

INTRODUCTION

Conductive hydrogels serve as an interface between conventional rigid electronics and mechanically compliant biological tissues.

Key Challenge: Achieving electrical conductivity while maintaining bioorthogonal crosslinking capabilities.

Our Strategy: (1) Employ clickable polymer networks combined with peptide-guided conductive nanomaterials. (2) Peptide-functionalized nanomaterials provide a biocompatible route to electrical conductivity. (3) Click chemistry facilitates rapid, selective, and gentle hydrogel crosslinking under biologically compatible conditions.

Objectives:

- Develop clickable conductive hydrogel platforms.
- Incorporate gold-binding peptides and carbon nanotubes (CNTs) as conductive components.

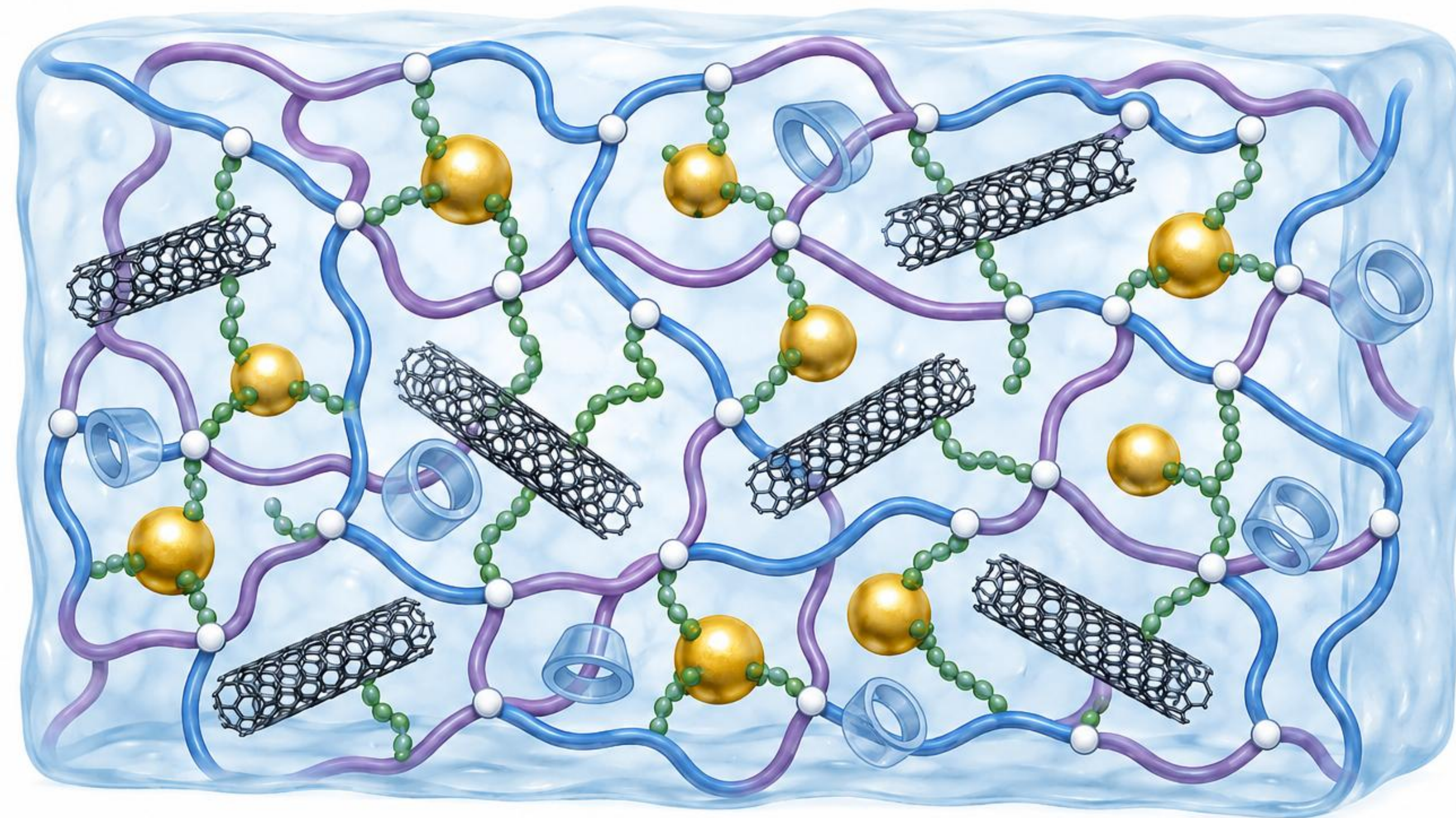


Fig. 1 Schematic illustration of a multifunctional supramolecular hydrogel nanocomposite. The 3D network is formed by two distinct polymer backbones (blue (Carboxymethyl cellulose (CMC)) and purple (polyethylene glycol (PEG)) chains) crosslinked with peptide strands (green) via click chemistry reactions (indicated by small glowing yellow nodes). The structure is functionalized with large gold nanoparticles (AuNPs) conjugated to the peptides. Additionally, carbon nanotubes (black cylinders) are embedded within the matrix, threaded with β -cyclodextrin (β -CD) macrocycles (toroidal ring structures), creating a hybrid conductive network.

MATERIALS DESIGN & SYNTHETIC STRATEGY

Functionalization of CMC and PEG with clickable groups:

Thiol (–SH), Norbornene (Nb), Maleimide (MI)

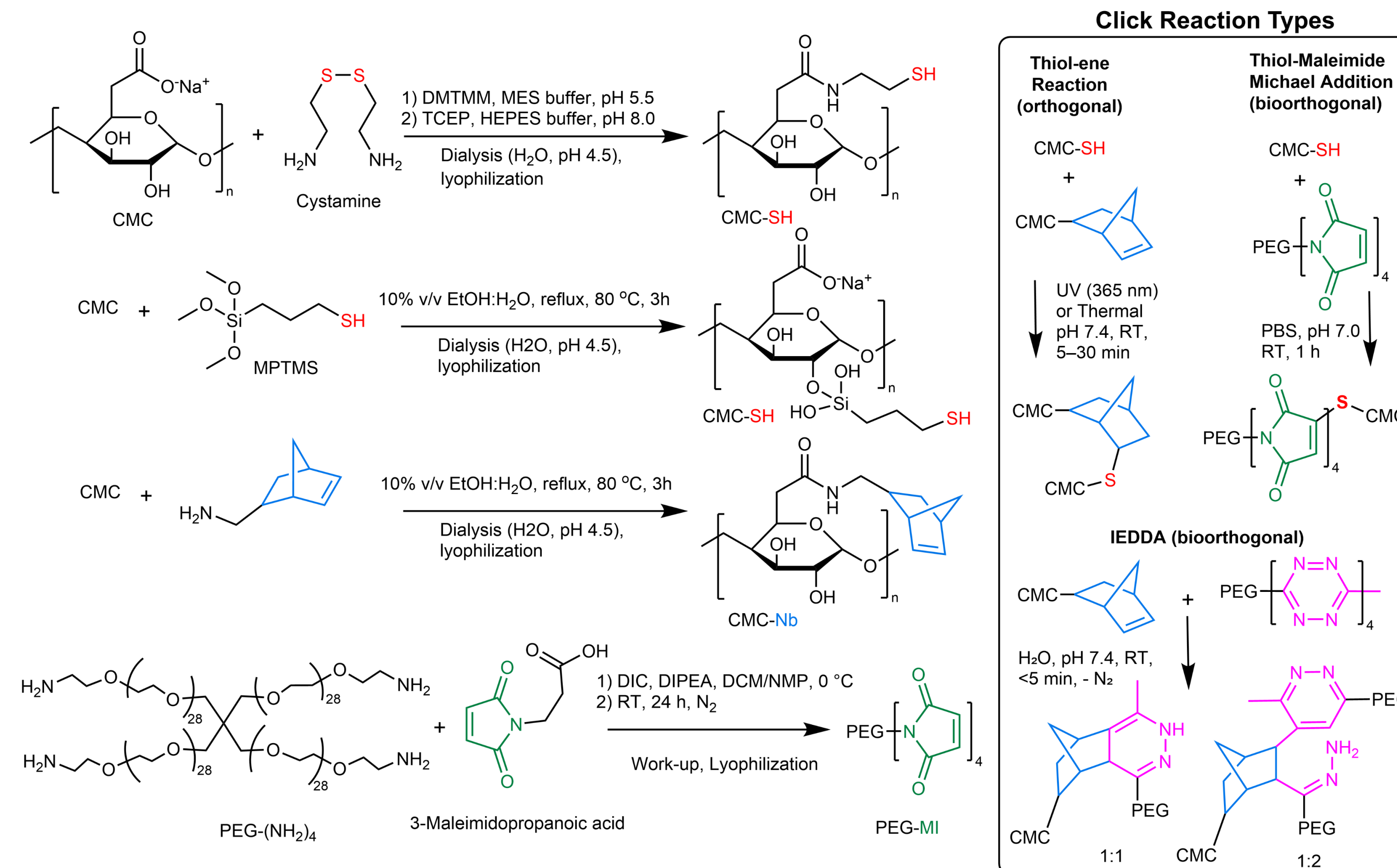


Fig. 2 Thiol-, maleimide-, and norbornene-functionalized CMC/PEG enable three orthogonal click reactions for modular hydrogels.

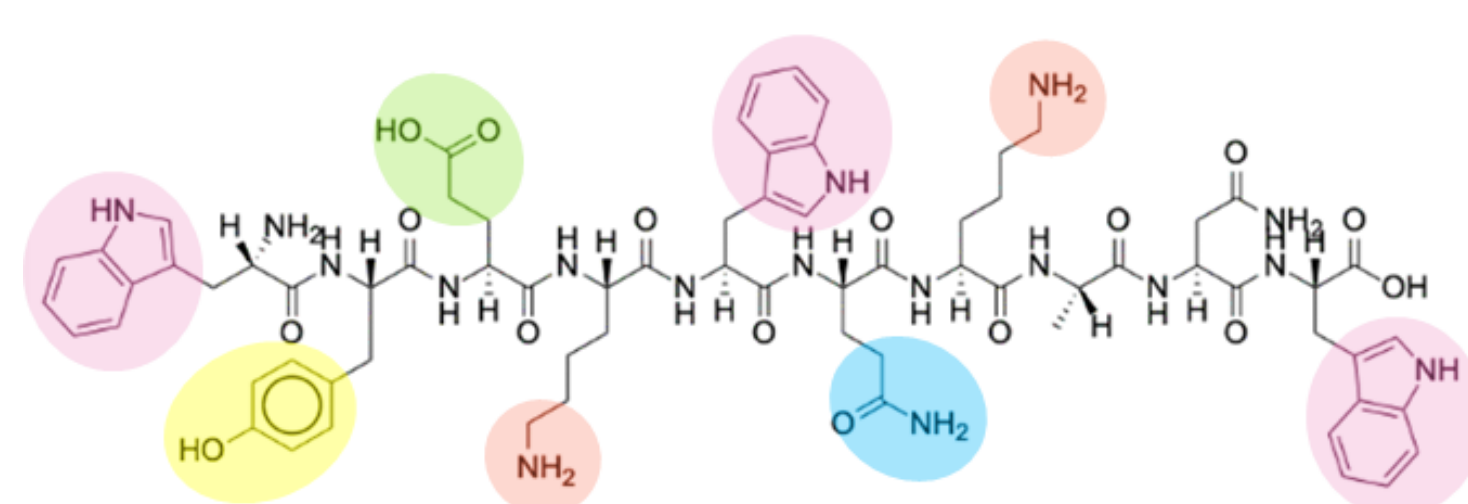
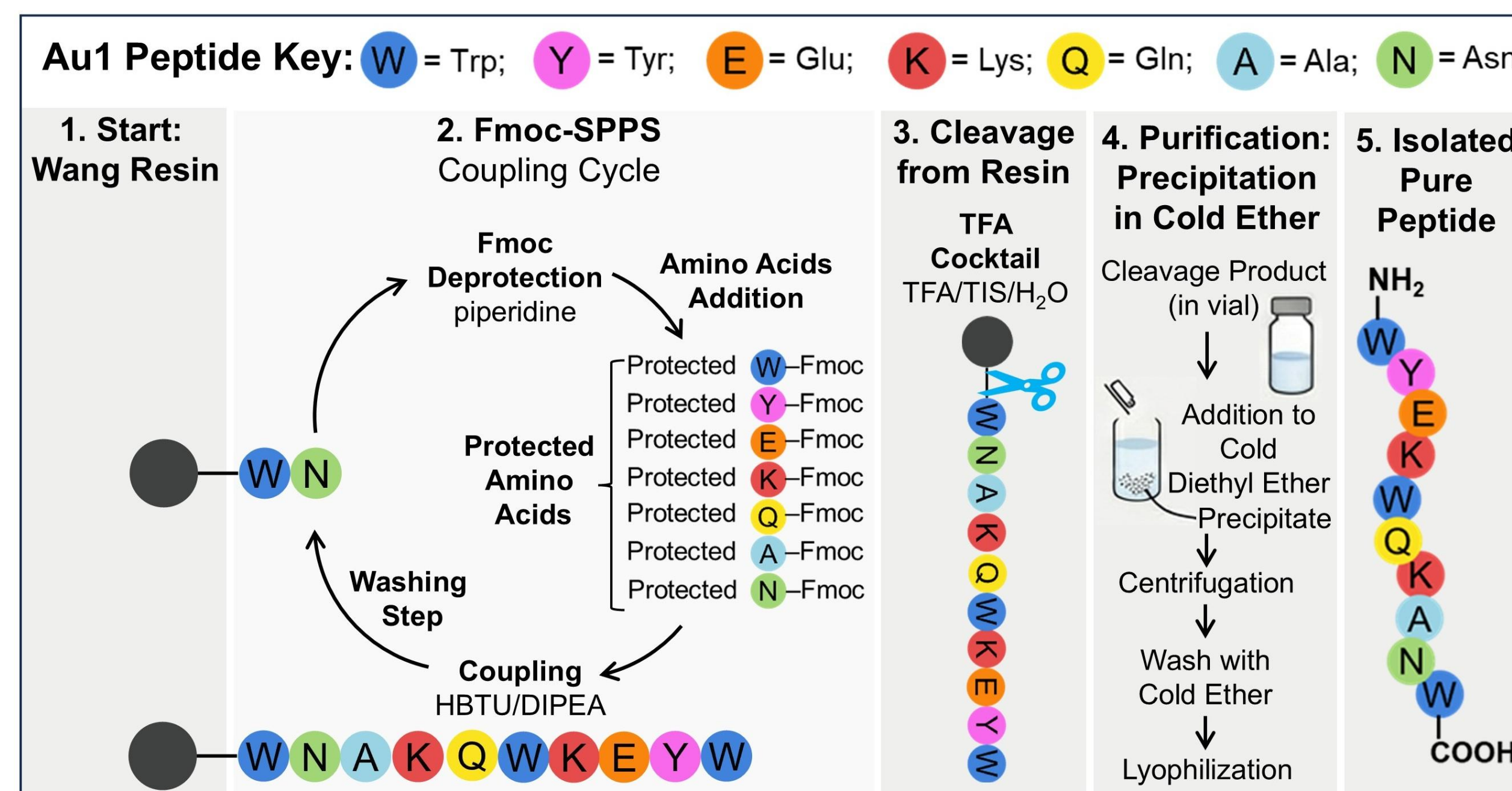


Fig. 4 Chemical structure of the peptide.

RESULTS & DISCUSSION

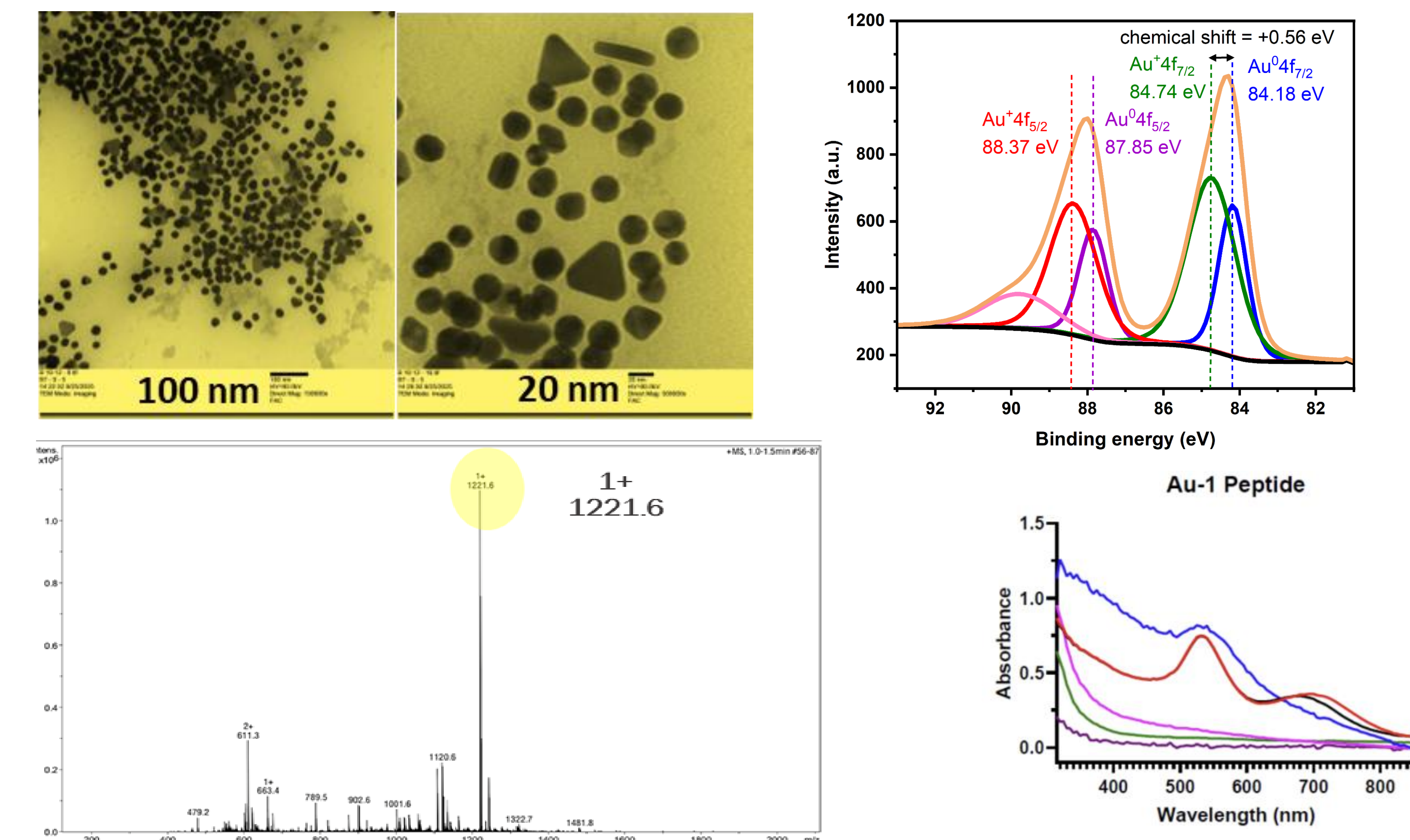


Fig. 5 (top left) TEM images revealing polygonal (hexagonal and trigonal) Au nanoparticles, confirming the successful formation of Au-1; (top right) XPS spectra demonstrating the reduction of Au(III) to metallic Au⁰; (bottom left) mass spectrum of the peptide verifying successful synthesis; (bottom right) UV-vis spectra recorded at different pH values showing that optimal formation of Au-1 nanoparticles occurs at pH 4.5.

Future Work

- Optimize peptide–Au loading in hydrogels
- Evaluate electrical & mechanical properties
- Develop CNT-functionalized clickable systems (Nb, SH)
- Explore synergistic conductivity (Au + CNT)
- Test in bioelectronic platforms:
 - Retinal interfaces
 - Wearable sensors
 - Drug delivery systems

Referecnes

- Ruan, Yongqiang et al., Applications of material-binding peptides. *ACS Biomater. Sci. Eng.* **8**, 4738–4750 (2022)
- Kalaoglu-Altan, O. I., Recent progress in click-crosslinked bio-based hydrogels for biomedical applications. *React. Funct. Polym.* **225**, 106771 (2026)
- Rahman, Md Saifur et al., Soft, stretchable conductive hydrogels for high-performance electronic implants. *Sci. Adv.* **11**, eads4415 (2025)