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Review

Carbon nanotubes: A review of novel strategies for cancer diagnosis and treatment

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ABSTRACT

Recently, carbon nanotubes (CNTs) have attracted a lot of attention in the field of cancer diagnosis and therapy. The probability of variable functionalization, compatibility with biological systems, and the thermodynamic properties of CNTs might be the main reasons for such vast investigations. The aim of this study is to review the conducted researches in this field. Studies regarding to the contribution of CNTs in the diagnosis of cancer are reviewed, and the more accurate techniques which need lowest amounts of samples are introduced. In the case of cancer therapy, the studies are categorized in two main classes based on the conducted therapy strategies, including targeted drug delivery systems (DDS), and thermal ablation. In both schemes, use of chemical conjugation is the crucial parts of the studies, which is also emphasized in this review. It is tried to classify the researches based on the cancer type, and introduce the novel strategies developed for both diagnosis and treatment of cancer. The focus is mostly on the biomedical aspect of the methodologies and the subsequent biological responses of the cancer cells to the conducted procedures.

Contents

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1. Introduction

Cancer is a well-known disease to almost all populations of the world. Despite the development of advanced treatment strategies like chemotherapy methods, an effective treatment strategy is not yet found, and most of the techniques suffer from lack of selectivity and efficiency for targeting and destruction of tumors. Cancer can affect different tissues of the body causing diverse kinds of defects which need different treatments. Breast cancer is the most common invasive cancer which affects 12% of the women of the world [1,2]. This cancer type comprises 22.9% of invasive cancers in women [1]. Lung cancer in the other hand is the most common cancer among man and the second most common cancer within women [1]. Prostate cancer is the next most frequent cancer among man causing 15% of cancers in men [3]. Colon cancer also is a common cancer type which was the next most occurring cancer type in women in 2012 [3]. Table 1 presents a summary on the incidence of the different types of cancer (both in man and women) in 2012.

Treatment of cancer has been the focus of researches for the development of new therapy strategies.

1.1. Current strategies

Surgery is one of the oldest treatments for cancer. Surgical procedures may be curative, reconstructive or palliative. The aim of curative surgery is the removal of a tumor and in some cases surrounding tissues. Depending on the size and the location of the tumor, curative surgery can affect the functionality of organs or cause permanent disfiguration. Palliative surgery aims to relieve tumor side effects and restore functionality of the tissue. Reconstructive surgery is used to restore function or correct disfigurement. Sometimes surgery may be done to confirm the presence of cancer. Overall difficulties in surgery and later complications for patients let to the development of other types of cancer treatment.

Another treatment for cancer is radiation. In this treatment method, high-energy rays are used to destroy cancer cells and inhibit the proliferation of them. The goal of radiation is to cure or eliminate the symptoms. Radiation therapy may be delivered both internally or externally. In the external scheme, high-energy rays emit from a device and passing the skin and targeting the underlying tissue. Internal radiation therapy that is also known as brachytherapy involves placing small amounts of radioactive material inside the tissue [4]. Limitations in selectiveness of radiation therapy are the most problematic feature of this therapy which can cause serious damages in structure and function of surrounding tissues depending on the dosage of radiation and the part of body receiving the radiation.

Table 1
Incidence of different types of cancer in 2014 [3].

Cancer type	Incidence (million)
Lung	1.825
Breast	1.677
Colorectum	1.361
Prostate	1.112
Stomach	0.952
Liver	0.782
Cervix	0528
Oesophagus	0.456
Bladder	0.430
Other	4.969

1.2. Promised strategies

Chemotherapy is one of the most common treatments that involves using of drugs to terminate cancer cells and prevent their proliferation. Chemotherapeutic strategies usually include administration of high doses of drugs which can also affect normal cells; especially the cells that grow and divide rapidly such as the skin cells, hair follicle cells, and bone marrow cells. So the side effects of this approach include hair loss, bone marrow depression resulting anemia [5], nausea, vomiting, etc. A newer procedure for cancer therapy is immunotherapy, whose aim is to improve immune system so that it recognizes cancer cells as foreign objects and eliminate them. Many types of immunotherapy are used to treat cancer such as monoclonal antibodies, cytokines, and vaccines. Immunotherapy has the advantage of good selectivity, but unfortunately, hypersensitivity and allergic reaction are probable which can cause harmful effects [6].

Since one of the most significant problems of cancer treatment methods is the low selectivity of the techniques, many types of research have focused on developing targeted drug delivery systems (DDS). In this field, many types of carriers have been found to be advantageous. Among them, nanoparticles [7], polymers [8,9] and liposomal structures [10] are notable. A schematic representation of the mentioned vectors is available in Figs. 1–3.

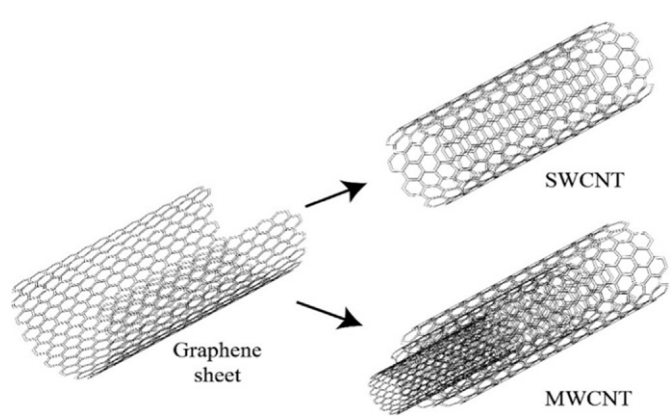

Fig. 1. Carbon nanotubes: a kind of nanoparticle vectors [11]. Reprinted with permission from Elsevier.