Journal of The Gujarat Research Society
ISSN: 0374-8588
Volume 21 Issue 10, October 2019

APPLICATION OF NANOTECHNOLOGY IN CANCER THERAPY: A REVIEW PAPER

Suhas Ballal
Assistant professor, Department of Chemistry,
School of Sciences, B-II, Jain (Deemed to be University), Bangalore-560027, India.
Email Id: b.suhas@jainuniversity.ac.in

Abstract: *The utilization of nanotechnology for cancer therapy has gotten significant consideration as of late. Cancer nanotechnology (an interdisciplinary zone of exploration in science, engineering, and medicine) is a forthcoming field with broad applications. It gives an extraordinary methodology and complete innovation against cancer through early finding, forecast, avoidance, customized therapy, and medicine. Target-explicit medication therapy and strategies for early finding of pathologies are the need research territories in which nanotechnology would have an imperative impact. This review centers on the methodologies of cancer nanotechnology in the headway of cancer therapy*

Keywords: *Drug-delivery, Encapsulation, Nanotechnology, Nanoparticles, Cancer Therapy.*

I. INTRODUCTION

Cancer is a significant reason for mortality: in excess of ten million individuals are determined to have the disease every year. Cancer is known to create by means of a multistep carcinogenesis measure involving various cell physiological frameworks such as cell flagging and apoptosis, making it an exceptionally vast and complex disease [1]. At first, cancers start as localized diseases, however they are inclined to spread to inaccessible sites inside the body, which makes cancer serious. Until this point, cancer therapies have been performed on the basis of clinical and pathologic staging that is resolved utilizing morphologic diagnostic tools, such as conventional radiological and histopathological examinations. The most widely recognized cancer therapies are confined to chemotherapy, radiation, and surgery [2]. As of now, be that as it may, the early acknowledgment and therapy of cancer stay an innovative bottleneck. Regardless of numerous advances in conventional therapy choices such as chemotherapy and radiation, cancer therapy is still a long way from ideal since it is tormented by certain downsides [3].

Incessant difficulties experienced by current cancer therapies incorporate nonspecific systemic distribution of antitumor agents, inadequate drug concentrations reaching the tumor site, intolerable cytotoxicity, limited ability to monitor therapeutic responses, and development of multiple drug resistance [4][5]. Current diagnostic and prognostic classifications are inadequate to make forecasts for effective treatment and patient result [6]. In this way, there is a critical need

and significant occasions to grow new and inventive advancements that could assist with depicting tumor edges, recognize lingering tumor cells and micro metastases, and decide if a tumor has been totally eliminated.

II. CANCER NANOTECHNOLOGY: A TRANSFORMATION FOR CANCER THERAPY

As with any cancer therapy, the main point of interest is to accomplish the ideal centralization of the therapeutic specialist in tumor sites, thereby devastating cancerous cells while limiting harm to ordinary cells. With this vision, it is basic to make single agents with colossal potential to make a significant commitment in cancer anticipation, discovery, and therapy. In such manner, a few ligand-focused on therapeutic techniques, including immunotoxins, radioimmunotherapeutics, and drug immunoconjugates, are being created to beat the issues associated with conventional chemotherapeutic drugs, thereby giving extra tools in the weapons store of cancer therapy [7]. Albeit these formed agents have indicated promising viability contrasted and conventional chemotherapy drugs, constraints in their conveyance actually stays a significant issue. Late advances recommend that nanotechnology (which includes the creation and control of materials at nanoscale levels to make items that display novel properties) will profoundly affect disease avoidance, conclusion, and treatment. Cancer nanotechnology is arising as another field of interdisciplinary exploration – cutting across the orders of science, science, engineering, and medicine – and is expected to prompt significant advances in cancer discovery, determination, and therapy [8] (Figure 1). Crafting more viable cancer therapies by engineering matter at the nanoscale gives a convincing panacea to special disposal of cancer cells without genuine harm to ordinary cells. Nanotechnology is a multidisciplinary field that has arisen as of late as quite possibly the most auspicious fields in cancer therapy [9]. Nanomedicine (the clinical use of nanotechnology)

Journal of The Gujarat Research Society
ISSN: 0374-8588
Volume 21 Issue 10, October 2019

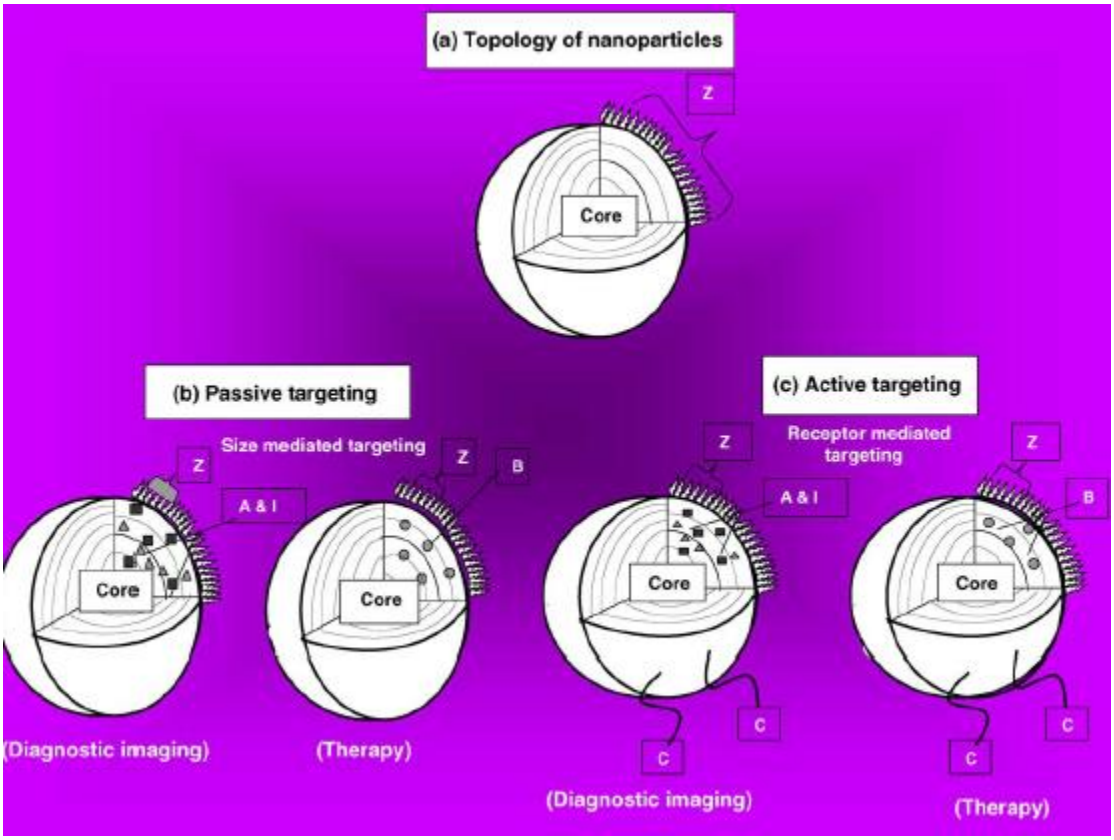

Fig. 1: Cancer therapy. Nanoparticulate architecture and drug delivery modalities. (a) Universal structural topology of nanoparticles illustrating core compartment with terminal surface groups (Z). (b) Size-mediated passive targeting of multifunctional nanoparticles carrying diagnostic and imaging agents (A and I) and therapeutic drugs for cancer therapy. (c) Active receptor-mediated targeting of multifunctional nanoparticles by different homing agents.

has fantastic potential for changing cancer therapeutics and diagnostics by creating sharp biocompatible nanocomposites for drug conveyance purposes, which speak to the most relevant utilization of nanoparticles [5]. Ongoing years have seen remarkable utilization of nanocarriers (especially in the size range from 10 nm to 100 nm) as an arising class of therapeutics for cancer therapy. Two therapeutic nanocarriers-liposomes and egg whites nanoparticles have been affirmed by the US FDA for clinical practices. What's more, liposomal doxorubicin, egg whites bound paclitaxel (Abraxane1) is another illustration of upgraded permeability and retention (EPR) - based nanovector application for breast cancer chemotherapy [10]. These nanosystems have four novel properties that recognize them from other cancer therapeutics: (I) the nanosystems would themselves be able to have therapeutic or then again diagnostic properties and can be intended to convey a huge therapeutic 'payload'; (ii) nanosystems can be connected to multivalent focusing on ligands, which yield high proclivity and explicitness for target cells; (iii) nanosystems can be made to oblige multiple drug atoms that at the same time empower combinatorial cancer therapy and (iv) nanosystems can bypass conventional drug resistance systems. By utilizing both passive and dynamic focusing on methodologies, the nanocarriers can accomplish an increased intracellular

centralization of drugs in cancer cells while limiting toxicity in ordinary cells, at the same time improving anticancer impacts and decreasing systemic toxicity [11]

III. ASPECTS OF FOCUSED CANCER THERAPY

Preferably, for anticancer drugs to be compelling in cancer therapy, they should first (after organization) have the option to arrive at the ideal tumor tissues through the infiltration of obstructions in the body with insignificant loss of volume or action in the blood course. Second, in the wake of reaching the tumor tissue, drugs ought to can specifically kill tumor cells without influencing ordinary cells with a controlled release instrument of the dynamic structure. These two basic procedures are likewise associated with enhancements in patient endurance and personal satisfaction, by all the while increasing the intracellular convergence of drugs and lessening portion restricting toxicities. On a basic level, nanoparticle conveyance of anticancer drugs to tumor tissues can be accomplished by either passive or dynamic focusing on (Figure 2).

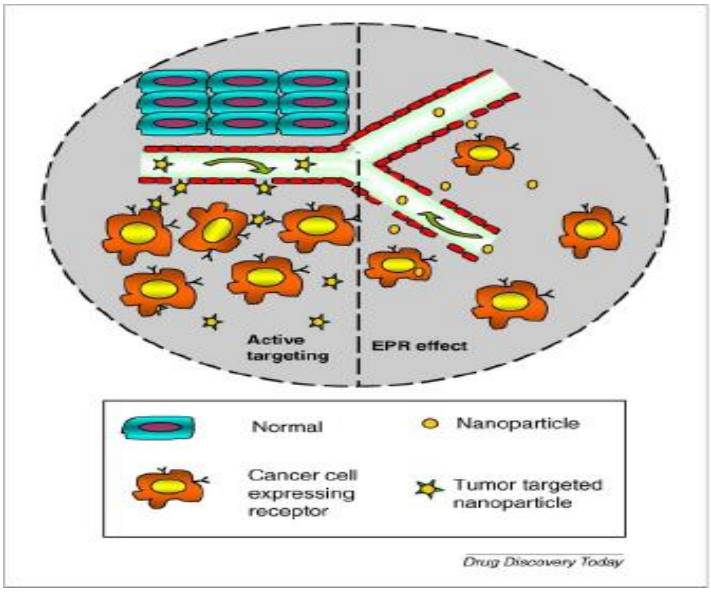

Fig. 2: Tumor targeting. The right-hand part of the figure depicts the increased accumulation of nanoparticles in tumor owing to leaky tumor vasculature, leading to the enhanced permeability and retention effect. The left-hand part of the figure shows active targeting mediated by targeted nanoparticles.

Passive Targeting: Passive Targeting alludes to the gathering of a drug or drug transporter framework at the ideal site inferable from Physico-substance or pharmacological factors. It exploits the inborn size of nanoparticles and the one of kind properties of tumor vasculature, such as the EPR impact and the tumor microenvironment. This methodology can adequately improve drug bioavailability and viability: it utilizes the anatomical and utilitarian contrasts among ordinary and tumor vasculature to convey the drug to a focused on site or may incorporate localized conveyance. Tumor vasculature is totally different from ordinary tissue. Angiogenic veins in the tumor tissues, in contrast to those in typical tissues, have holes as extensive as 600–800 nm

between adjoining endothelial cells. The flawed and imperfect design of tumor vasculature may be because of raised degrees of vascular mediators such as bradykinins, nitric oxide, vascular endothelial development factor, basic fibroblast development factor, prostaglandins, and so on. The novel pathophysiologic qualities of tumor vessels combined with poor lymphatic waste incite the EPR impact, which empowers macromolecules, including nanoparticles, to extravagate through these holes into extravascular spaces and amasses inside tumor tissues [12].

Drastic increases in tumor drug gathering, typically tenfold or more prominent can be accomplished when a drug is conveyed by a nanoparticle rather than as a free drug. Another contributor to passive focusing on is the remarkable microenvironment encompassing tumor cells, which is diverse to that of ordinary cells. Fast-developing, hyper proliferative cancer cells have a high metabolic rate, and the inventory of oxygen and supplements is normally not adequate for them to look after this. Therefore, tumor cells use glycolysis to get additional energy, coming about in an acidic climate. The pH-touchy liposomes are intended to be steady at a physiologic pH of 7.4 yet corrupted to release dynamic drug in objective tissues in which the pH is not exactly physiologic qualities, such as in the acidic climate of tumor cells. What's more, cancer cells express and release one of kind catalysts, such as grid metalloproteinase, which are involved in their development and endurance systems. An egg whites bound type of doxorubicin fusing a lattice metalloproteinase-2-explicit octapeptide succession between the drug and the transporter was seen to be effectively and explicitly divided by grid metalloproteinase in an in vitro study [13].

Active Targeting: The polymeric nanoparticles that have been tried clinically so far have generally come up short on a focusing on moiety and rather depend essentially on the EPR impact of tumors, the tumor microenvironment, and tumor angiogenesis to advance some tumor-specific conveyance of nanoparticles to tumor tissues. Nonetheless, these drug conveyance frameworks utilizing a parallel construction form unavoidably have inborn limits to the level of focusing on explicitness they can accomplish. One proposed way to deal with defeating these restrictions is known as dynamic focusing on. It includes the connection of a homing moiety, such as a monoclonal immunizer or a ligand, to convey a drug to pathological sites or to cross organic boundaries based on sub-atomic acknowledgment measures [14][15]. While developing ternary-organized nanoparticles (comprising of drugs and focusing on moiety), a few factors should be considered to make more productive conveyance frameworks. To start with, the antigen or receptor ought to be communicated only on tumor cells and not communicated on ordinary cells. Second, they ought to be communicated homogeneously on completely focused on tumor cells. At long last, cell-surface antigens and receptors ought not to be shed into the blood course. Disguise of focused forms subsequent to official to target cells is a significant standard in the choice of appropriate focusing on ligands. Disguise as a rule happens by means of receptor-intervened endocytosis. For instance, when a folate-focused on form ties with a folate receptor on the cell surface, the invaginating plasma film envelopes the complex of the receptor and ligand to for man endosome. Recently shaped endosomes are moved to target organelles. As the pH esteem in the inside of the endosome becomes acidic and lysozymes are actuated, the drug is released from the form and enters the cytoplasm if the drug has the legitimate physicochemical properties to cross the endosomal film. Released drugs are then dealt by their objective organelle, contingent upon the drug. In the interim, the folate receptor released from the form re-visitations of the cell film to

begin the second round of transport by authoritative with new folate-focused on forms. Ligands focusing on cell-surface receptors can be regular materials, such as folate and development factors, which have the benefits of lower sub-atomic weight and lower immunogenicity than antibodies. Some ligands, nonetheless, such as folate that is provided by food, show normally high concentrations in the human body and may contend with the nanoparticle-formed ligand for authoritative to the receptor, adequately lessening the intracellular grouping of the conveyed drug.

Nanotechnology-intervened novel cancer therapy

In the therapy of cancer, directed therapy – in which just cancer cells are executed and ordinary cells are not hurt – has gotten increasingly alluring. The presentation of nanotechnology has brought new materials and pathways for the focused on therapy of cancer. Designed properties of nanoparticles are making the way for new, noninvasive methodologies for cancer therapy that was not already conceivable, including nanotechnology-based progressed cancer therapy techniques such as photodynamic therapy (PDT), radiotherapy and radiofrequency therapy, and theragnostic (Box 2 and Fig. 4)

Nanotechnology-based novel cancer therapy

- Nanotechnology-based gene therapy
- Nanotechnology-based photodynamic therapy
- Nanotechnology-based radiotherapy and radiofrequency therapy
- Nanotechnology-based cancer theragnostics

IV. DISCUSSION

Nanotechnology has become an empowering innovation for customized oncology, in which cancer discovery, conclusion, and therapy are custom fitted to every individual's tumor atomic profile, and for prescient oncology, in which hereditary and/or sub-atomic markers are utilized to anticipate disease development, movement and clinical results. In acknowledgment of its potential effect on cancer research, the US National Cancer Institute has as of late supported eight national Centers of Cancer Nanotechnology Excellence. Investigating the future, there are a few exploration themes or bearings that are especially encouraging yet require deliberate exertion for progress. The first is the plan and development of nanoparticles with mono capacities or multiple capacities. For cancer and other clinical applications, significant capacities incorporate imaging (single or double methodology), therapy (a solitary drug or then again a mix of at least two drugs), and focusing on (at least one ligands).

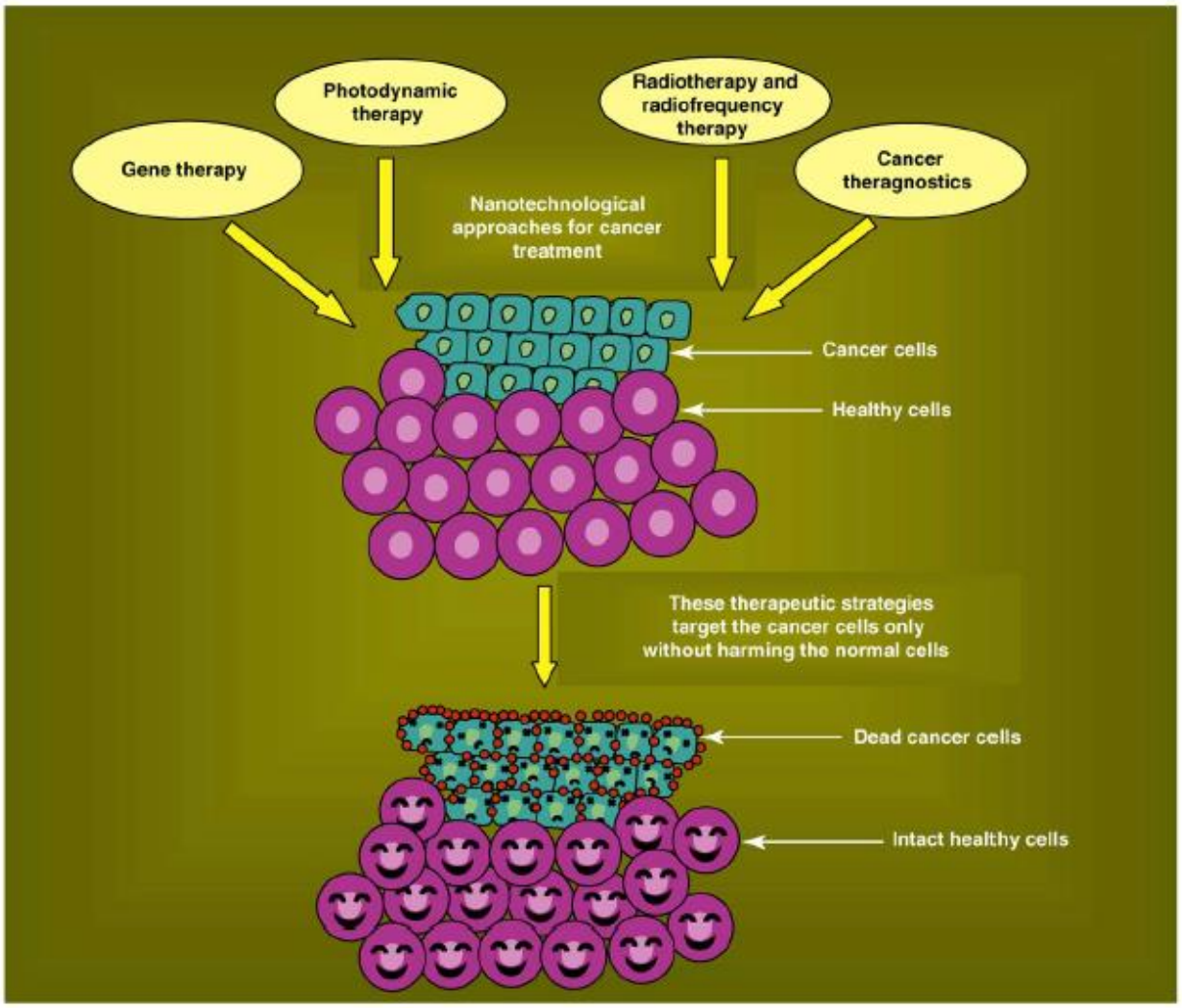

Fig 3: Different approaches of nanotechnology such as gene therapy, photodynamic therapy, radio therapy, and radiofrequency therapy and cancer theragnostic are being applied for the treatment of cancer. These advanced technologies help target cancer cells only, without affecting normal cells. Ultimately, this leads to death of the cancer cells while the normal, healthy cells survive. [16]

Nanoparticles give occasions to planning and tuning properties that are unrealistic with other sorts of therapeutic drugs and have demonstrated they have a splendid future as another age of cancer therapeutics. Furthermore, the development of multifunctional nanoparticles may in the long run render nanoparticles ready to identify and murder cancer cells at the same time. Despite the fact that there are sure significant inquiries and numerous difficulties staying for the clinical development of nanoparticles, as additional clinical information are accessible, further understanding in nanotechnology will unquestionably prompt the more levelheaded plan of enhanced nanoparticles with improved selectivity, adequacy, and security. Current information

with respect to the wellbeing of nanocarriers, nonetheless, is inadequate. The pharmacokinetic conducts of various sorts of nanoparticles require definite examination and a database of health chances associated with various nanoparticles ought to be made. Starter and integral creature studies ought to be completed to distinguish the dangers associated with nanoparticle use, with specific attention paid to disposal measures. Furthermore, almost no attention has been paid to natural impacts and the potential consequences for the health of those assembling these particles. Thinking about the innumerable potential applications of nanoparticles in the health sector, especially in cancer research, there is a critical requirement for the development of security rules by the public authority. The development of Nanotechnology Examination Centers, set up lately (some of which are subsidized through the National Institutes of Health and the National Science Foundation), show the enthusiasm of investigators and allowing offices for the innovation. In the following not many years, numerous uses of nanotechnology will get typical inside clinical practice. Since these headways will be gradual and will be at first gotten from continuous 'wet science' rather than downsized machining and registering, they might, unexpectedly, in some cases be too little to be taken note.

V. CONCLUSION

The use of nanotechnology in the field of cancer nanotechnology has encountered dramatic development in the past few a long time. Nanoparticles give occasions to planning and tuning properties that are impractical with other kinds of therapeutic drugs and have indicated they have a splendid future as another age of cancer therapeutics. The multidisciplinary field of nanotechnology holds the guarantee of conveying a mechanical achievement and is moving exceptionally fast from idea to the real world.

VI. REFERENCES

[1] J. M. Reichert and J. B. Wenger, “Development trends for new cancer therapeutics and vaccines,” *Drug Discovery Today*. 2008, doi: 10.1016/j.drudis.2007.09.003.

[2] S. Singhal, S. Nie, and M. D. Wang, “Nanotechnology applications in surgical oncology,” *Annual Review of Medicine*. 2010, doi: 10.1146/annurev.med.60.052907.094936.

[3] M. Das, C. Mohanty, and S. K. Sahoo, “Ligand-based targeted therapy for cancer tissue,” *Expert Opinion on Drug Delivery*. 2009, doi: 10.1517/17425240902780166.

[4] S. Parveen and S. K. Sahoo, “Nanomedicine: Clinical applications of polyethylene glycol conjugated proteins and drugs,” *Clin. Pharmacokinet.*, 2006, doi: 10.2165/00003088-200645100-00002.

[5] S. Parveen and S. K. Sahoo, “Polymeric nanoparticles for cancer therapy,” *Journal of Drug Targeting*. 2008, doi: 10.1080/10611860701794353.

[6] X. Wang, L. Yang, Z. Chen, and D. M. Shin, “Application of Nanotechnology in Cancer Therapy and Imaging,” *CA. Cancer J. Clin.*, 2008, doi: 10.3322/ca.2007.0003.

[7] J. K. Vasir and V. Labhasetwar, “Biodegradable nanoparticles for cytosolic delivery of

therapeutics," *Advanced Drug Delivery Reviews*. 2007, doi: 10.1016/j.addr.2007.06.003.

[8] M. Ferrari, "Cancer nanotechnology: Opportunities and challenges," *Nature Reviews Cancer*. 2005, doi: 10.1038/nrc1566.

[9] S. Sengupta *et al.*, "Temporal targeting of tumour cells and neovasculature with a nanoscale delivery system," *Nature*, 2005, doi: 10.1038/nature03794.

[10] D. J. Bharali, M. Khalil, M. Gurbuz, T. M. Simone, and S. A. Mousa, "Nanoparticles and cancer therapy: A concise review with emphasis on dendrimers," *International Journal of Nanomedicine*. 2009, doi: 10.2217/17435889.4.1.1.

[11] S. Acharya, F. Dilnawaz, and S. K. Sahoo, "Targeted epidermal growth factor receptor nanoparticle bioconjugates for breast cancer therapy," *Biomaterials*, 2009, doi: 10.1016/j.biomaterials.2009.07.008.

[12] H. Maeda, J. Wu, T. Sawa, Y. Matsumura, and K. Hori, "Tumor vascular permeability and the EPR effect in macromolecular therapeutics: A review," *J. Control. Release*, 2000, doi: 10.1016/S0168-3659(99)00248-5.

[13] K. Cho, X. Wang, S. Nie, Z. Chen, and D. M. Shin, "Therapeutic nanoparticles for drug delivery in cancer," *Clinical Cancer Research*. 2008, doi: 10.1158/1078-0432.CCR-07-1441.

[14] I. Brigger, C. Dubernet, and P. Couvreur, "Nanoparticles in cancer therapy and diagnosis," *Advanced Drug Delivery Reviews*. 2002, doi: 10.1016/S0169-409X(02)00044-3.

[15] L. Fenart *et al.*, "Evaluation of effect of charge and lipid coating on ability of 60-nm nanoparticles to cross an in vitro model of the blood-brain barrier," *J. Pharmacol. Exp. Ther.*, 1999.

[16] R. Misra, S. Acharya, and S. K. Sahoo, "Cancer nanotechnology: Application of nanotechnology in cancer therapy," *Drug Discovery Today*. 2010, doi: 10.1016/j.drudis.2010.08.006.