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Precision cancer immunotherapy with synergistic nano-biotechnological integration

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Abstract

Objectives

Nanotechnology, the manipulation of matter at the anatomical and molecular levels, has paved the way for the creation of materials with unique and enhanced properties. One of its significant applications is in the realm of nano-biotechnology, where various subfields, such as nanostructures, play a crucial role in fields like biotechnology and structural and cellular genomics. Nano-biotechnology offers a groundbreaking approach to research by allowing scientists to introduce chemicals and components into cells and fabricate novel materials through innovative techniques like assembling. Particularly noteworthy is its contribution to the in vivo administration of Nucleic Acid (NA) therapeutics. Advanced nanoscale biotechnology strategies have played a pivotal role in this domain by providing precise control over crucial parameters such as dimension, charge, drug loading, and response to external signals of delivery transporters. The integration of cutting-edge nanoscale biotechnology in the field of cancer immunotherapy holds significant promise for overcoming obstacles in NA treatment. This involves addressing challenges related to the clinical and preclinical research of different nanocarriers. This article serves as a concise overview, delving into the characteristics and encountered difficulties associated with various nanocarriers during clinical and preclinical investigations.

Materials and methods

This paper discusses a range of NA methods and elucidates how state-of-the-art nanoscale biotechnology actively supports and enhances NA treatment. By manipulating the physical and

chemical attributes of delivery transporters, nanotechnology allows for the optimization of therapeutic outcomes, making it an invaluable tool in the advancement of medical research.

Conclusions

In conclusion, the merger of nanotechnology and biotechnology, specifically in the field of nano-biotechnology, opens up new avenues for scientific exploration and medical advancements. The precision and versatility offered by nanoscale techniques hold immense potential in revolutionizing the landscape of NA therapeutics, paving the way for more effective and targeted treatments. The ongoing progress in cutting-edge Nanobiotechnology (N-Bio-Tech) exemplifies the relentless pursuit of solutions to some of the most significant challenges in medical science, particularly in the realm of cancer immunotherapy.

Keywords: Cancer immunotherapy, Biotechnology, Nanotechnology, Nucleic acid

Paper Type: Review Paper.

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Introduction

Nanotechnology is manipulating matter at the atomic and molecular levels to produce novel and improved materials (Kirtane et al. 2021). Structures between one nanometer and one hundred nanometers are the focus of nanotechnology. Biological assessment, electro-spinning, chemical technology, materials research, and mechanical synergies are all parts of nano-biotechnology (Kumar et al. 2022). When applied to biological systems, such as disease therapy, nano-devices or nano-biomaterials form nano-biotechnology. The market is well-known for over 4000 biotechnology items. With nanotechnologies, the fields of medicine and engineering can work together to advance healthcare more quickly (Sahu et al. 2021). Any particle smaller than 100 nm

that exhibits new or magnified size attributes compared to bigger particles is considered a nanoparticle. Many things in nature include nanoparticles, such as photochemical byproducts and ash from volcanic eruptions (Hojjati-Najafabadi et al. 2021). Nanomaterials have a longstanding history of being used in cooking and combustion, in addition to their more contemporary use in automobile industry. For ages, scientists have attempted to understand and interact with nanoparticles, yet they have been unable to do so due to a lack of structural transparency. Up before the invention of the microscope, researchers could observe atomic unit particle activity using a magnifying glass. Nanomaterials paved the way for substantial technological advancement (Zhu et al. 2022).

Unlike conventional medications like tiny molecules and antigens, Nucleic Acids (NAs) mainly depend on endocytosis processes to enter cells (de Oliveira Mann and Hornung 2021). Delivery vectors are required to reach the cell's nuclei or cytoplasm. As of now, viruses remain the gold standard for NA distribution vehicles used in human treatment research. However, immunology and biological safety remain significant limitations regarding viral vectors. Pharmaceutical businesses actively seek pharmacological solutions that provide NA safely, efficiently, and tractably (Kenderdine and Fabris 2023). The use of cutting-edge nanoscale biotechnology offers promising prospects for accomplishing this objective. Among the many possible benefits of delivery methods based on nanomaterials are the preservation of payload NAs from fast degradation and the specific targeted areas or tissues. To draw attention to the NA treatments that use nanoscale biological sciences, this article will detail the many nanocarriers studied in clinical and experimental settings and their unique characteristics.

Superior visualizations of enhancing patient care are produced by nano-biotechnology. Nanoparticles or nanorobots are used to describe nano-medical. The nanomedicine field combines medicine and engineering elements to raise global healthcare standards. The most recent advancements in nanobiotechnology have been in nanoparticle creation, -use, and -target tissue uptake (Sahu et al. 2021). Nanoparticles also show great promise in enhancing medical care for many diseases. Using nano-biotechnology ensures the right medicine reaches the proper tissue at the right moment. Precision, effectiveness, security, and rapidity are the hallmarks of this approach. Several methods are either in various testing stages or already used in business and medicine; others are only concepts (Gibney et al. 2021). Many investigators employ Nanorobots via Nanomedicine to improve and treat the cell surface.

Nano-Biotechnology (N-Bio-Tech) can develop highly desirable pharmaceuticals with enhanced specificity and monetization potential (Sahu et al. 2021). One example is the substitution of gold nanomaterials for chemotherapeutic drugs. The field of nanobiotechnology,

often known as nanomedicine, is a rapidly expanding one right now. Creating drug delivery systems is arguably the most significant use of nanotechnology (Sahu et al. 2021).

The primary contributions are listed below:

- This study proposes using nanotechnology and biotechnology to develop a cancer immunotherapy approach.
- The use of biotechnology in cancer immunotherapy involves the application of cell culture and molecular dynamics techniques.
- An in vitro flow chamber study analyzes the recommended technique's efficacy.

The remaining parts are structured as follows: Section 2 provides a comprehensive examination and evaluation of the literature review about cancer immunotherapy. Section 3 elucidates the cancer immunotherapy based on nanobiotechnology, including details on the experimental setup and the procedural steps involved. Section 4 examines the empirical analysis and results. Section 5 of the document discusses the conclusion and potential future developments of cancer immunotherapy.

Literature Survey and Analysis

There are new prospects to enhance cancer immunotherapy and lessen its side effects via nanomaterials and theranostic systems, which are potential target-based approaches. New opportunities for nanoparticles in immunotherapy for tumors have emerged due to careful engineering that accounts for nanoparticle attributes like dimensions, form, and surface features and uses those physical and chemical features for fitting biological reactions.

The main emphasis is on the most recent and cutting-edge ways of nanoparticle delivery of antigens and adjuvants to medical Antigen-Presenting Cells (APC). The research also designs specialized T lymphocytes to improve the effectiveness of tumor-specific immunotherapy (Nasirmoghadas et al. 2021). Researchers are actively investigating nanotechnology-based tumor nano vaccines as a potential improvement to treatments for cancer. These vaccines have already shown promise in many areas, including presenting antigens, APC maturation promotion, T cell growth, T cell function modification, and conquering barriers to cancer administration in vivo (Xie et al. 2022).

The research investigated cancer cells and immunological response endorsements to various therapies by integrating high-throughput and high-content methods, such as a removable microdevice that can give nano doses of different drugs to multiple tumor locations and multiplexed imagining of cancer microenvironmental contents (Tatarova et al. 2022). As a potential long-term strategy for controlling breast cancer, effective pharmacological combinations

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enhanced the spatial interaction of cancer lymphocyte cells with dendritic cells produced during immunological cell demise.

Therapeutics based on Natural Killer (NK) cells have the potential to use a variety of heterologous cell sources, which opens the door to the idea of "off-the-shelf" antibodies with fewer adverse effects and faster production timeframes (El-Mayta et al. 2021). The research provides a synopsis of NK cell antibodies for tumors, their present position in clinical research, and the development and use of means of delivery for NK population immunotherapies, such as viral, non-viral, and nanoparticle-based methods.

The greatest intriguing among several various Bispecific Abs (BsAbs) is the T Cell-Engaged BsAb (TCEB), a novel family of immunological medications that bind to both tumor cells and T at the same time using cancer cell-specific antigens (Moon et al. 2022). The research provides a synopsis of where TCEB's progress stands. The current clinical information, difficulties in treating patients, harmful elements of toxicities, and opposition to TCEB treatment are among the many parts of a novel TCEB examined.

To administer the IFN inducer ORY-1001, the research constructed a genomic nanoinducer adorned with the T lymphocyte membranes and designed with planned cell Programmable Demise Protein 1 (PD1); the study refers to this construct as OPEN (Zhai et al. 2021). OPEN causes the ingestion of OPEN and immunological checkpoint molecules when it recognizes tumors that produce Programmable Dead Cell Ligand 1 (PDL1) via PDL1/PD1 association.

The research has covered the latest developments in hydrogel-by-design delivery techniques, which allow for the administration of immune cells, ecologically regulating chemicals, and immunomodulatory particles such as cytokines, adjuvants, checkpoint inhibitors, and antigens in tumor immunotherapy (Cui et al. 2021). Difficulties persist, necessitating more collaboration among specialists from many sectors. The research demonstrates the development of a Conductive Organic Foundation made of straight and turned AIEgen-based motifs as a dual-inducer of pyroptosis and iron deficiency for effective immunity against tumors. The research anticipates that this intelligent administration method will keep contributing to the fight against cancer through immune therapy and other areas of bettering human wellness (Zhang et al. 2023). It successfully suppresses tumor spread and relapse by inducing pyroptosis and iron metabolism, leading to a cancer growth suppression of over 90% and a curative rate of over 80%.

The survey analyzes and presents the many available strategies for cancer immunotherapy. However, these approaches are constrained by restrictions and face practical obstacles. Therefore, an improved system using biotechnology and nanotechnology is necessary.

Proposed Nanobiotechnology (N-Bio-Tech) for Cancer Immunotherapy

The article delves into nano-material-assisted vaccinations' current and future possibilities for preventing tumor dissemination and repetition. Topics covered include altering immunized activity within the initial tumor, influencing the immune response outside the cancer, and preventing recurrence after surgical removal (Figure 1). The primary objective of this article is to provide a thorough overview of the most recent developments in nano-enabled tumors for the treatment of tumor dissemination and recurring; this approach has tremendous potential to improve cancer survival rates.

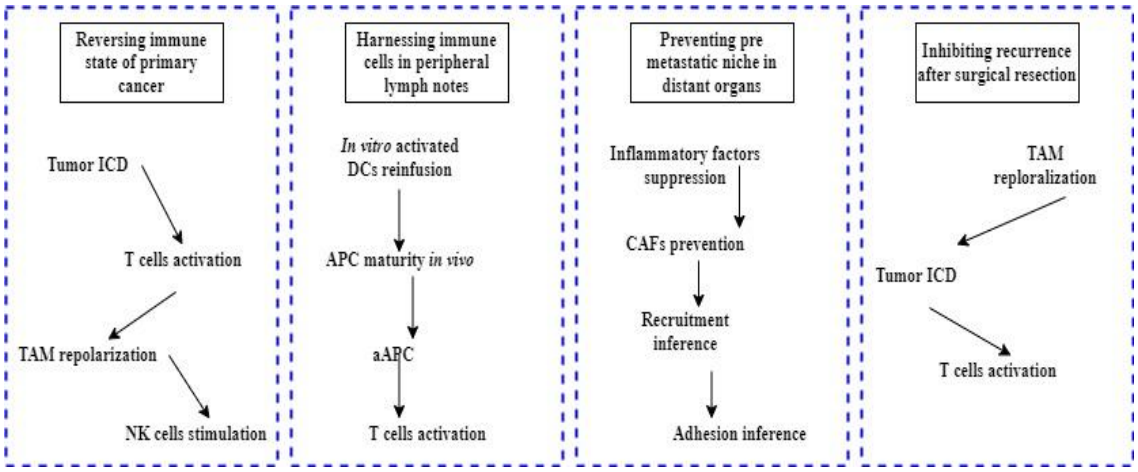

Figure 1. Nanobiotechnology for Cancer Immunotherapy Process

A malfunction in host immune surveillance brought about by a cascade of malignant escape routes is the underlying cause of tumor formation. Due to the immunodeficient characteristics of the tumor's surrounding microenvironment, the newly formed antigens in tumors lack sufficient lethality to effectively stimulate the immune response. One novel approach to removing this obstacle to therapeutic effectiveness is using nanomaterials. Malignant tumors that accumulate tailored nanoparticles enhance the immunosuppression impact by making cancer cells less stealthy; this, in turn, allows the body's defenses to identify tumor neo-antigens and eliminate tumor cells. Its capacity to monitor and inhibit the development of distant tumors is another potential benefit of an engaged immunity system.

Cell Culture and Labelling: This research utilized the following human tumor cell lines: MDA-MB-241, MCF-8, 796, etc., all Renal Cell Carcinomas (RCC) type cancers, and Jurkat, a cell line associated with lymphoma. Leibovitz's L-16 substrate and ACHN individuals were cultivated in a specific order, with MDA-MB-241, MCF-8, and 796 cells correspondingly grown in these media. All three cell types had 10% Fetal Bovine Serum (FBS) and 1% Penicillin/Streptomycin (P/S). Cells of the MDA-MB-241 type were cultured in room temperature

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air at 37 °C. A regulated humidified environment containing 5% carbon dioxide (CO_2) was maintained at 37 °C to cultivate all other cell lines.

A single-layer culture was used for cancer cells, whereas a suspended culture was used for Jurkat lymphocytes. For tissue retention/capture assays, tissues were cultivated in T-20 flasks, whereas for exosome collection, they were cultured in T170 pitchers till they reached 65-85% confluence.

After three gentle washes with Phosphate-Buffered Saline (PBS) remedy, cells were carefully removed from an incubator flask using 0.20% trypsin Ethylenediaminetetraacetic Acid (EDTA) and centrifuged at 300g for 5 minutes for cell labeling. Trypsin was omitted while collecting Jurkat tissues in the tissue medium used for culture.

After that, the cells were left to marinate for 15 minutes in 1 mL of full Dulbecco's Modified Eagle Medium (DMEM) media (containing 12% FBS and 2% P/S), which also included 12 uM of CellTracker green stain per 4 × 12 cells. Before being placed back in 5 mL of DMEM media, the cells were spun at 300 g for 5 minutes. Centrifugation is carried out multiple times to remove any residual luminous dye (Lu and Ai 2022).

Molecular Dynamics Simulation: Utilizing the CHARMM protein pressure area, NAMD was used to mimic natural solutions containing the pPD-1S-PEG and proteins along the PD-L1 antigens that they target. The mixtures included 0.12 M NaCl in a water-based medium. The long-range Coulombic connection was described using the Particle Mesh Ewald (PME) approach. The experiment was run in the isothermal-isobar ensembles at 313 K and 2 bar utilizing Langevin dynamical with a dampening value of 2ps. A 2 kcal/(mol ^{3}) spring factor and harmonic pressures were used to constrain the protein throughout the experiment. The research ran the simulation thrice, each run lasting 210 ns, for every peptide combination to determine the mean retention durations and binding energies.

The NAMD power plugin was used to determine the binding values of the peptides to PD-L1. During the extended retention period simulations, the residues interacting with PD-L1 were identified using a 5A˚cutoff range and confirmed visually. Utilizing the NAMD power extension, the roles of electricity and energy to two contacting parts were computed. The research can see the electrical impact in Equation (1),

$$V_e = \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} \frac{1}{4\pi\varepsilon} \frac{q_x q_y}{|\vec{r}_x| - |\vec{r}_y|} \quad (1)$$

q_x, q_y, and ε represent the solvent's electrical constants, which were set to 78.65 and 78.5 in the power computations, and $|\vec{r}_x| - |\vec{r}_y|$ is the separation among the two electrons. The technique was used to determine electrostatic charges across long distances. According to the Lennard-Jones

(LJ) prospective resources, the contacts, and close-range atomic attraction were characterized, as shown in Equation (2).

$$V_L = \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} \varepsilon_{xy} \left(\left(\frac{\beta_{xy}}{r_{xy}} \right)^2 - \left(\frac{\beta_{xy}}{r_{xy}} \right)^3 \right) \quad (2)$$

ε_{xy} refers to the highest stabilization power for the xth and xth molecules, β_{xy} denotes the length that separates xth and yth molecules at the minimal potential, and r_{xy} denotes the actual distance the two atoms cover. The LJ variables for various atomic types were determined by using the combination rules of Lorentz and Berthelot, which are $\beta_{xy} = \beta_{xx}\beta_{yy}$, and $\beta_{xy} = \frac{\beta_{xx}+\beta_{yy}}{2}$.

In Vitro Flow Chamber Assessment: Flow tunnels allowed for the housing of the peptide-functionalized surfaces (Illath et al. 2022). The fluorescently tagged cells were introduced into the flow container by a syringe pump operating at an ultimate shear stress of 3.4 dyne/cm. For 25 minutes, the cells were left to ferment at ambient temperature. The proportion of cells remained on the surface after 25 minutes of washing at the highest shear stresses of 0.31, 3.4, and 30 dyne/cm. It was used to calculate cell preservation, also known as retaining effectiveness. The adsorption selectivity of the interfaces coated with peptides or antibodies was determined by analyzing the survival effectiveness of 796 tissues and Unfavorable Jurkat T cells on every appearance. A particular interface targeting PD-L1 was defined as one with a high preservation effectiveness for 796 tissues and a poor persistence effectiveness for Jurkat T cells in vitro.

Surface durability versus serum, temperature stress, and enzyme breakdown were compared using the flow tube cell survival experiment. Before the cell survival testing, the exterior was exposed to either 10% FBS or a 1:1 dilute human serum in a PBS mixture for 25 minutes to see how stable the serum remained. The research tested the captured surfaces' thermal stability by culturing them at (iii) 85 °C for 25 minutes. Using either iv) 0.2 mg/mL of proteinase K or v) 0.35% trypsin-EDTA at temperatures of 39 °C or at ambient temperature, the durability against digestion was assessed by contacting glasses slides personalized with peptides or antibodies with one of these solutions.

Cell Tumor Capture (CTC): A flow chamber was used to hold the whole cell capturing slide, which included capture sections that were either coated with peptides or antibodies that targeted PD-L1 and cell rolling areas that had been modified with E-Selectin (Jeong et al. 2022). A chamber's passageways extract PBMC sheets or suspended cells at a 0.32 dyne/cm flow rate. Before being rinsed for 25 minutes in the opposite directions at double the initial flow rate, the caught tissues were incubated in a moving chamber for 8 minutes. Following the steps outlined in the earlier work, capture slides were carefully removed from the flow tank and co-stained using CK (red), CD45 (green), or DAPI (blue) for CTC testing. Capturing efficiency was calculated

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for in vitro specimens as the proportion of surface-captured cells to starting cell count; this yielded around 2000 entities/test (or 8500 entities/test when considering the tumor cells' spatially dispersion).

Exosome Capture and Analysis: For three hours, plasma specimens or exosomes produced from cells in a lab were placed with three-well PDMS covers (3 μL/mm^2). Afterward, the holes were rinsed thrice with a 450 μL PBS mixture. Surface imperfections, protein test, and DiO membranes staining test were used to quantify the number of exosomes collected on all surfaces.

Analysis of Nanoparticles in Motion: The specimens were collected before and after being treated on PEGylated slides. The research used a flow mode and a rate of 60Au to record three 30-second movies for each specimen (Cahn and Duncan 2022). The specimen's thickness was set to the appropriate consistency to a PBS solution at 20°C, and the smallest track width was set to 12, while the measurement sensitivity was set to 4. For clinical specimens, testing was done in duplicates; models produced from in vitro cells were done threefold.

Exosome Labeling: For 10 minutes at 35°C, exosomes attached to PEGylated surfaces were stimulated with 6 g/mL of vibrant dio. The holes were delicately rinsed each time with a 450 mL PBS mixture. Scanning a 5x magnifying glass, the tiled pictures were obtained by positioning the plates over the inverted fluorescence microscope. Similar exposure times were used to capture photos of each hole, and contrast and lightness was adjusted uniformly across all specimens.

Surface Roughness Measurement: Utilizing silicon probing with a resonant frequency of 350 kHz and a spring rate of 25 N/m, the height characteristics of several exosome capturing regions were acquired employing an Asylum MFP-3D Infinity Biosystem. The surface ruggedness was analyzed using the median root mean square of three separate 10um × 10um squared photographs.

Biotechnology-Drug Delivery: Electrospinning in a green environment can create biotechnology-drug delivery carriers that do not include viruses. The Complexation with medicinal nucleic acids is made possible by the charged foundations of chitin and gelatin, which are cellulose nanofibers. Until they are taken up by cells, genetic warheads are protected. For example, a gelatin and chitin material structure can slowly distribute plasmid DNA over seven days. Virus vectors pose safety risks; nontoxic carriers circumvent these problems. Scaffolds imbued with growth hormone genes promote vasculature and wound healing, two uses for regenerating tissue. Consistent delivery of nucleic acids simulates the efficacy of viral transfection. Using biocompatible biopolymers and nanostructured material allows for the local distribution of scaffolds. The hydrophilic nature and porosity of the material adjust the release dynamics and safeguard fragile cargo. The goal of future research is to improve temporal control and translation. One possible use of ligand binding in localized gene treatment is the potential

for systemic organ restoration. These environmentally friendly nanocarriers have promise as a virus-free, secure means of delivering DNA and RNA for cutting-edge biotechnology and nanotechnologies. They align with green biological materials development concepts as they are regenerative and recyclable.

Experimental Analysis and Outcomes

This section examines the experimental use of biotechnology and nanotechnology in cancer immunotherapy. This section discusses the analysis of several nanomaterials' capture and drug release characteristics, followed by a discussion of the findings.

Binding characteristics of pPD-1 as a function of PEG conjugated site were shown in Figure 2. Figure 2 (a) shows the CD spectrum of 1S-PEG and 1T-PEG in PBS or following coupling with PEGylated tiny beads. The colors range from brilliant red and blue to deep red and deep blue. Insets: peptide variations in spectra (CD emissions from unconjugated peptides in PBS subtracted from peptides bound to particles). Figure 2 (b) displays AFM analysis of the off-rate binding dynamics of 1S-PEG or 1T-PEG to PD-L1, using the force-distance graphs adapted to the revised Bell-Evans theory. Figure 2 (c) illustrates the rapture force analysis of different loading rates. As the loading rate increases, rapture force also increases.

Figure 3 depicts the effect of different PEG coupling sites on the in vitro binding effectiveness of pPD-1 peptides. Figure 3 (a) shows the Surface effects of 1S-PEG and 1T-PEG on cell retention in vitro. After 25 minutes of washing at maximal stress levels of 0.32, 3.5, and 38 dyne/cm—50, 100, 500, 1000 L/min, and 5000 L/min, respectively—cell retention was assessed. Figure 3 (b) demonstrates the outcomes of an in vitro cell capturing experiment on surfaces coated with 1S-PEG and 1T-PEG at flow rates of 25 L/min (0.12 and 0.38 dyne/cm). Figure 3 (c) displays the spatial distributions of cancer cells bound to 1S-PEG and 1T-PEG, which appear measured at 50 L/min (0.36 dyne/cm). The amount of tumor cells caught on the two interfaces bound by peptide was examined based on their distance from the intake.

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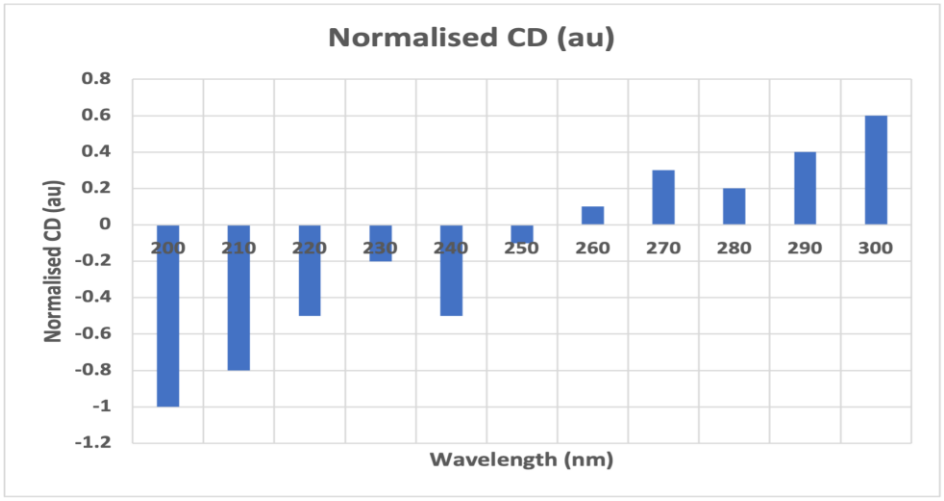

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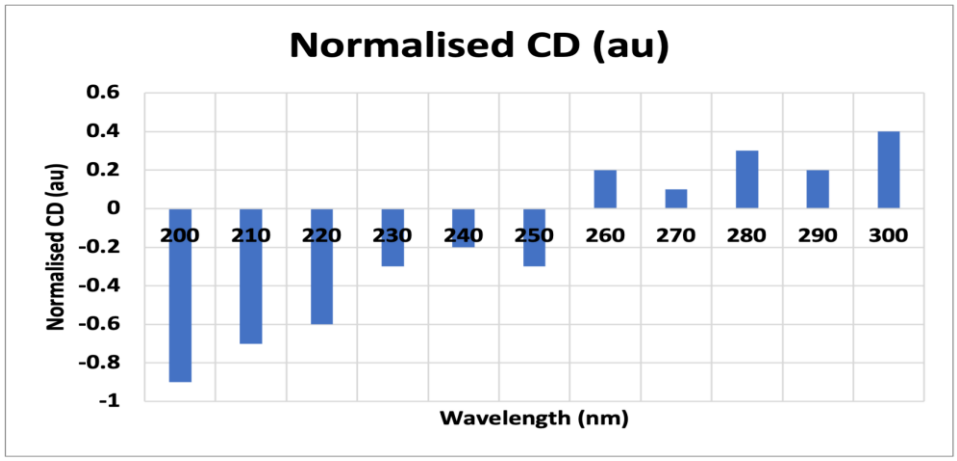

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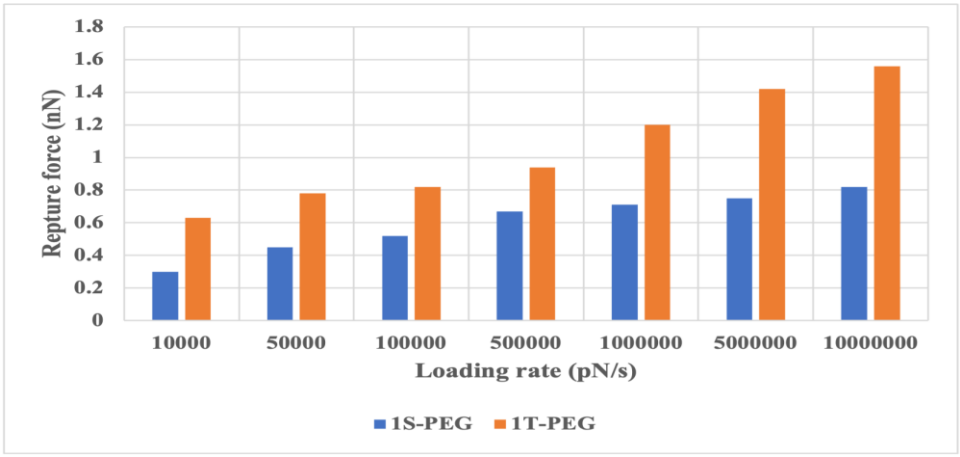
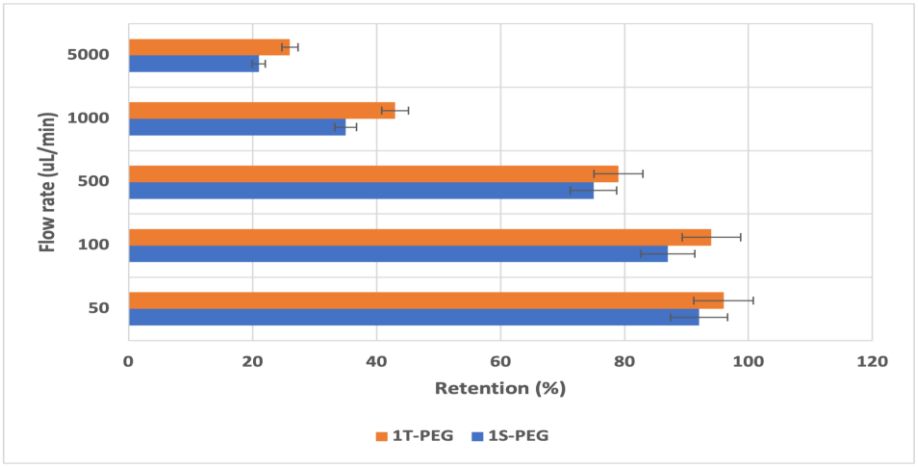


(c)

Figure 2. (a). Normalized CD Analysis of Peptide, (b). Normalized CD Analysis of Binding Dynamics and (c). Rapture Force Analysis of Different Loading Rate



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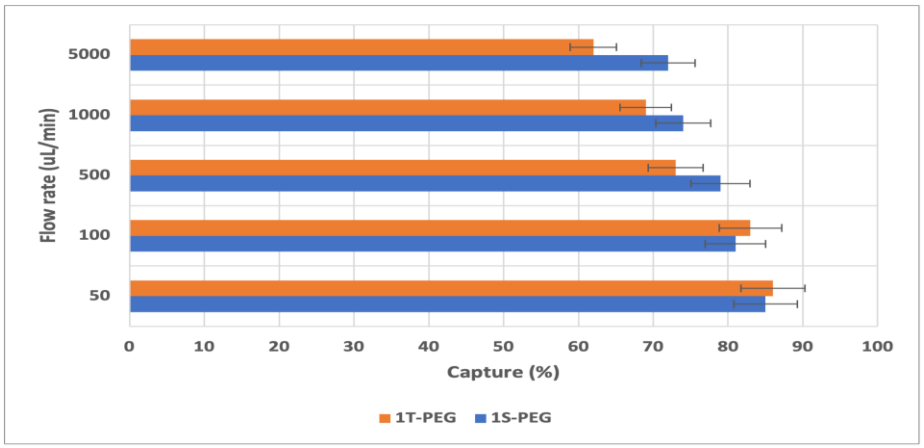

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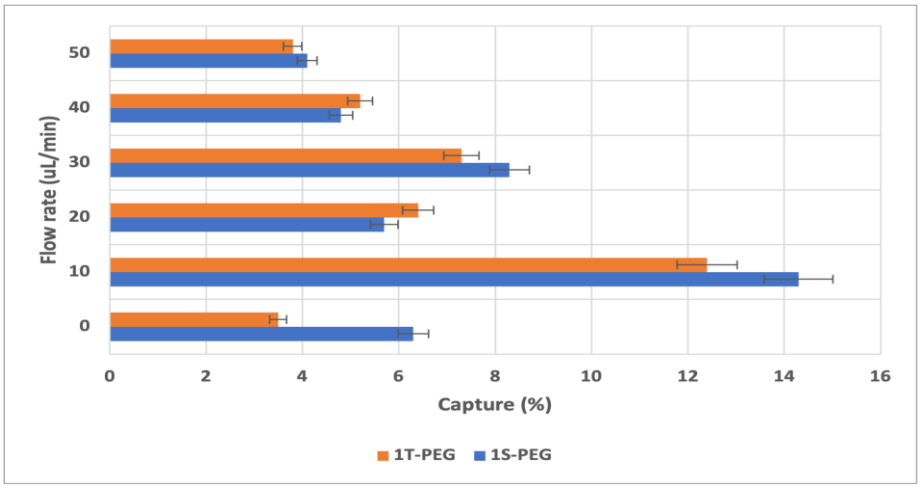

(c)

Figure 3. (a). Surface Effects of 1S-PEG and 1T-PEG, (b). Flow Rate of 1S-PEG and 1T-PEG and (c) Spatial Distributions of Cancer Cells1s-PEG and 1T-PEG

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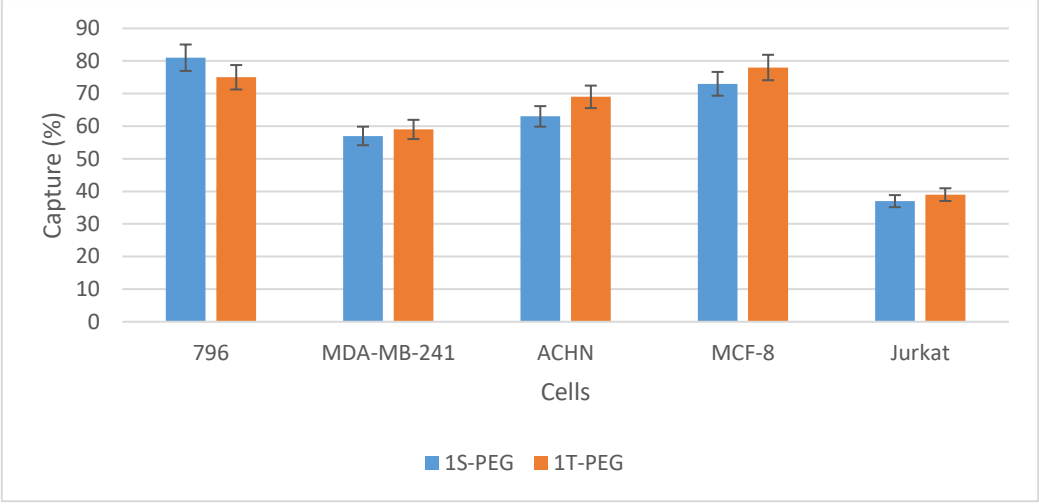
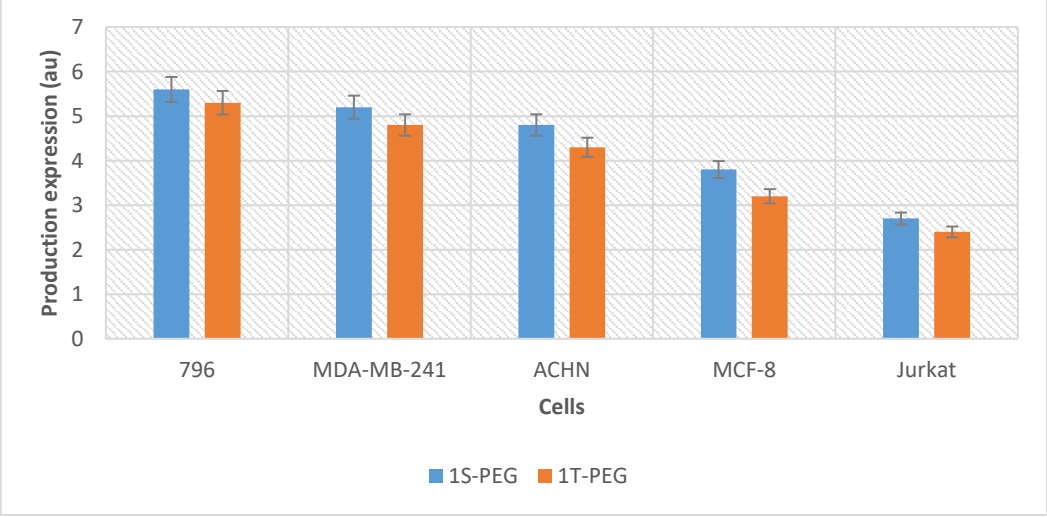
Figure 4 depicts engineered pPD-1 peptides that successfully trap CTCs expressing PD-L1. The structure of pPD-1G, where glycine repeats, replaces duplicated cells in 1S-PEG. Figure 4(a) shows the effectiveness and selectivity of cell capture by 1S-PEG and 1T-PEG surfaces. Bioluminescence spectroscopy studies of 1S-PEG and pPD-1G indiscriminate absorption onto probes anchored. The tracking of forces adhering to 1S-PEG and pPD-1G surfaces with probes mounted with PD-L1. Figure 4 (b) demonstrates the 796 Jurkat, MDA-MB-241, ACHN, MCF-8, and cell capturing effectiveness of 1S-PEG and pPD-1G substrates. When the cellular lines were stained with IHC, the production of exterior PD-L1 was assessed. Remember that the highest shear pressure achieved in any cell capturing test was 0.36 dyne/cm, and all tests were performed at a flow velocity of 50 L/min.



(a)



(b)

Figure 4. (a). Cell Capture Analysis and (b). Cell Production Expression Analysis

Conclusion and Outcomes

One area of medicine that has been profoundly affected by the development of nanotechnology is drug delivery. There is a lot of variety in the design works of nanoparticles and the properties of these materials. There is also a lot of room to improve these features. Studies are looking into ways to assess and optimize the efficacy of drug delivery methods. Among the existing therapeutic approaches, the application of nanoparticles for drug administration at the nano-scale has the most promise for delivering drugs. Encasing the medicine in the nanoparticles begins with deliberately selecting its intended cell. Designing the private interactions of those proteins at the outermost layer of nanoparticles boosted the individualized nature of this technique, as the majority of malignant tumors contain molecules on their surfaces that are entirely private.

By manipulating their physicochemical characteristics or using their inherent nanobiology features, many nonviral delivery methods have been utilized to transport NAs. Some demonstrate clinically optimal delivery effectiveness; examples include liposomes, persistent NA lipid particulates, and more. Highly effective and biocompatible NA delivery methods might be developed using nanoparticles and particles originating from biological sources, such as exosomes generated from different types of cells. Nanocarriers derived from nanotechnology have many benefits but drawbacks, such as nanotoxicity caused by substances and production processes. Such critical problems need immediate attention in NA treatment. Research into how nanoparticles communicate with living things (such as proteins and immune cells) is crucial. To ensure constant NA-loaded effectiveness and amount in homogeneous nanoparticles, more work is required to establish targeted quality assurance processes. Nanotechnology with exceptional selectivity for cancer cells is created by combining these features, according to nanoparticle use case studies. Studies should have resolved this challenge and reduced the present cancer therapy challenges as soon as feasible.

Conclusions: In conclusion, the merger of nanotechnology and biotechnology, specifically in the field of nano-biotechnology, opens up new avenues for scientific exploration and medical advancements. The precision and versatility offered by nanoscale techniques hold immense potential in revolutionizing the landscape of NA therapeutics, paving the way for more effective and targeted treatments. The ongoing progress in cutting-edge Nanobiotechnology (N-Bio-Tech) exemplifies the relentless pursuit of solutions to some of the most significant challenges in medical science, particularly in the realm of cancer immunotherapy.

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ایمونوتراپی دقیق سرطان با ادغام نانو بیوتکنولوژیک هم‌افزا

جیتندرا سینها

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چکیده

هدف: نانوتکنولوژی، دستکاری ماده در سطوح آناتومیکی و مولکولی، راه را برای ایجاد موادی با خواص منحصر به فرد و افزایش یافته هموار کرده است. یکی از کاربردهای مهم آن در حوزه نانو بیوتکنولوژی است که در آن زیرشاخه‌های مختلفی مانند نانوساختارها نقش مهمی در زمینه‌هایی مانند بیوتکنولوژی و ژنومیکس ساختاری و سلولی دارند. نانو بیوتکنولوژی با اجازه دادن به دانشمندان برای وارد کردن مواد شیمیایی و اجزاء به سلول‌ها و ساخت مواد جدید از طریق تکنیک‌های نوآورانه مانند مونتاژ، رویکردی پیشگامانه برای تحقیق ارائه می‌کند. به ویژه سهم آن در تجویز داروهای نوکلئیک اسید (NA) در داخل بدن قابل توجه است. استراتژی‌های بیوتکنولوژی پیشرفته در مقیاس نانو با ارائه کنترل دقیق بر پارامترهای حیاتی مانند ابعاد، شارژ، بارگیری دارو و پاسخ به سیگنال‌های خارجی ناقل‌های تحویل، نقشی محوری در این حوزه ایفا کرده‌اند. ادغام بیوتکنولوژی پیشرفته در مقیاس نانو در زمینه ایمونوتراپی سرطان نوید قابل توجهی برای غلبه بر موانع در درمان NA دارد. این شامل رسیدگی به چالش‌های مرتبط با تحقیقات بالینی و پیش بالینی نانوحامل های مختلف است. این مقاله یک مرور مختصر بر این موضوع دارد و به بررسی ویژگی‌ها و مشکلات مواجهه با نانوحامل‌های مختلف در طول تحقیقات بالینی و بالینی می‌پردازد.

مواد و روش‌ها: این مقاله طیف وسیعی از روش‌های NA را مورد بحث قرار می‌دهد و توضیح می‌دهد که چگونه بیوتکنولوژی پیشرفته در مقیاس نانو به طور فعال از درمان NA پشتیبانی و حمایت می‌کند. نانوتکنولوژی با دستکاری ویژگی‌های فیزیکی و شیمیایی ناقل‌های تحویل، امکان بهینه‌سازی نتایج درمانی را فراهم می‌کند و آن را به ابزاری ارزشمند در پیشرفت تحقیقات پزشکی تبدیل می‌کند.

نتیجه‌گیری: در پایان، ادغام نانوتکنولوژی و بیوتکنولوژی، به‌ویژه در حوزه نانو بیوتکنولوژی، راه‌های جدیدی را برای اکتشافات علمی و پیشرفت‌های پزشکی باز می‌کند. دقت و تطبیق پذیری ارائه شده توسط تکنیک‌های نانومقیاس پتانسیل بسیار زیادی در ایجاد تحول در چشم انداز درمان NA دارد و راه را برای درمان‌های موثرتر و هدفمندتر هموار می‌کند. پیشرفت مداوم در فناوری نانوبیوتکنولوژی پیشرفته (N-Bio-Tech) نمونه‌ای از پیگیری بی وقفه راه حل‌ها برای برخی از مهم‌ترین چالش‌های علم پزشکی، به ویژه در حوزه ایمونوتراپی سرطان است.

کلیدواژه‌ها: ایمونوتراپی سرطان، بیوتکنولوژی، نانوتکنولوژی، اسید نوکلئیک

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