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Commentary

Multi-Responsive Nanohydrogel Networks of Chitosan for Controlled Drug Delivery

Jung Kwon*

Department of Materials Science, University of Seoul, South Korea

DESCRIPTION

In the pursuit of more effective drug delivery systems, researchers have turned to nanotechnology to engineer advanced carriers capable of precise, controlled release of therapeutic agents. One such innovation is the development of multi-responsive nanohydrogel networks using chitosan, a natural biopolymer derived from chitin. This groundbreaking approach combines the versatility of nanoscale materials with the intrinsic biocompatibility and biodegradability of chitosan, leading to a promising platform for tailored drug delivery. Chitosan, a polysaccharide obtained from the exoskeletons of crustaceans, possesses unique attributes that make it an ideal candidate for drug delivery systems. Its biocompatibility ensures minimal immunogenic responses, while its cationic nature allows for facile crosslinking, enabling the formation of three-dimensional networks. These networks serve as the foundation for nanohydrogels, providing structural integrity and stability for encapsulated drugs.

The hallmark of these nano-hydrogels lies in their multi-responsiveness, a property arising from the incorporation of stimuli-responsive elements. These elements enable the hydrogel to alter its structure and drug release behavior in response to specific environmental cues, such as pH, temperature, and enzymatic activity. This dynamic behavior allows for precise control over drug release kinetics, enhancing therapeutic efficacy while minimizing adverse effects. The pH sensitivity of chitosan-based nanohydrogels is particularly noteworthy. Chitosan is protonated in acidic environments, leading to increased swelling and drug release rates. This property is exploited for targeted drug delivery to specific physiological compartments characterized by varying pH levels. For example, the acidic environment of the stomach can trigger accelerated drug release, ensuring optimal absorption. The introduction of thermoresponsive moieties further augments the versatility of these nanohydrogel networks. By incorporating polymers sensitive to temperature changes, the hydrogel can undergo reversible phase transitions, influencing drug release rates. At lower temperatures, the hydrogel may remain in a collapsed state, restricting drug release. As the temperature rises, the hydrogel expands, facilitating controlled release of the encapsulated drug. Enzyme-responsive elements represent another critical component in the design of these nanohydrogel networks. By integrating enzyme-sensitive linkages, the hydrogel can be engineered to respond to specific enzymatic activities within the body. For instance, in regions with elevated concentrations of particular enzymes, such as tumor environments, the hydrogel may undergo degradation, resulting in the targeted release of therapeutic agents. The multi-responsive nanohydrogel networks of chitosan hold immense potential for a wide range of therapeutic applications. Their adaptability to various environmental stimuli enables tailored drug delivery strategies for conditions like cancer, inflammation, and infectious diseases. Additionally, the use of chitosan, a naturally occurring and biocompatible material, minimizes the risk of adverse reactions. Moreover, ongoing research is focused on refining the design principles of these nanohydrogel networks. Fine-tuning the responsiveness to specific stimuli, optimizing drug loading capacities, and investigating novel combinations of responsive elements are just some of the avenues being explored. Furthermore, advancements in nanotechnology and materials science are likely to facilitate the translation of this technology from the laboratory to clinical settings. The design of multi-responsive nanohydrogel networks using chitosan represents a significant milestone in the field of controlled drug delivery.

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CONFLICT OF INTEREST

The author declares there is no conflict of interest in publishing this article.

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Corresponding author Jung Kwon, Department of Materials Science, University of Seoul, South Korea, E-mail: Jungkwon555@yahoo.com

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