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Using a Nanoparticle Drug Delivery System for Breast Cancer Therapy

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Abstract

Despite recent advances, cancer remains the leading cause of death on a global scale. Various types of research have been conducted in order to discover novel and effective anticancer medications. The complexity of breast cancer, combined with patient-to-patient variations and heterogeneity between cells within the tumour, is a major challenge. That problem is expected to be solved by revolutionary drug delivery. Chitosan nanoparticles have the potential to be a game-changing delivery system capable of increasing anticancer drug activity while decreasing negative effects on normal cells. The use of smart drug delivery systems as delivering materials to improve the bioactivity of NPs and to better understand the complexities of breast cancer has piqued the interest of many researchers. Current therapies are still ineffective in eradicating the disease as a whole, necessitating advancement through the use of far more specific treatments. Conventional chemotherapy employs poorly water-soluble drugs with limited delivery to target tissues, which leads to the development of resistant tumours, high drug toxicity in normal cells, severe side effects, rapid degradation, low specificity, and limited targeting. The main challenges in cancer therapy are drug development and drug delivery systems.

Keywords: Nanocarrier • Multimodal delivery • Stimulus response • Breast cancer

Introduction

Encapsulation or trapping of drugs in nanocarriers can increase their solubility, facilitate their transport in circulation to cancerous tissues, maintain anticancer potential, minimise drug toxicity by reducing inappropriate distribution, and increase drug accumulation at the targeted site, bioavailability, and half-life. Small size, large surface area, high drug-loading capacity, easy surface functionalization, and increased stability of nanoparticle formulations are the nanovehicles concepts that form the basis of the chemical approach to nanomaterials, making polymer-based NPs an efficient delivery platform. Recent studies have demonstrated the efficacy of NT in cancer treatment by developing a wide range of nanovehicles. Liposomes, dendrimers, polymeric nanoparticles, carbon nanotubes, iron oxide nanoparticles, and gold nanoparticles are just a few of the options for developing nanovehicles.

Literature Review

Polymeric nanoparticles' hallmark properties as cancer nanovehicles have been demonstrated in numerous studies, including targeted drug delivery, controlled drug release, enhanced therapeutic efficacy, and safety. Efforts in the development of chemotherapy drug delivery systems have concentrated on delivering chemotherapy drugs directly to cancer cells while minimising toxic effects on healthy tissue. This strategy has the potential to improve treatment efficacy while minimising side effects. Polymeric NPs are submicron colloidal particles that are widely used in drug delivery systems due to the ease with which targeting ligands can be attached to the surface of NPs. Surface modification of these PNPs with targeting ligands allows them to be recognised by specific receptors or ligand binding sites that are overexpressed on cancer cells or at target sites, allowing for controlled release of loaded drugs..

Numerous studies have demonstrated the hallmark properties of polymeric nanoparticles as cancer nanovehicles, including targeted drug delivery, controlled drug release, enhanced therapeutic efficacy, and safety. Chemotherapy drug delivery systems have been developed with the goal of delivering chemotherapy drugs directly to cancer cells while minimising toxic effects on healthy tissue. This approach has the potential to increase treatment efficacy while reducing side effects. Polymeric NPs are submicron colloidal particles that are widely used in drug delivery systems because targeting ligands can be easily attached to the surface of NPs. Surface modification of these PNPs with targeting ligands allows them to be recognised by specific receptors or ligand binding sites overexpressed on cancer cells or at target sites, allowing them to be recognised.

Discussion

Chitosan, a chitin-derived biodegradable and biocompatible polysaccharide, has been extensively researched as a promising nanovehicle for cancer therapy. Chitosan has shown promise in cancer therapy, particularly as a dissolving agent, drug stabiliser, and controlled-release drug control, providing a multifunctional platform for targeting, stimulus-responsive release, and image-guided medicine. The design criteria for achieving cancer-targeting goals, which include selective targeting of cancer cells, efficient anticancer drug release at target sites, and elimination of cytotoxicity to non-cancerous tissues, will be met by CSNPs. Chitosan has a unique combination of properties that make it a promising option for cancer therapy when compared to other natural polymers such as alginate or gelatin.

There have been many reviews of CSNPs that present various points of view, but none have described a cancer therapy series from cell uptake to cell death. This knowledge is critical in the development of chitosan-based preparations. This review focuses on CSNP-based SDD approaches that use stimulus-responsive particle engineering, passage targeting, and drug release mechanisms to improve the effectiveness and efficiency of cancer therapy. Smart polymer rational design will improve drug therapy and reduce side effects, resulting in more effective and cost-effective treatment and a faster recovery for patients.

Nature causes tumour cells to develop in an uncontrolled manner. This creates a distinct 'tumour microenvironment,' which promotes tumour cell growth

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and development. This includes changes to the circulatory system, oxygenation, perfusion, pH, and metabolic rate. Fibroblasts, immune cells, extracellular matrix, cytokines, and macrophages make up the tumour microenvironment. By altering the microenvironment, these cells can influence whether a tumour is pro- or anti-tumor. All of these elements have the potential to interact with cancer cells, thereby contributing to carcinogenesis. The tumour microenvironment, which includes stromal cells and matrix components, is thought to be a major impediment to nanomedicine delivery. TME has distinct enzymes, higher glutathione levels, lower pH levels, hypoxic conditions, and charge reversal.

Tumor cells develop in an uncontrolled manner by nature. This results in the formation of a distinct 'tumour microenvironment,' which promotes tumour cell growth and development. Changes to the circulatory system, oxygenation, perfusion, pH, and metabolic rate are all examples of this. The tumour microenvironment is made up of fibroblasts, immune cells, extracellular matrix, cytokines, and macrophages. These cells influence whether a tumour is pro- or anti-tumor by altering the microenvironment. All of these elements have the potential to interact with cancer cells, contributing to the carcinogenesis process. The tumour microenvironment, which consists of stromal cells and matrix components, is thought to be a significant impediment to nanomedicine delivery. TME contains unique enzymes, higher glutathione levels, lower pH values, hypoxic conditions, and charge reversal [1-5].

Conclusion

In this study, we highlight drug conjugates in CSNPs with enhanced multifunctionality that are decorated with stimuli and targeting sites that have been shown to improve their anticancer efficacy when compared to free drug compounds. Diverse polymeric co-delivery systems with high anticancer efficacy, particularly in multidrug-resistant cancers, have been developed. To promote active targeting and drug endocytosis of targeted cancer cells, targeting ligands can be attached to particles. pH, enzymes, or thermoresponsive particles or conjugates can be used to achieve controlled release of anticancer drugs from particle carriers. However, there are numerous challenges associated with co-delivery approaches, such as loading, capacity, stability, release kinetics, biocompatibility, and tumor-targeting efficacy.

Acknowledgement

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Conflict of Interest

There are no conflicts of interest by author.

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