CHAPTER 4

NANOMATERIALS FOR CANCER IMMUNOTHERAPY

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4.1 INTRODUCTION

According to the Pan American Health Organization (PAHO), written on its official website dated 4th February 2024, globally, an estimated 19.9 million new cases of cancer and close to 10 million fatalities related to cancer were reported. Over the next 20 years, the cancer burden will rise by about 60%, placing an additional burden on individuals, communities, and health systems. By 2045, it is expected that there will be roughly 30 million new cases of cancer worldwide (Rebecca et al., 2024). Without additional measures for cancer prevention and control, the number of cancer diagnoses is expected to increase by 59.3% by 2045.

Cancer has always been a fierce foe to human health and a major obstacle to medical research. Even with great advancements in our knowledge and ability to treat a variety of cancers, traditional treatments frequently fail to fully eradicate the illness, which has prompted researchers to look for more potent and focused methods. In recent years, cancer immunotherapy has begun as a potentially effective new front in the battle against cancer.

4.2 CANCER IMMUNOTHERAPY

Immunotherapy is one type of cancer treatment that increases the immune system's ability to combat cancer. Organs, tissues of the lymphatic system, and white blood cells make up the human body. The immune system helps our body fight off infections and other diseases by identifying and eliminating abnormalities or stopping and slowing the growth of most cancers. For example, immune cells have occasionally been detected surrounding and inside tumours. Markers for the reaction of the immune system to a tumour are known as tumour-infiltrating lymphocytes (TILs) cells. Usually, the prognosis is better for those with TIL-containing tumours than those without them. However, as tumours grow, the immune system becomes less effective (Ian Peate, 2021).

A theory known as immunoediting explains how clinically detectable cancer can start from normal cells. According to the theory, although the human immune system defends against cancer, it also promotes the growth of tumours that may withstand immune cell attacks and undergo immunogenic sculpting. Cancer immunoediting has three phases: elimination, equilibrium, and escape. The immune system identifies and effectively clears cancer cells in the elimination stage. Through the equilibrium stage, the immune system can control or stop the spread of cancer cells but cannot kill all cancer cells. In the escape phase, the cancer cells have developed under the immune system's selective pressure, and those that have mastered the ability to evade or suppress the immune response are still growing and spreading, making it impossible for the immune system to eradicate and regulate the tumour's growth (Rupen et al., 2022).

Cancer immunotherapy aims to overcome the mechanisms by which tumours evade and suppress the immune response, thereby restoring or boosting the ability of the immune system to identify and eradicate cancerous cells. In other words, the goal is to tip the scales back in favour of immune protection. Cancer cells can find ways beyond the immune system to prevent its destruction, even though the immune system can stop or delay cancer growth. For example, the malignant cells possess

genetic alterations that reduce their immunological system visibility or exhibit surface proteins that inhibit immune cells (Naitik et al., 2023).

4.2.1 Mechanism of Cancer Immunotherapy

A form of treatment known as cancer immunotherapy uses the immune system's capacity to identify and destroy cancer cells. The immune system is predisposed to recognise aberrant cells, including cancer cells, and eliminate them (Rupen et al., 2022). On the other hand, cancer cells occasionally manage to either suppress or avoid the immune system's detection.

4.2.1.1 Immune Checkpoint Inhibitors

Immune checkpoints are molecules on immune cells that function as "brakes" to stop the immune system from attacking healthy cells. Targeting these molecules is one method of cancer immunotherapy. These barriers provide cancer cells with an opportunity to avoid immune detection. Immune checkpoint inhibitors are treatments that stop these checkpoints from working, allowing the immune system to attack cancer cells more successfully and taking the brakes off it (Luisa et al., 2020). Examples of immune checkpoint inhibitors include drugs targeting cytotoxic T-lymphocyte-associated protein 4 (CTLA-4), programmed cell death protein 1 (PD-1), and programmed death-ligand 1 (PD-L1) (Yavar et al., 2022).

4.2.1.2 CAR T-cell Therapy

In chimeric antigen receptor (CAR) T-cell therapy, a patient's own T cells, a subset of immune cells, are genetically altered to express a synthetic receptor known as a CAR, which binds to specific proteins on cancer cells (Luisa et al., 2020). After being reinfused into the patient, these altered T cells are able to identify and combat cancer cells that are expressing the desired protein.