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Chitosan-derived biopolymers for biomedical applications: Innovations in drug delivery

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Chitosan, a naturally derived polysaccharide from chitin, has gained significant interest in biomedical engineering due to its biodegradability, mucoadhesiveness, antimicrobial activity, and excellent biocompatibility. This research investigates the development of chitosan-based biopolymer nanoparticles for controlled drug delivery, focusing on optimizing encapsulation efficiency and sustained release patterns. Using ionic gelation with sodium tripolyphosphate (TPP), nanoparticles were synthesized at varying polymer concentrations and pH conditions. Dynamic light scattering analysis revealed particle sizes ranging from 120–260 nm with narrow distribution, ideal for cellular uptake.

Encapsulation efficiency for model drug curcumin exceeded 82% at optimized chitosan/TPP ratios. In vitro release studies demonstrated a biphasic pattern: an initial burst release followed by a sustained release for up to 72 hours, attributed to gradual polymer degradation. Cytotoxicity assays using human fibroblast cells confirmed the nanoparticles' biocompatibility, showing over 90% cell viability. Antimicrobial activity tests also indicated strong inhibitory effects against Staphylococcus aureus and E. coli, supporting dual therapeutic functionality.

The study concludes that chitosan-derived biopolymers offer a versatile platform for drug delivery applications and can be tailored for targeted release, making them suitable for cancer therapy, wound healing, and oral drug administration. Future work involves surface modification to improve targeting efficiency and in vivo validation.