Self-Assembled Peptide-Au Nanoparticle Hybrid Systems for Catalytic Applications

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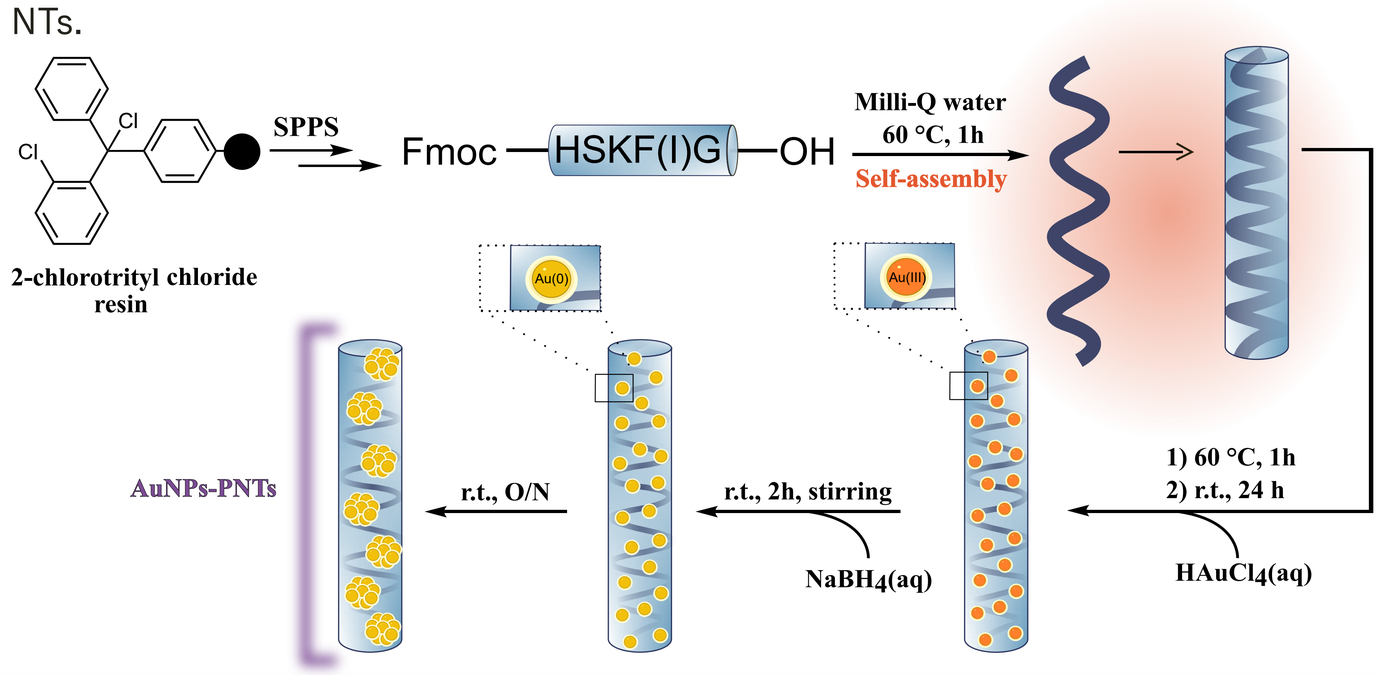
Background

Peptide-inorganic nanoparticle **hybrid structures** have attracted considerable attention due to their potential applications in biomedicine, electronics, or catalysis. The challenging aspect is the controlled design of **metal nanoparticles** (NPs), whose properties are highly dependent on their size, shape, composition, and spatial distribution.[1] To address this, **peptides** have emerged among various scaffolds for the controlled assembly and growth of NPs, owing to their self-assembly, binding capabilities, and sequence tunability.[2,3]

In this work, we exploit a short peptide's ability to self-assemble and, through physicochemical characterization, confirm the formation of **ordered and homogeneous supramolecular architectures, with preliminary investigations also suggesting catalytic activity in the reduction of 4-nitrophenol to 4-aminophenol.**

Synthesis

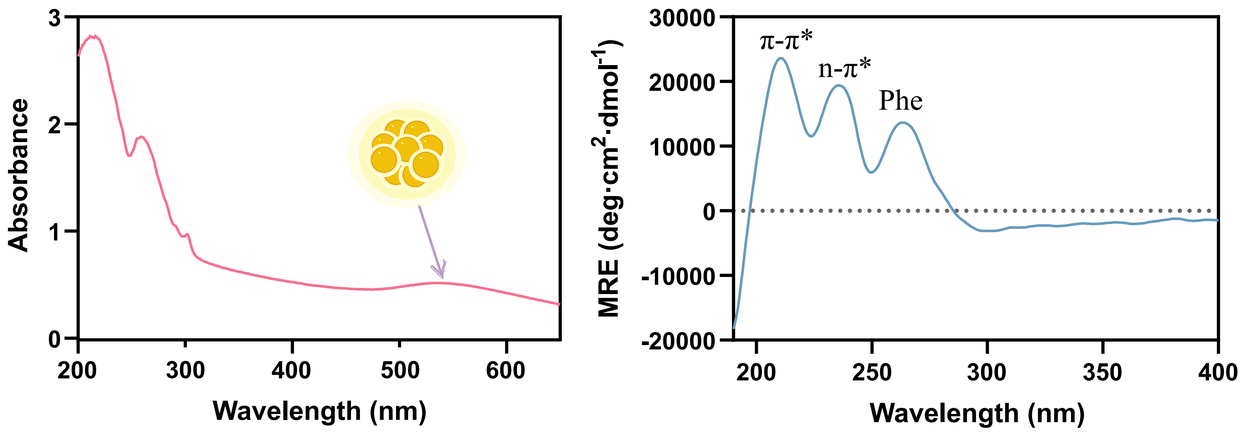
Herein we present the synthesis of hybrid peptide-gold nanostructures, harnessing a **Fmoc-pentapeptide's self-assembly into nanotubes** (NTs) as a supramolecular template able to **direct the nucleation and growth of gold NPs** evenly spaced over the surface of the NTs.



Characterization

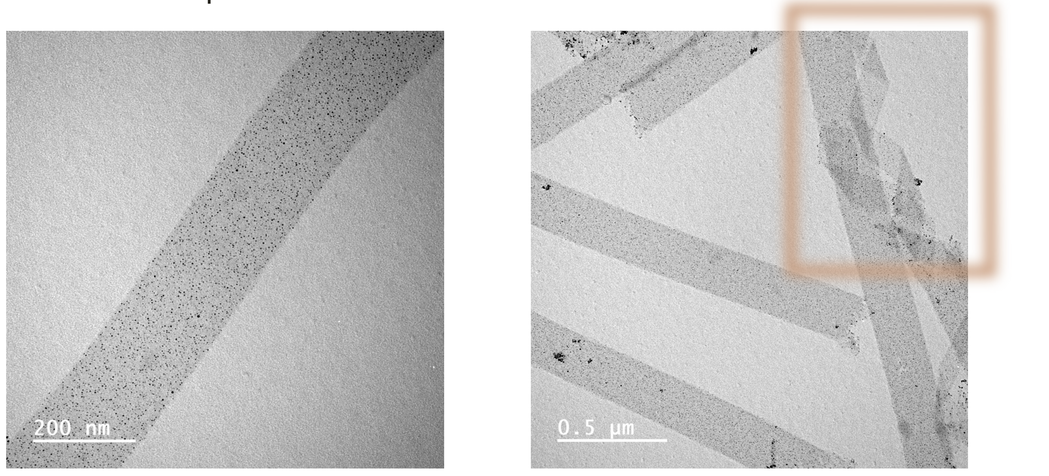
The **UV-vis** spectrum showed a distinct **plasmonic band around 530 nm**, indicating the presence of **Au-NPs**. Fluorescence spectra were also acquired, and the absence of a clear emission band upon excitation at different wavelengths further corroborated the presence of NPs rather than smaller NCs.

The **CD signal** contains **contributions from peptide conformation and interactions between Phe residues** which provide insights into the supramolecular arrangement of the system.



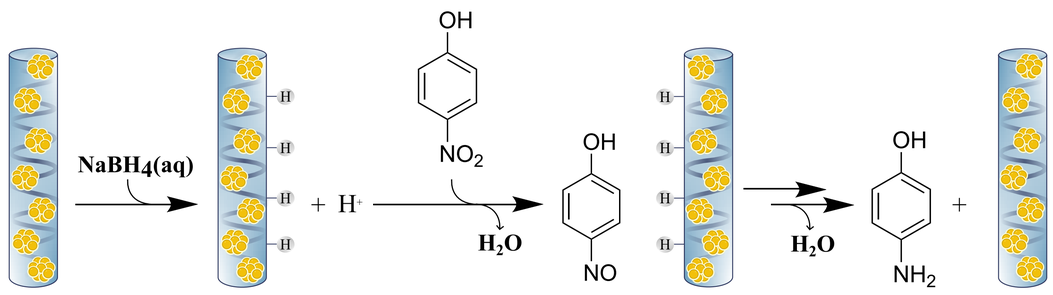
Left. UV-vis spectrum of 250 µM AuNPs-PNTs hybrid architectures ([P]:[Au] = 1:1) solution in Milli-Q water, T= 25 °C . Absorption bands at 214 and 258 nm correspond to peptide bonds and Phe respectively. Plasmonic band around 530 nm. **Right.** CD Spectrum of 250 µM AuNPs-PNTs hybrid system solution in Milli-Q water.

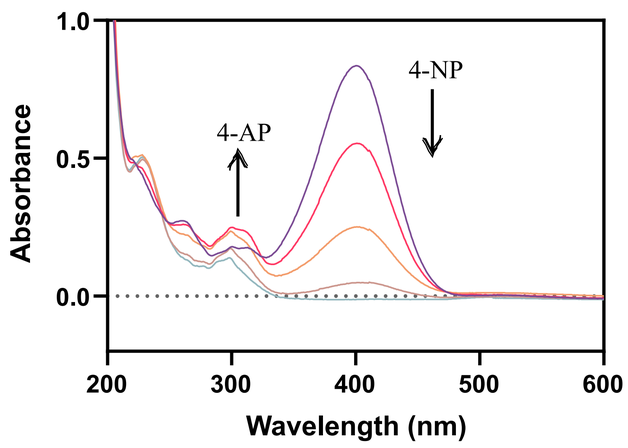
TEM images showed a population of **nanotubes with homogeneous diameter of ~ 200 nm, uniformly decorated with Au-NPs** with an **average diameter of around 2 nm**. Notably, intermediate stages of the nanotubes formation were captured.



Above. TEM images of 50 µM AuNPs-PNTs hybrid nanostructures in Milli-Q water.

Catalysis





Above. The reaction was monitored acquiring UV-vis spectra after 3 min (—), 15 min (—), 35 min (—), 55 min (—), 15 h (—). The decreasing intensity of the peak at 400 nm corresponds to 4-nitrophenol conversion over time. Reaction conditions: reaction temperature, 20 °C; 4-nitrophenol concentration, 50 µM; AuNPs-PNTs concentration, 22.2 µM; $NaBH_4$ concentration, 5 mM.

Conclusion

Harnessing peptide self-assembly enables the rational design of hybrid peptide-nanoparticle systems with controlled nanoparticle size and morphology, opening new opportunities for advanced catalytic applications.

References

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