Cyclic peptide-inorganic nanoparticles as co-assembled hydrogels for drug delivery

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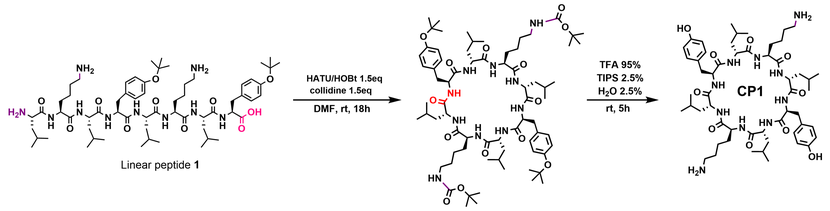
Introduction

Nanocomposite hydrogels are garnering attention for their versatile applications. These materials can be fabricated from the co-assembly between peptides and inorganic nanoparticles resulting in hydrogels with enhanced mechanical and functional properties. A recent study has shown the co-assembly of nanosilicates (laponite) with linear peptide amphiphiles, resulting in hydrogels for potential applications in neovascularization and hierarchical mineralization.[1] The latter provides the basis for further exploration of nanosilicate-peptide interactions, paving the way for the development of hydrogels tailored for various biomedical applications such as drug delivery, wound healing.

Goal: To develop an injectable hydrogel through the co-assembly between cyclic peptide (CP1) nanostructures and nanosilicate (nSi) for biomedical purposes, such as the drug release of antiobiotics.

Peptide synthesis



Scheme 1. Synthesis of cyclic peptide **CP1**

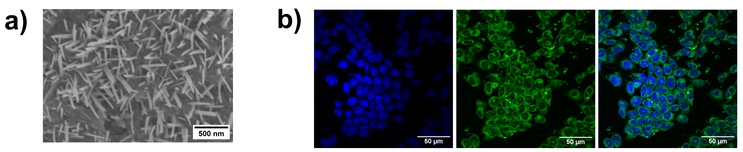


Figure 1. (a) FESEM of previous CP1 nanotubes. (b) Confocal fluorescence images of LNCaP cells with co-assembled CPNTs derived from CP1.[2]

Fabrication of hydrogel

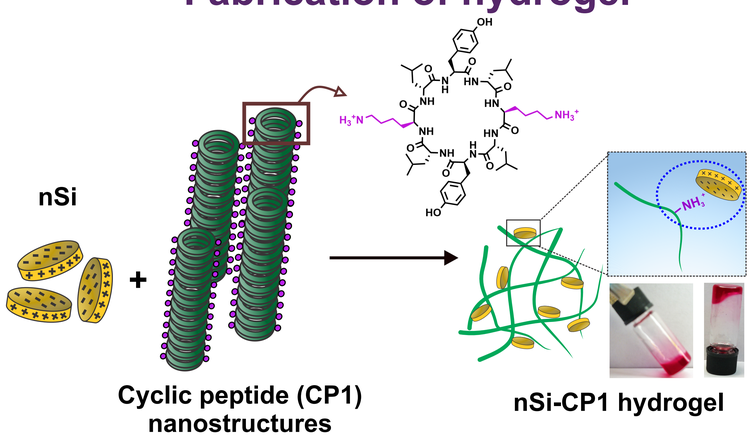


Figure 2. Representative diagram of co-assembly to form the gel

Characterization

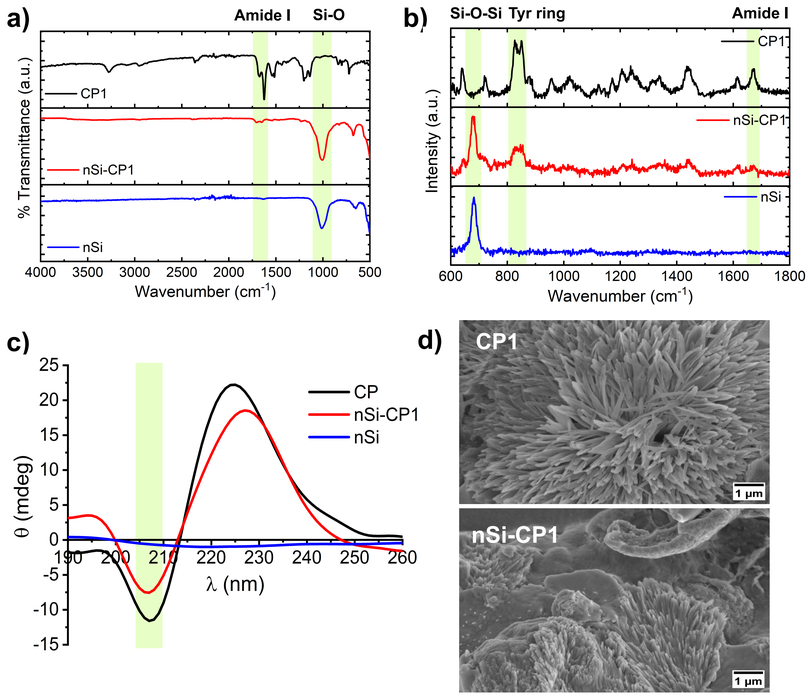


Figure 3. a) FTIR spectra, b) Raman spectra, c) CD spectra of nSi, CP1, and nSi-CP1 d) FESEM images of CP1 and nSi-CP1 in solution (drop casting).

Rheological properties

Rheological characterization demonstrated an increased elasticity of the material compared to a non-peptide containing counterpart.

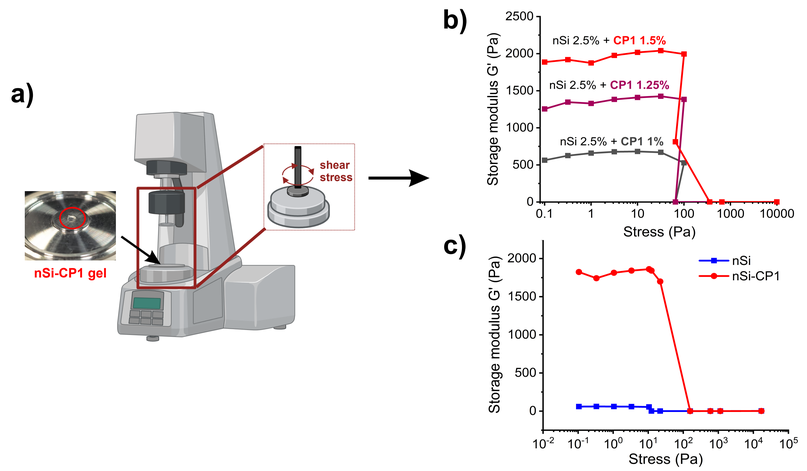


Figure 4. a) Schematic representation of the rheometer measurement. b) Amplitude sweep experiment of different gel formulations. c) Amplitude sweep experiment of the selected gel and non-peptide counterpart at 37 ºC.

Application

Drug release

After loading vancomycin onto the gel, 42.2% of this drug was released after 24 h.

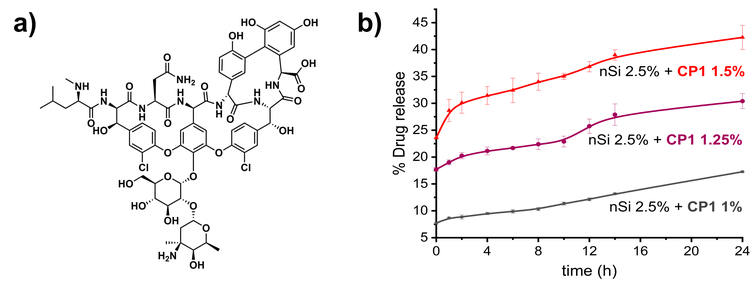


Figure 5. a) Structure of vancomycin. b) Cumulative release profile of vancomycin in different gel formulations.

Bacterial growth

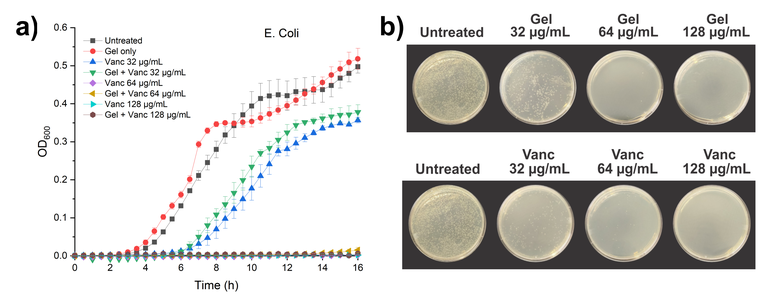


Figure 6. a) Bacterial growth curve b) Images of bacterial cultured plates (*E. Coli* DH5-α).

Conclusions

Summary

We report the the design of an inorganic-organic nanocomposite hydrogel based on the aqueous co-assembly of CP1 nanostructures and silicate nanodisks (nSi). Field emission SEM confirmed the formation of elongated nanostructures through the self-assembly of CP1. Drug release experiments showed that our gel released 42% of vancomycin, which was sufficient to eradicate *E. Coli* DH5-α growth.

Future directions

This inorganic-organic composite hydrogel will be explored for diverse drug delivery and therapeutics applications.

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1. Babatunde *et al.* ***ACS Nano*** 2021,15, 11202 - 11217.
2. F. Santillán, C. Charron, B. Galarreta, L. Luyt. ***Nanoscale*** 2024, 16, 22001 - 22010.

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