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Design & Biomedical Application of 2D Self-assembled Peptide Nanosheets

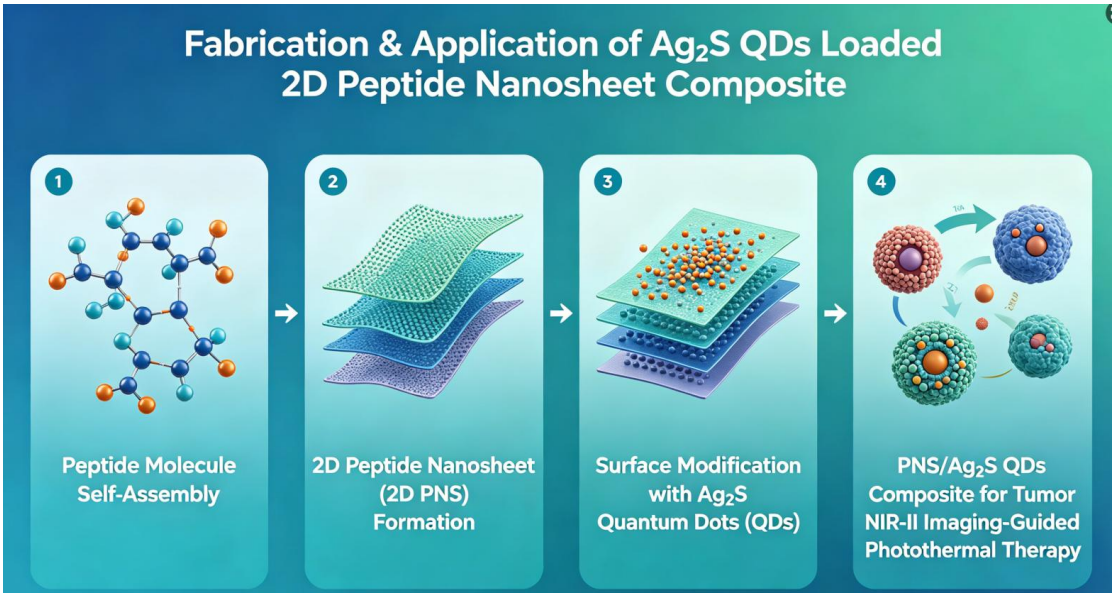
1.Research Background

Peptide molecules can rely on hydrogen bonding, hydrophobic and π-π stacking interactions to self-assemble into multi-dimensional nanostructures. Among them, two-dimensional peptide nanosheets (2D PNS) own ultra-large specific surface, abundant surface active sites and excellent biological safety & degradability, becoming ideal biomedical carrier materials. Traditional inorganic two-dimensional nanomaterials suffer poor biocompatibility and difficult in-vivo degradation; common single-component peptide carriers also lack functional responsiveness, limiting their further clinical transformation. Therefore developing functional composite materials based on self-assembled 2D peptide nanosheets has important research value for tumor precise therapy.

2.Research Purpose and Significance

This research designs specific peptide sequences, controls temperature, solvent and pH parameters to prepare uniform 2D peptide nanosheets via self-assembly. On this basis, two kinds of functional

composite platforms are constructed respectively: Ag_2S quantum dot modified composite for NIR-II imaging-guided photothermal therapy, and disulfide-linked doxorubicin peptide conjugate embedded in thermosensitive chitosan hydrogel for responsive chemotherapy. The study provides a novel preparation route of multifunctional peptide biomaterials and new ideas for developing minimally invasive tumor therapeutic reagents.



3.Research Content

Preparation of blank 2D PNS: Design Fmoc-modified polypeptide sequences, optimize incubation time and solvent environment to obtain size-uniform, β-fold structured two-dimensional peptide nanosheets with stable morphology.

Photothermal composite system: Covalently conjugate PEG-modified Ag_2S quantum dots onto PNS surface to form PNS/PEG-Ag_2S SQDs composite. The composite achieves high photothermal conversion

efficiency up to 52.46%, realizes NIR-II fluorescence in-situ tumor imaging and efficient photothermal ablation both in vitro and in vivo with low biological toxicity.

Stimuli-responsive drug delivery system: Synthesize thiol-modified DOX, connect with PNS via cleavable disulfide bond to get PNS-SS-DOX peptide-drug conjugate; encapsulate the conjugate into injectable thermosensitive chitosan hydrogel. The hydrogel presents pH-dependent swelling and sustained drug release, while disulfide bond can be cut by high glutathione inside tumor cells to trigger targeted drug release, effectively inhibiting cancer proliferation and lowering systemic side effects.

4.Conclusion & Outlook

The study successfully constructs two functional biomedical platforms based on controllable self-assembled 2D peptide nanosheets, covering imaging-guided photothermal treatment and tumor microenvironment responsive sustained chemotherapy, and verifies favorable biosafety and anti-tumor efficacy from multiple experimental levels. In future research, researchers will further optimize peptide sequence design, enrich modification types of functional nanoparticles and chemotherapeutic drugs, improve in-vivo long-term stability of composite materials, promote pilot production and preclinical research, and accelerate the industrial transformation of peptide-based anti-tumor biomaterials.