Section A-Research paper

Nanomotors – An Emerging Contrivance for Cancer Remediation

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Abstract:

Nanomotors are small devices that have been developed with the help of recent advancements in science and technology for the betterment of healthcare systems as novel disease therapy and therapeutics. They employ various technologies and techniques to perform their functions in the delivery of drugs, including modifying the location of the motor to increase cell orientation and internalization. Synthetic nanomotors have been designed as a multifunctional superparamagnetic/catalytic micro robot (PM/Pt mini robots) and are being used for cell manipulation and drug delivery such as anticancer agents. Nanomotors have the potential to revolutionize cancer research and treatment. They can be designed to target specific biomarkers in cancer cells, enabling early detection and real-time monitoring of the disease. They can also offer a non-invasive method for diagnosis. The use of nanomotors may reduce the need for invasive treatments like biopsies, resulting in less discomfort for patients and quicker diagnosis timeframes. Additionally, nanomotors in cancer treatment, can facilitate the deep penetration of medications into sick tissues and promote normalization of the tumor vascular system and the destruction of the intrinsic extracellular matrix. This has been shown to increase the capacity of T cell tumor infiltration in vivo. Overall, nanomotors have the potential to revolutionize the way cancer is diagnosed and treated. They can offer targeted drug delivery, early cancer detection, and minimize invasive surgery. The use of nanomotors may reduce discomfort for patients and improve cancer outcomes. Worldwide rise in cancer morbidity and mortality rates are observed, and

nanomotors may provide new opportunities for improving cancer remediation and further work on nanomotors may provide new avenues for combating this disease.

Keywords- Nanomotors, Biomarkers, healthcare system, therapeutics, targeted drug delivery, mortality.

Introduction

Cancer is a category of illnesses that characterized by the body's aberrant cells growing and spreading out of control. These aberrant cells have the potential to damage and dysfunction the body by forming tumors or invading other tissues and organs. There are numerous cancer types, each with a unique set of certain characteristics and risk factors as well. Recent data show that cancer continues to have a significant impact on world health, with high rates of morbidity and mortality However, there have been significant advancements in cancer research and treatment, giving those who have the disease hope for better outcomes and a higher quality of life. Here are some current cancer mortality and morbidity rates, along with predictions for the future: According to the International Agency for Research on Cancer's Global Cancer Statistics 2020 report, there were approximately 10.2 million cancer deaths and 19.3 million new cases of cancer worldwide in 2020 (excluding nonmelanoma skin cancer, which accounted for 18.1 million new cases). According to new cancer diagnoses, the most prevalent cancers were skin (non-melanoma) (1.20 million cases), prostate (1.41 million cases), colon and rectum (1.93 million cases), lung (2.21 million cases), and breast (2.26 million cases). With an expected 1.8 million fatalities (18%), lung cancer continued to be the most common type of cancer. It was then followed by colorectal (9.4%), liver (8.3%), stomach (7.7%), and female breast (6.9%) cancers.(1–5)

Nanomotors, which are extremely small machines, are revolutionizing the field of cancer research by offering novel and modern approaches to cancer diagnosis and treatment. These nanomotors are made to target cancer cells and biomarkers with extreme selectivity and effectiveness, delivering new tools for both early detection and targeted therapy. They can possibly be made to move in response to particular stimuli, delivering active drug delivery to cancer cells while avoiding healthy cells. By using this strategy, chemotherapy side effects can be minimized and treatment results can be enhanced. A study, for instance, described the development of a nanomotor-based biosensor for the early detection of prostate cancer biomarkers in the journal ACS Nano in 2020. Prostate-specific antigen (PSA), a biomarker for prostate cancer, could be detected by the biosensor with high sensitivity and specificity. The unique characteristics of nanomotors, such as their small size and capacity to move in response to external stimuli, have demonstrated potential in cancer treatment and detection.

The following are some benefits of nanomotors in the prevention and treatment of cancer: Targeted drug delivery: Chemotherapy medications can be placed into nanomotors and sent directly to the cancerous area, enabling specific drug delivery and minimizing chemotherapy side effects. Early cancer detection and therapy are made possible by the use of nanomotors, which can identify cancer biomarkers in blood or other physiological fluids. Nanomotors can be employed in minimally invasive surgery to target malignant tissue while navigating through the body, hence minimizing the necessity for invasive treatments.(1, 5–8)

Cancer causing agents:

There are many factors and causes of cancer among which chemical, pharmaceutical, cosmeceutical, industrial, environmental, microorganism, agricultural and radiation are considered important and are summarized in tables for the convenience of researchers and stakeholder.

Table 1: Chemicals (9–12)

Chemical Agents	**Exposure source**	**Mechanism**	**Major Cancer Type**
Asbestos	Occupational exposure (mining, manufacturing construction)	Causes inflammation and DNA damage	Mesothelioma, Lung cancer.
Benzene	Industrial exposure (Petroleum, refining rubber production, printing)	Interfere with DNA replication and repair.	Leukemia, Lymphoma
Vinyl chloride	Industrial exposure (plastics manufacturing)	Damages DNA and disrupts cell growth and division	Liver cancer, angiosarcoma
Formaldehyde	Industrial exposure (manufacturing, healthcare)	Damages DNA and disrupts cell growth and division	Nasal cancer, leukemia
Arsenic	Environmental exposure (water, food, industrial waste)	Damages DNA and disrupts cell growth and division	Lung cancer, skin cancer
Acrylamide	Food exposure (cooked starches, such as potato chips and French fries)	Damages DNA and disrupts cell growth and division	Kidney cancer, endometrial cancer
Polycyclic aromatic hydrocarbons (PAHs)	Environmental exposure (water, food, industrial waste)	Interferes with DNA replication and repair	Lung cancer, skin cancer

Table 2: Radiation (13–15)

Radiation-Emitting Agent	Exposure Source	Mechanism	Major Cancer Type
Ionizing Radiation	Medical imaging (X-rays, CT scans), nuclear power plants, atomic bomb fallout	Damages DNA and disrupts cell growth and division	Leukemia, thyroid cancer, breast cancer, lung cancer
Ultraviolet (UV) Radiation	Sun exposure, tanning beds	Damages DNA and disrupts cell growth and division	Skin cancer (basal cell carcinoma, squamous cell carcinoma, melanoma)
Radon	Naturally occurring gas that can accumulate in homes and buildings	Damages DNA and disrupts cell growth and division	Lung cancer

Table 3: Agricultural (16–18)

Radiation-Emitting Agents	Exposure Source	Mechanism	Major Cancer Type
Glyphosate	Herbicide used in agriculture and landscaping	Disrupts hormonal balance and DNA damage	Non-Hodgkin lymphoma
Atrazine	Herbicide used in agriculture	Disrupts hormonal balance	Ovarian cancer, non-Hodgkin lymphoma
Chlorpyrifos	Insecticide used in agriculture	Disrupts neurological function	Lung Cancer
DDT	Insecticide previously used in agriculture	Disrupts hormonal balance, DNA damage	Breast cancer

Table 4: Cosmeceutical (19–21)

Cosmeceutical agents	Exposure Source	Mechanism	Major Cancer Type
Retinoids	Used in some anti-aging creams and acne treatments	Stimulate cell growth and division, increasing the risk of DNA mutations	Skin cancer

Hydroquinone	Used in some skin lightening products	Damages DNA and disrupts cellular signaling pathways	Skin cancer
Phthalates	Used in Fragrances and nail polishes	Disrupt hormonal balance and cause DNA damage	Breast cancer
Titanium dioxide	Used in sunscreens	Generates free radicals and causes DNA damage	Lung cancer

Table 5: Pharmaceuticals(21–25)

Pharmaceutical Agents	**Exposure source**	**Mechanism**	**Major cancer type**
Diethylstilbestrol (DES)	Prenatal exposure, postnatal exposure in males	Acts as an endocrine disruptor, alters DNA methylation and histone modifications	Clear cell adenocarcinoma of the cervix/vagina, breast cancer, testicular cancer
Tamoxifen	Long-term use for breast cancer treatment and prevention	Acts as an endocrine disruptor, stimulates proliferation of endometrial cells	Endometrial cancer
Progesterone only contraceptives	Oral contraceptives	Suppression of ovulation and alters hormone levels	Breast cancer Endometrial cancer
Azathioprine	Long-term use in transplant patients, autoimmune diseases	Acts as a mutagen, induces DNA damage and chromosomal abnormalities	Non-Hodgkin's lymphoma, skin cancer
Methotrexate	Long-term use in autoimmune diseases, cancer chemotherapy	Acts as a mutagen, induces DNA damage and chromosomal abnormalities	Lymphoma, leukemia, lung cancer

Table 6: Pathogens (26–28)

Microorganism	Exposure Source	Mechanism	Major cancer Type
Human Papillomavirus (HPV)	Sexual contact	Infection of HPA into host cell, interfere with tumour suppressor gene	Cervical, vulvar, vaginal, anal, and oropharyngeal cancers
Helicobacter pylori	Cervical, vulvar, vaginal, anal, penile, and oropharyngeal cancers	Chronic inflammation and cellular damage	Stomach cancer
Epstein-Barr virus	Saliva, Blood, sexual contact	Viral integration, expression of oncogene proteins, interfere with tumour suppressor genes	Nasopharyngeal, Lymphoid Cancer
Hepatitis C, B Virus	Blood, Sexual contact	Chronic inflammation and cellular damage	Liver cancer

Emergence role of nanomotors in cancer detection:

Through the development of a highly sensitive and non-invasive method for cancer detection, nanomotors have the potential to completely change the way cancer is diagnosed. Nanomotors are incredibly small machines with the ability to move. They can be created to target particular disease biomarkers, enabling early cancer detection. They can also be used to track the development of cancer in real time, giving doctors a more individualized and efficient course of therapy. Additionally, nanomotors can be used to find cancer biomarkers in bodily fluids like blood and urine, offering a non-invasive way to diagnose cancer. This strategy may lessen the need for intrusive treatments like biopsies, resulting in less discomfort for patients and quicker diagnosis timeframes. Given their capacity to move through biological fluids and target cancer cells, nanomotors have been suggested as a potential tool for early cancer detection. The use of DNA nanomotors for identifying cancer biomarkers in blood samples was proved in a recent study that was published in the journal ACS Nano. In order to detect the presence of cancer biomarkers, the nanomotors were made to travel in the direction of particular target molecules and then create a fluorescent signal when they arrived at their destination. At concentrations as low as 30 picomolar in blood samples, the researchers were able to identify the biomarkers.(29–31)

Regular screening examinations and tests help identify cancers, as can coming to a medical professional with a particular set of symptoms. Blood tests, and imaging tests including ultrasound, CT, and MRI scans, as well as X-rays are frequently performed by medical experts after a physical examination and review of the patient's medical history. Imaging of tissues in particular regions can also be done via endoscopy. With the injection of a mildly radioactive substance that can identify abnormal tissue, radionuclide scanning can be used in regions that are challenging to visualize. By excluding the risk of malignancy, these tests can assist in identifying physiological abnormalities.(32,33)

A promising technique for the detection of cancer cells is a tiny device called a nanomotor. They can be created to target cancer cells specifically and are capable of transportation through biological fluids. The use of nanomotors in cancer diagnosis has given rise to a variety of methods, including:(34–39)

Table 7: Nanomotors in Cancer diagnosis

S.No.	Diagnostic Technique	Cancer cell Type	Aid of Nanomotors
1.	Brain Tumour Image Segmentation	Brain Tumour	PAMAM dendrimer is used for drug delivery to brain across BBB
2.	Ultrasound-based targeted contrast-enhanced detection	Prostate cancer	pRNA-3WJ nanoparticles used by nanomotors for antioncogenic effect
3.	Her2Net: A deep framework for semantic segmentation	Breast cancer cell	rGO-TPA/FeHCF/Anti-HCT immunosensor loaded on nanomotors
4.	Convolutional Neural Networks (CNN)	Prostate cancer recurrence	pRNA-3WJ nanoparticles used by nanomotors for antioncogenic effect
5.	Locality Sensitive Deep Learning	Colon cancer	Nanomotors with MC-1 magneto tactic bacteria placed on them are used to deliver SN-38 to HCT116 colorectal xenografts.

6.	Magnetic nanospheres of Bovine sperm	Tumor cells	Using magnetic bovine sperm nanospheres to deliver DOX to tumor spheroids
7.	Hollow-shape micromotor	Circulating tumor cells (CTCs)	Near-infrared-driven fluorescent nanomotors for detection of circulating tumor cells in whole blood
8.	Nano porous Au-Ni-Au nanorod segments	HeLa cell	Using an electrostatic contact to deliver the medication DOX to HeLa Cell
9.	P(VDF-TrFE) nanowires with FeGa	MDA MB 231	Drug delivered by alternating magnetic field

Schematic Biomarkers used for cancer detection:

Biomarkers are biological substances or warning signs that can be used to find cancer or detect its development. Blood, urine, and tissue samples may all have biomarkers, which can reveal important details about the molecular and genetic makeup of cancer cells. For different types of cancer, such as breast cancer, lung cancer, prostate cancer, and colorectal cancer, a number of biomarkers have been discovered. For instance, it has been demonstrated that using mammography in conjunction with the detection of high levels of the breast cancer biomarker CA 15-3 has been shown to improve the sensitivity and specificity of breast cancer screening. Digital rectal examination (DRE) and the prostate-specific antigen (PSA) biomarker have been demonstrated to improve the early diagnosis of prostate cancer. Biomarkers can also be used to track how effectively cancer patients respond to treatment. For instance, it has been demonstrated that the tumor marker carcinoembryonic antigen (CEA) can be used to track how efficiently chemotherapy is working for individuals with colorectal cancer. Biomarkers are essential in the fight against cancer. In cancer, a biomarker is a quantifiable indicator of a biological process or condition that can be used to assist diagnose the condition, assess the prognosis, and direct therapy choices. Diagnosis: By detecting particular genetic or protein markers linked to the illness, biomarkers can assist physicians in determining the presence of cancer.

According to the unique features of the tumour, biomarkers can also assist doctors in predicting how a patient's cancer is likely to progress. Among the often-utilized biomarkers for cancer detection are: (40–44)

1.Cancer protien biomarker

- Elisa
- Eletrochemical and optical method

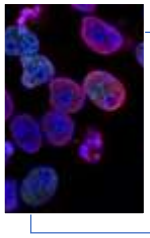
2.Cancer related enzyme disregulation

- Telomerase
- Protease

3. Nucliec acid base biomarker

- Measurement of DNA &RNA
- Electrophoresis & Flouroscence method

4. Small chemical products of cellular metabolism



5. Direct analysis of cancer cells

Isolation of CTC

Measurement of cancer cells

Nanomotors in cancer remediation:(45–47)

Nanomaterials have been successfully applied in the treatment of cancer on a large scale. Targeted medication delivery to cancer cells using nanomotors proved to be highly efficacious. These tiny devices are programmed to move in reaction to various inputs, enabling them to move within the body and deliver medication to particular areas. Nanomotors can minimize harm to healthy cells and reduce therapy adverse effects by directly targeting cancer cells. It has been postulated and verified that nanomotors can facilitate the deep penetration of both themselves and medications into sick tissues. There hasn't been any discussion of whether such nanomotor motion behaviour may also encourage the deep penetration of microscopic immune cells in the pathological microenvironment, which is crucial for some illnesses' immunotherapy. Consider a nanomotor powered by nitric oxide (NO) that can move inside the confines of a tumour, and pay particular attention to how

it moves and how NO, the useful byproduct created during movement, affects immune cell infiltration and activity. The capability of drug-loaded nanomotors to endorse the normalization of the tumor vascular system and the destruction of the intrinsic extracellular matrix (ECM) has been shown to dramatically increase the capacity of T cell tumour infiltration in vivo.

A. Targeted Delivery of Cancer Cell by using Nanomotors

Currently, systemic circulation is the only route for administering drugs, which limits drug penetration and targeting and lowers therapeutic effectiveness. In order to overcome this, biological carriers like liposomes or viral carriers are used, although they come with uncontrolled delivery concerns. By increasing therapeutic efficacy while lowering side effects, nanomotors offer a possible substitute for medication delivery. Self-propelled nanomotors give carriers a constant driving force and the flexibility to change orientation to promote cell targeting and internalization while transporting drugs through biological tissues and fluids. This makes the system for delivering drugs more coordinated, controlled, and adaptable, making it a more effective substitute for passive drug carriers. Nanomotors have definite benefits over conventional drug delivery methods, which has resulted in significant improvements in the drug delivery process. By enhancing therapeutic efficacy and lowering systemic side effects of risky drugs, the creation of nanomotors offers a novel and enticing alternative for drug administration.(48,49)

1. Extracellular Delivery System

To satisfy the needs of creating optimum drug delivery vehicles and to encourage the development of nanomotor based drug delivery systems, several research have been undertaken on the manufacturing and creation of nanomotors. Many synthetic nanomotors were initially created and set up to help with medicine delivery to cancer cells (extracellular delivery system). High quantities of H_2O_2 produced by cancer cells have been proven to cause oxidative stress. (50)

a) Synthetic nanomotors:

A number of synthetic nanomotors have been created in order to demonstrate the delivery performance while employing local H_2O_2 as an energy source for propulsion. For instance, superparamagnetic/catalytic multifunctional microrobots (PM/Pt microrobots) are used to influence cells and carry anticancer medications. These tiny components can connect together to build micromotor chains and move through an external magnetic field thanks to their super paramagnetic core. The tosyl groups on the motors enable cell manipulation and the release

of bioactive substances at the desired location, while the (platinum)Pt hemisphere of the Janus microsphere enables catalytic self-propulsion. These microrobots can trap breast cancer cells while also diffusing the anticancer medicine doxorubicin (Dox) into the malignant cells after being loaded with the drug. Such a versatile device simplifies and facilitates the application of nanomotors to a wide range of biomedical applications.(51)

b) Biocompatible enzymes driven power nanomotors:

Nanomotors powered by biocompatible enzymes have created new opportunities for the active delivery of certain medications to the desired spot. Enzyme-powered micromotors offer various benefits over traditional catalytic motors, including bioavailability and biocompatibility, making them more appropriate for biological use. The nanomotors were composed of a solid silica core covered in urease enzymes and a mesoporous silica shell with a high (doxorubicin)Dox loading capacity. Additionally, the urease enzyme modified nanomotors convert chemical energy into mechanical effort even in an ionic environment (phosphate buffered saline buffer solution), indicating a potential use for them in biomedical applications. The enhanced drug release and the ammonia produced at high urea substrate concentrations work together to improve the anticancer efficiency of the nanomotors-based Dox-loaded system towards HeLa cells. The enhanced drug delivery capabilities of these nanomotors may prove valuable in upcoming biomedical applications.(39,52)

c) Structurally modified nanomotors:

In addition to the above-mentioned uses, the molecular energy of H_2O_2 has been captured by nanomotors by shaping them into tubular shapes. Reduced nano graphene oxide (n-rGO) platinum (Pt) micromachines were created for efficient drug delivery. Notably, even at incredibly low H_2O_2 concentrations, the n-rGO/Pt micromachines demonstrated great Dox molecule loading efficiency and quick speed. The drug was found to be released in a precise location in a matter of seconds when nanocarriers and an electrochemical stimulation were combined, the researchers found. The self-propelled machine, which combines the powerful self-propulsion and high loading capacity of n-rGO/Pt micromachines, represents a significant step towards the deployment of cutting-edge drug delivery systems.

2. Intracellular Delivery System:

Nanomotor-based intracellular delivery systems have demonstrated potential in the treatment of cancer. In these systems, targeting molecules like antibodies or aptamers that are known to precisely recognize cancer cells are functionalized onto nanomotors. Chemotherapy medicines, siRNA, or other therapeutic substances may be released once the nanomotor has reached the target cell. The intracellular delivery system seeks to delivery system seeks to deliver a cargo to a specific intracellular site, if possible, in order to exert a local action.

a) Enzyme-powered nanobots:

Enzyme-powered nanobots enhance the delivery of anticancer drugs. In recent years, the efficacy of numerous nanomotors for distribution, including H_2O_2 -powered microrobots, enzyme-powered micromotors, and magnetic or ultrasonic field driven nanomotors, has been demonstrated. The most important thing is that in order to achieve efficient delivery to cancer cells and significant intracellular release of payloads, they must be created and constructed logically to get over various transportation obstacles. To effectively deliver drugs or other payloads to subcellular targets in tumours, for example, considerations including size, charge, shape, and surface chemistry need to be made. Additionally, for in vivo delivery, it is crucial to consider the nanomotors' clearance efficiency, nonspecific interactions with healthy cells, and interactions with other organs (such as the kidney, spleen, brain, and cancer). The effective delivery of various medicinal substances into cells using nanomotors to penetrate cell membranes has been studied in some detail(53).

Enhanced Succinylated -lactoglobulin and a catalase-assembled biocatalytic micro-motor have been developed for improved intracellular medication release. The succinylated -lactoglobulin in the micromotors may control the micromotor's access to H_2O_2 fuel through its pH-sensitive and responsive activity. As a result, by altering the pH of the surrounding environment, the state of the micromotor can be altered from "on" to "off". When biological H_2O_2 was able to make contact with catalase at pH, the autonomous micromotors started to move. Following that, there was cellular absorption and increased particle retention in acidic compartments (pH 6.3–4.7). Here, the drug was released as a result of the breakdown of the micromotors. Furthermore, fuel-free nanomotors controlled by external power, such as magnetic or ultrasonic fields, hold significant potential for intracellular precision targeted delivery. This study described the first chemically driven motors with reversible pH responsive motility(54).

b) Biocompatible delivery system:

Magnetic-driven sperm micromotors are proposed as a targeted drug delivery method for a biocompatible delivery system. By pre-loading a motile sperm cell with doxorubicin hydrochloride, this method is demonstrated to be an efficient drug delivery mechanism. Under the influence of an external magnetic field, the sperm-driven micromotor may be steered to the tumour spheroid, liberating the sperm cell and releasing the drug. In comparison to purely synthetic micromotors, the sperm hybrid micromotor may encapsulate higher concentrations of doxorubicin hydrochloride within the sperm membrane. To deliver local medication into cancer cells via sperm cell membrane fusion, sperms' ability to fuse with somatic cells still stands out as a unique property. These hybrid sperm cell membrane micromotors have the potential to cure different disorders of the female reproductive system in addition to gynecologic cancer. The suspended foreign particles are subjected to a number of steady hydrodynamic forces when they are suspended in a fluid and exposed to an ultrasonic field (e.g., microdroplets, gas microbubbles, solid microparticles). The interaction between ultrasonic forces and foreign items led to numerous distinct states such as suspension swarming at certain spots, attraction one another, or rotation and results in the propulsion of nanomotors due to their varied acoustic characteristics, i.e., density and compressibility.(3,55)

Due to its millimeter-scale wavelength, ultrasound (frequency ranges above the human audible range; N20KHz) can be concentrated on incredibly small areas. It has been used for more than 20 years to improve the administration and effectiveness of drugs. For instance, siRNA administration has utilised the unique ability of gold nanowires driven by ultrasound to penetrate cells[14]. In this invention, rolling circle amplification (RCA) DNA constructs were employed to wrap nanowires that were selectively targeted to the green fluorescent protein using siRNAs. The contrast between propelled and static motors demonstrated the significance of ultrasonic propulsion. This research showed a 94 percent silencing on HEK293 and MCF-7 cells within minutes of treatment, a 13-fold improvement in silencing response compared to static nanomotors. The nanomotors penetrated the cell membrane and constant to transfer quickly inside the cells, resulting in a high gene-silencing effectiveness, according to motor optimisation tests. (56)

c) Photoacoustic Computed Tomography-guided Micro robotic System:(57,58)

A notable example is a photoacoustic computed tomography directed microbotic system that has been shown to be capable of in vivo deep imaging and precise control. To protect them from erosion caused by stomach acid, the micromotors are housed in microcapsules. PACT can monitor the movement of microcapsules in real time towards the lesion site in vivo (photoacoustic computed tomography). The PACT-based micro robotic is an interesting method for targeted drug administration in vivo in cancer because near infrared light irradiation promotes capsule breakup and micromotor propulsion, thereby prolonging and lengthening the drug's residence period. Given recent developments in the creation of nanorobots and their use in in vivo delivery, it is anticipated that the nanorobots will develop into more potent active transporters, opening up a range of therapeutic applications that would otherwise be challenging to implement using current passive delivery systems.

3. Other nanomotors used in the cancer treatment

a) Magnetic Nanomotors:

Due to their exceptional super magnetic properties and isolation capacity, magnetic nanospheres are highly suggested for isolating and locating tumour cells. Real-time photoacoustic (PA) imaging of methylcellulose (MCs) in the GI tract is enabled by near-infrared (NIR) light, which in some GI tract regions also activates micromotor propulsion. The NIR radiation caused the MCs to collapse and the micromotors to become active when the enteric coating of the MCs was opened, which improved payload delivery and retention in the gut. Rapid-responding magnetic nanospheres were built by layer-by-layer assembly, and after being modified with an anti-EpCAM antibody, they were able to capture cancer cells in whole blood with an efficiency of over 94 percent in just 5 minutes. This commercially available automated immunomagnetic enrichment method cell search for the detection of circulating tumour cells (CTC) has been authorised by the US FDA. It was required to mix blood and tissue in order to maximise capture efficiency, but this complicated things and resulted in cell loss. Furthermore, the in-situ detection of tumour cells is hampered by the difficulty of localising magnetic nanospheres when body fluid circulation is impossible. Using improvements in synthesis processes, researchers have effectively created specialised nanomotors for efficient target capture and segregation. A motor with loading, transporting, and releasing capabilities was created in a recent study employing nanowires to more efficiently include a magnetic nanoparticle. The use of an o-nitro benzyl linker, which

connects the target to the motor and encourages photolysis and cargo uploading under UV irradiation, is part of a loading strategy based on chemical reactions that was also reported. These advancements signal a new era in tumour cell segregation and separation and emphasise the demand for specialised materials with particular qualities to handle current issues.(45,59,60)

b) Helical micromotors:

Individual cells are further controlled by helical micromotors. The micromotor was initially turned on in this study on human B cells. The motor was put back together once they made contact and kept moving in the target's direction. The motor had been removed by the time it arrived[23]. The nanomotors are particularly attractive for use in sensing microchip devices because to their extremely precise and selective detection and isolation capabilities. Numerous groups have thought about utilising nanomotors in fluidic electronics. By detecting, capturing, and analysing data along specified pathways inside channel networks, the usual biological analysis methods were streamlined[2]. These prior discoveries, when combined, cemented the technique for the usage of nanomotors in the transport and release of various targets, including the use of nanomotors to reach and separate tumour cells, in order to separate and identify cancer cells. Many studies including the use of nanomotors to detect cancer, starting with cells and nucleic acid proteins, have been motivated by the exceptional performance of nanomotors and provide the potential for precise cancer diagnosis. (61)

c) Hollow-shape Micromotor:

A hollow-shape micromotor was built utilising a three-layer rolled metal plate (with platinum on the inside, iron in the centre, and gold on the outside) for the efficient separation and detection of circulating tumour cells (CTCs) in the blood. The inner platinum layer successfully provides power for the active movement of the micromotors by catalysing the conversion of peroxide into oxygen and water. The micromotor's capacity to separate magnetic fields is enhanced by the intermediary iron layer. The outside gold coating makes it simple and convenient to modify antibodies or compounds that are targeted to proteins that are overexpressed on the cell surface. Due to the unique design of the micromotor, it can move relatively quickly in diluted serum, has a high surface-to-volume ratio (about 85 m s1), and can drag bigger cancer cells. The micromotor can precisely detect target cells thanks to antibodies that have been functionalized for it, while passing nontarget cells along for further identification. The created immunomicromotors were efficient at picking up and moving

CTCs. It is significant to notice that the payload of the CTC has no effect on the micromotor velocity, despite the fact that the speed in the same medium drastically decreases to 80 m/s1. The research lays the door for the separation of cancer cells in high ionic strength and viscosity biological fluids in the future.(62, 63)

Cancer Cells Phototherapy Nanomotors-based phototherapy:

The advancement of nanotechnology has made it possible to build effective, specialised, and customised nanomedicine. Two phototherapies that have demonstrated potential in the treatment of cancer are photodynamic therapy (PDT) and photothermal therapy (PTT). In PDT, photosensitizers are activated, producing reactive oxygen species that harm cells. PTT, however, relies heavily on a chemical that effectively transforms near-infrared (NIR) light energy into heat energy, which, when heated, can destroy cancer cells. When used in phototherapy, nanomotors provide a number of benefits. By overcoming biological barriers and accumulating in the vicinity of the tumour cell via increased permeability and retention (EPR) effects, they can target tumours more successfully. For use in PTT and cancer imaging, nanomotors composed of substances with excellent photothermal characteristics are being developed. A lot of interest has been paid to gold nanoparticles because of their exceptional photothermal properties. With the use of Janus nanohybrids with thermophoresis active motion, such as AU-BP7@SP, it is now possible to destroy cancer cells within two days by raising the temperature of treated cells and transforming their kinetic energy into thermal energy. These nanohybrids pinpoint the malignancy while causing minimal damage to neighbouring healthy tissue, maximising the therapeutic benefits and minimising unfavourable side effects. Copper (II) 5,9,14,18,23,27,32,36-octabutoxy2,3-naphthalocyanine (NC) and Pt NPs are enclosed in PEG44-b-PS141 nanomotors and are suitable for application as catalysts for the catalytic decomposition of H2O2 and as powerful NIR light absorbers, respectively. The nanomotors have the ability to travel in a precise direction towards H2O2 produced by cancer cells, resulting in the photothermal destruction of the cancer cells.(64–66)

Conclusion:

Cancer diagnosis and treatment now have more options because to the development of micro- and nanomotors. In order to solve complex problems like developing cutting-edge delivery systems, diagnostic procedures, imaging probes, and other areas, these self-propelled devices have been widely used in cancer nanomedicine. However, there are still restrictions and difficulties related to their use, such as the immunogenicity of inorganic materials and the requirement for chemicals having clinical approval in order to produce biocompatible

micro/nanorobots. To overcome these obstacles, flexible synthetic nanomotors with superior in vivo motion control are required. Developing complete micro/nanomotors that integrate a range of imaging modalities is also crucial for combination therapy or image-guided therapy. Additionally, a variety of nanomachines may be created by combining micro/nanobots with other cutting-edge materials. The creation of micro/nanomotors powered by near-infrared light is required for in-vivo oncology, and real-time monitoring of the motor vehicle's journey could increase the effectiveness of medication administration. Additionally, adaptable detection technologies that can handle the issue of a deficient detection signal require multifunctional micro/nanomotors. Despite the advancements, much work needs to be done before micro/nanomotors can be applied to in vivo cancer treatment.

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