DEVELOPMENT OF AN OXIDIZED NANOCELLULOSE-REINFORCED CHITOSAN HYDROGEL FOR GASTRIC-TARGETED DELIVERY OF AMOXICILLIN TETRAHYDRATE

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Abstract

Conventional oral administration of amoxicillin tetrahydrate (AMT) is associated with rapid drug degradation in the acidic gastric environment, frequent dosing requirements, and inadequate drug concentrations at gastric infection sites, resulting in reduced therapeutic efficacy. pH-responsive hydrogels offer a potential approach for localized and sustained antibiotic delivery. This study aimed to develop an oxidized cellulose nanocrystal (CNC)-reinforced chitosan hydrogel for gastric-targeted AMT delivery. Unlike formulations incorporating unmodified CNCs, this approach employed potassium permanganate oxidation following sulfuric acid hydrolysis of microcrystalline cellulose to introduce carbonyl-containing functionalities into CNCs before their incorporation into the chitosan matrix. Oxidized CNCs were incorporated into chitosan and crosslinked using glutaraldehyde, with AMT added during hydrogel preparation. Formulations were evaluated using particle size analysis, Fourier-transform infrared (FTIR) spectroscopy, drug entrapment efficiency, pH-dependent swelling, mechanical testing, in vitro drug release, and antimicrobial assays. CNCs had an average diameter of 71.18 nm, while FTIR bands at 1720–1740 cm^{-1} were consistent with oxidation-associated carbonyl groups. AMT entrapment efficiency was 70.60 % for oxidized CNC hydrogels compared with 53.30 % for non-oxidized controls. The optimized formulation reached a maximum swelling ratio of 125% at pH 2.01, with a crosslinking degree of 82.69% and maximum compressive stress of 0.1815 MPa. Under simulated gastric conditions, cumulative AMT release reached approximately 80% over four hours. The AMT-loaded hydrogel demonstrated antibacterial activity against Escherichia coli and Staphylococcus aureus. Because glutaraldehyde was used as a crosslinker, residual crosslinker content, cytotoxicity, and overall biocompatibility require assessment before claims of safety for biomedical use can be established. Overall, potassium permanganate-oxidized CNC reinforcement offers a defined surface-modification strategy for tailoring chitosan hydrogel performance, supporting pH-responsive swelling, sustained AMT release, and antimicrobial activity. Subject to further biocompatibility and safety evaluation, this material platform may contribute to innovative, cellulose-derived drug-delivery approaches aligned with sustainable global wellbeing.

Keywords: Amoxicillin tetrahydrate, chitosan hydrogel, gastric-targeted delivery, nanocellulose, sustained release.