Self-healing injectable smart hydrogel for NIR triggered drug delivery application

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Abstract:

Cancer remains one of the leading causes of mortality worldwide, with conventional treatments such as chemotherapy, radiotherapy, and surgery often presenting challenges such as off-target effects, drug resistance, and insufficient therapeutic efficacy. In response to these limitations, advanced drug delivery systems, particularly those utilizing hydrogels, are emerging as promising solutions for more precise and effective treatment [1].

A self-healing injectable hydrogel composed of synthetic and natural polymers with outstanding mechanical properties and structural integrity was developed, showcasing remarkable resilience and adaptability. Mechanical characterization confirmed its superior stretching and bending capabilities, which were assessed through universal testing machine (UTM) and rheological analysis [2, 3]. The storage modulus exhibited a concentration-dependent trend, with values reaching approximately 868 Pa for the highest cross-linker concentration, 799 Pa for the intermediate concentration, and 606 Pa for the lowest concentration, indicating tunable mechanical strength. The hydrogel's self-healing ability was validated through cyclic loading tests, demonstrating efficient recovery of mechanical properties after damage. Moreover, the incorporation of nanomaterials further enhanced its structural stability, elasticity, and toughness. Morphological analysis revealed a well-defined porous network with pore size ~4 µm, contributing to its durability and suitability for biomedical applications. Notably, NIR-triggered drug release was observed at pH 5.0, with irradiation parameters of 0.56 W/cm², demonstrating the hydrogel's ability to provide controlled, site-specific drug delivery in response to external stimuli.

These findings highlight the hydrogel's potential for advanced biomedical use, particularly in cancer therapy and drug delivery systems, where precision and controlled release is critical. Further investigation into this hydrogel system could open new avenues for more effective cancer treatments.

Keywords: Injectable hydrogel, Self-healing hydrogel, NIR-triggered drug release, Cancer therapy, Controlled drug delivery

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