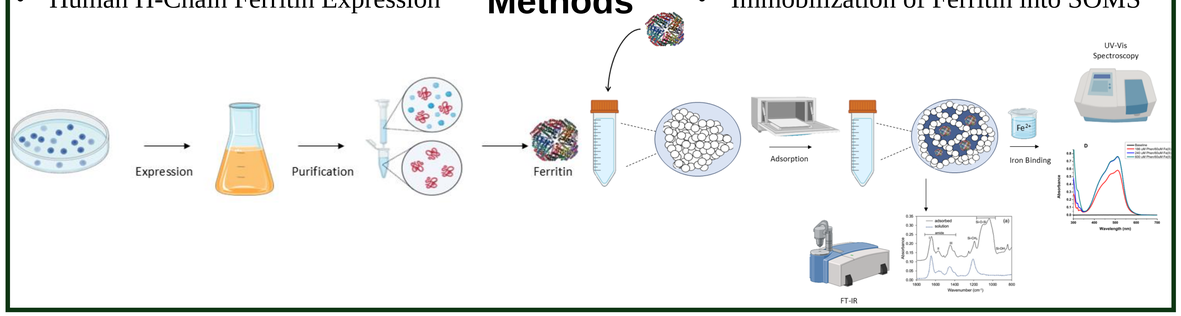
## Research Question & Goals

**Is ferritin immobilized in SOMS able to bind $Fe^{2+}$?**

- Expression and purification of human H-chain ferritin
- Using UV-Vis spectroscopy, measure adsorption of ferritin into SOMS.
- FT-IR to detect structural changes in ferritin upon adsorption.
- Add iron solutions to immobilized ferritin and measure with UV-Vis with EDTA, an iron chelator
- FT-IR to detect structural changes in ferritin when bound to iron

## Methods

- Human H-Chain Ferritin Expression
- Immobilization of Ferritin into SOMS




## Expression & Purification of Human H-chain Ferritin

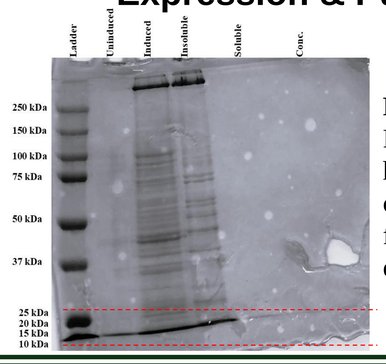



**Fig. x**: SDS-PAGE gel of human H-chain ferritin expression.

- Expression of human H-chain ferritin shows low yields.
- Large portion of expressed ferritin is in the insoluble fraction.

## Ferritin Adsorption into SOMS

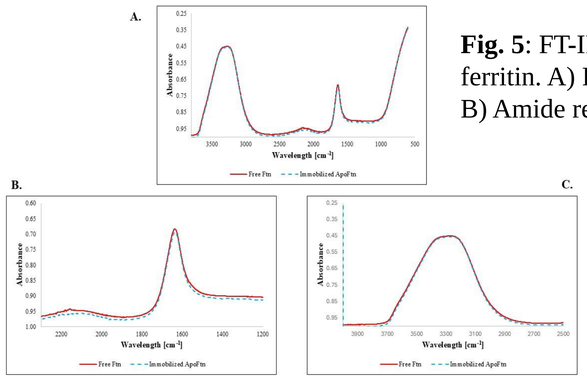



**Fig. 5**: FT-IR spectra of free ferritin and immobilized ferritin. A) Full spectrum from 4000 $cm^{-1}$ to 500 $cm^{-1}$. B) Amide region. C) 3900 $cm^{-1}$ to 2500$^{-1}$.

- No difference in IR spectra between free ferritin and ferritin immobilized in SOMS
- Ferritin was able to adsorb into SOMS

| Trial | Amount (mg) | % Protein Adsorption |
|---|---|---|
| 1 | 7.994 | 99.93 |
| 2 | 7.995 | 99.94 |
| 3 | 7.995 | 99.94 |
| avg | 7.995 | 99.94 |

**Table 1**: Amount of ferritin adsorbed to SOMS from 1 mg/mL stock solution.

## $Fe^{2+}$ Binding to Immobilized Ferritin

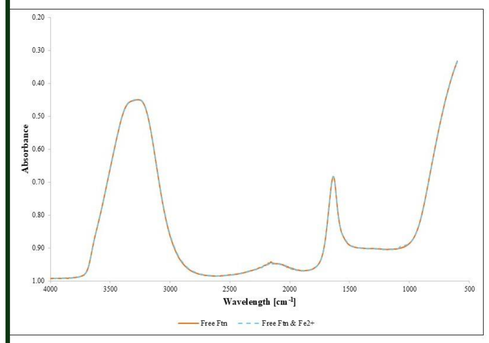



**Fig. 6**: IR spectra of apoferritin and mineralized ferritin from 4000 $cm^{-1}$ to 500 $cm^{-1}$.

- No difference in structure between apoferritin (no iron) and mineralized ferritin (bound to iron)
- Immobilized ferritin is unable to bind $Fe^{2+}$

| Trial | Amount (mg) | % Iron Adsorption |
|---|---|---|
| 1 | 0.326 | 3.26 |
| 2 | -0.4298 | 0 |
| 3 | 0.182 | 1.82 |
| avg | 0.026 | 1.69 |

**Table 2**: Amount of $Fe^{2+}$ bound by immobilized ferritin.

## Conclusions/Limitations

- SOMS can adsorb ferritin despite its large size
- Immobilized ferritin is unable to bind iron, most likely due to the lack of space for iron to enter SOMS pores
- FT-IR detected no structural changes when ferritin is bound to iron and immobilized in SOMS

## Future Work

Immobilization of ferritin could be explored with a different material. The pores of SOMS were large enough to encapsulate ferritin, but too small to allow interactions between ferritin and iron. A scaffold with a larger pore size may allow for immobilized ferritin to bind iron.

## Acknowledgements

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## Works Cited

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