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Iron Chelation and Total Bio-Based Materials for Drug Delivery in the Battle against Cancer

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Abstract

Cancer is one of the leading causes of death worldwide, with millions of people affected by this devastating disease each year. While significant progress has been made in the field of cancer treatment, there is still a pressing need for more effective and targeted therapeutic strategies. In recent years, iron chelation and total bio-based materials have emerged as promising approaches for drug delivery in the battle against cancer. This article will explore the potential of these innovative techniques and their impact on improving cancer treatment outcomes. Iron is an essential element for normal cellular function, but it can also play a role in cancer progression. Tumor cells often have an increased demand for iron to support their rapid growth and proliferation. Therefore, targeting iron metabolism in cancer cells has become an attractive strategy for therapeutic intervention. Iron chelation refers to the process of binding and removing excess iron from the body. By reducing the availability of iron, chelation therapy can hinder tumor growth and enhance the effectiveness of traditional cancer treatments.

Keywords: Cancer • Tumor • Reactive oxygen species • Deferoxamine

Introduction

Natural and synthetic. Natural iron chelators, such as deferoxamine and deferiprone, have been used for the treatment of iron overload disorders, such as thalassemia and hemochromatosis. These chelators have also shown potential as anticancer agents due to their ability to inhibit iron-dependent enzymes involved in tumor progression. Synthetic iron chelators, such as desferrioxamine derivatives and Dp44mT, have been specifically designed to target cancer cells and disrupt their iron metabolism. These compounds have demonstrated promising anticancer activity in preclinical studies and are currently being evaluated in clinical trials. Traditional drug delivery systems often face challenges such as poor stability, limited bioavailability, and off-target effects. Bio-based materials offer an alternative approach by utilizing natural compounds derived from renewable sources. The combination of iron chelation and total bio-based materials offers a synergistic approach for effective drug delivery in cancer treatment. Iron chelators, such as DFO, can be incorporated into bio-based material matrices, creating composite systems that possess the advantages of both strategies. The incorporation of iron chelation in bio-based materials provides a dual mechanism for enhanced drug delivery. The iron chelators facilitate targeted delivery to cancer cells by binding to iron ions, while the bio-based materials offer sustained drug release and improve biocompatibility. Furthermore, bio-based materials can be modified to respond to specific stimuli, such as pH or enzymes, allowing for triggered drug release at the tumor site [1].

Literature Review

Cancer remains one of the most formidable challenges in modern medicine, affecting millions of lives worldwide. Conventional cancer treatments often involve chemotherapy, which involves the administration of potent drugs to target and destroy cancerous cells. However, these treatments can have severe side effects on healthy tissues and organs. To address this issue, researchers have been exploring novel drug delivery systems that can selectively target cancer cells while minimizing damage to healthy tissues. Two promising approaches in this battle against cancer are iron chelation and the use of total bio-based materials for drug delivery. In this article, we explore these innovative strategies and their potential impact on cancer therapy. Iron is an essential element for various cellular processes, including DNA synthesis and energy production. However, cancer cells often display a higher demand for iron due to their rapid growth and proliferation. To satisfy this increased need, cancer cells upregulate iron uptake and storage mechanisms, making them more susceptible to iron depletion strategies.

Iron chelation is a therapeutic approach that involves the use of chelating agents to bind and remove excess iron from the body. Chelators are molecules capable of forming stable complexes with metal ions like iron, making them unavailable for cellular processes. Several iron chelators have been investigated for their potential anti-cancer effects, and some have even demonstrated promising results in preclinical studies and clinical trials.

One of the iron chelators extensively studied in cancer therapy is Deferoxamine (DFO). DFO can sequester iron and prevent its participation in the Fenton reaction, a process that generates harmful Reactive Oxygen Species (ROS) through the reaction of iron with hydrogen peroxide. By limiting ROS production, DFO helps reduce oxidative stress in cancer cells, thereby impeding their growth and survival.

Discussion

These materials are biocompatible, biodegradable, and can be tailored to meet specific drug delivery requirements. They have the potential to enhance drug stability, control release kinetics, and improve targeting to tumor sites, thereby maximizing therapeutic efficacy and minimizing side effects. Polysaccharides, proteins and lipids are examples of bio-based materials commonly used in drug delivery applications. Polysaccharides, such as chitosan and alginate, are abundant in nature and can form hydrogels or nanoparticles for drug encapsulation. These materials exhibit excellent biocompatibility and can be easily modified to achieve desirable drug release profiles. Proteins, such as albumin and gelatin, possess inherent targeting capabilities due to their interactions with specific receptors expressed on

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cancer cells. They can be used to formulate nanoparticles or conjugated with drugs to improve their delivery to tumor sites. Lipids, including liposomes and solid lipid nanoparticles, offer unique advantages in terms of encapsulation efficiency and controlled release. They can be functionalized with targeting ligands or surface modifications to achieve tumor-specific accumulation [2].

The integration of iron chelation with bio-based materials holds great promise for cancer treatment. By incorporating iron chelators into bio-based drug delivery systems, it is possible to achieve a synergistic effect that disrupts iron metabolism in cancer cells while delivering therapeutic agents specifically to tumor sites [3]. For example, iron chelators can be conjugated with nanoparticles or encapsulated within hydrogels to create multifunctional platforms. These systems can simultaneously chelate iron, inhibit tumor growth, and release anticancer drugs in a controlled manner. Furthermore, bio-based materials can enhance the stability and bioavailability of iron chelators, which are often prone to degradation and rapid clearance from the body. The use of biodegradable polymers or lipid-based carriers can protect iron chelators from enzymatic degradation and extend their circulation time, leading to improved therapeutic outcomes. Additionally, bio-based materials can be functionalized with targeting ligands or stimuli-responsive moieties to achieve site-specific drug delivery. This approach ensures that the therapeutic agents are selectively delivered to cancer cells, minimizing systemic toxicity and improving treatment efficacy [4].

Iron chelation and total bio-based materials offer exciting opportunities for drug delivery in the battle against cancer. By targeting iron metabolism and leveraging the advantages of bio-based materials, researchers can develop innovative therapies that enhance the efficacy of anticancer drugs while minimizing side effects. The integration of iron chelation with bio-based drug delivery systems holds great promise for personalized medicine, allowing for tailored treatments that address the unique characteristics of individual tumors. Continued research and development in this field will undoubtedly contribute to the advancement of cancer treatment and bring us closer to overcoming this formidable disease [5]. Cancer remains one of the leading causes of mortality worldwide, necessitating the development of innovative therapeutic strategies. In recent years, researchers have turned their attention to iron chelation and total bio-based materials for drug delivery as potential avenues to enhance cancer treatment outcomes. Iron chelation therapy and bio-based materials offer unique advantages, including targeted drug delivery, reduced side effects, and improved efficacy. This article explores the role of iron chelation and bio-based materials in the battle against cancer and their potential impact on future treatment approaches. Iron is an essential element for cell growth and proliferation, but cancer cells exhibit a higher demand for iron compared to normal cells. This dependency on iron has made cancer cells an attractive target for iron chelation therapy. Iron chelators are molecules that bind to excess iron, effectively reducing its availability to cancer cells. By depriving cancer cells of iron, chelation therapy disrupts their growth and survival mechanisms, thereby exerting an anti-cancer effect [6].

Conclusion

One promising iron chelator is Deferoxamine (DFO), which has shown potential in inhibiting tumor growth and metastasis. DFO can effectively sequester iron, preventing its utilization by cancer cells. Additionally, DFO has been found to induce apoptosis (Programmed Cell Death) in cancer cells and enhance the efficacy of conventional chemotherapy. The combination of iron chelation therapy and traditional cancer treatments has the potential to improve patient outcomes. The use of bio-based materials in drug delivery has gained considerable attention due to their biocompatibility, biodegradability, and potential for controlled release. Total bio-based materials are derived from renewable sources such as plants, bacteria, and algae, making them sustainable and environmentally friendly. They can be modified to encapsulate therapeutic agents, protecting them from degradation and delivering them directly to cancer cells. One such bio-based material is cellulose, a polysaccharide found in the cell walls of plants. Cellulose-based nanomaterials have been extensively investigated for drug delivery applications. These nanomaterials can be functionalized with targeting ligands to specifically recognize cancer cells, enabling selective drug delivery and reducing off-target effects. Moreover, cellulose-based carriers possess excellent stability, long circulation time, and minimal toxicity, making them ideal candidates for cancer treatment.

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Conflict of Interest

None.

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