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A REVIEW PAPER ON CANCER MANAGEMENT AND THERAPY THROUGH DESIGNER NANOMATERIAL

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Abstract

The ability of nanotechnology is to circumvent many limitations of traditional therapeutic formulations. Important progress has actually been made in the application of engineered nanomaterials with high precision, sensitivity and efficacy for the treatment of cancer. Tailor-made nanomaterials functionalized with unique ligands can predictably target cancer cells and effectively deliver encapsulated payloads. In addition, by changing their structure, scale, morphology, and surface chemistry, nanomaterials can also be engineered for increased drug loading, enhanced half-life in the body, controlled release, and selective delivery. As smart drug delivery systems for cancer treatment, polymeric nanomaterials, metallic nanoparticles, carbon-based materials, liposomes, and dendrimers have been developed to date, demonstrating improved pharmacokinetic and pharmacodynamics profiles over traditional formulations because of their nanoscale size and specific physicochemical characteristics. The knowledge provided in the literature indicates that nanotechnology can provide cancer management and anticancer therapy platforms for the next decade.

Keywords: *Anticancer, Cancer, Management, Nanotechnology, Physicochemical.*

I. INTRODUCTION

Cancer is one of the main causes of death worldwide. The prevalence of cancer continues to increase, despite attempts to mitigate risk factors in recent decades. Current treatment norms integrate accurate cancer staging with chemotherapy, radiotherapy, and/or surgical resection. Radiotherapy and chemotherapy are considered to have serious adverse effects, with most approaches targeting cells that do not specifically divide rapidly, regardless of whether or not they are tumorous. In addition, weak pharmacokinetic features of anticancer drugs resulting from poor solubility, stability and metabolism face various toxicity, inefficacy and limited bio-distribution challenges[1].

Anticancer drug	Results
Tamoxifen	Nanoparticles exhibited significantly increased drug accumulation levels within tumors: below 5% of control drug and over 15% of nanoparticles were accumulated in tumor and systemic circulation after 1 h, respectively
Docetaxel	In vitro cell studies showed increased cytotoxicity in nanoparticles compared with free drug. After 24 h, cell viability of nanoparticle and free drug was about 15% and 30%, respectively at concentration of 20 μg/mL. IC_{50} of docetaxel and nanoparticle were about 8 and 5 μg/mL after 24 h, respectively. Nanoparticle showed significantly cellular uptake compared with free drug
Psoralen	The tumor weight after administration with psoralen-polymeric nanoparticles (< 1 g) showed significantly decreased in comparison with control group (~ 4 g)
Erlotinib/doxorubicin	The cytotoxicity in MDA-MB-231 cell showed that the cell viability of erlotinib/doxorubicin nanoparticle (about 10%) was lower than that of doxorubicin nanoparticle (about 30%) after 48 h incubation at concentration of 1 μg/mL

Table 1 Illustrates anticancer drug by polymeric nanoparticles to breast cancer cells[2].

The creation of effective formulations that can overcome the above-mentioned challenges and provide selective targeting of tumor sites without substantial harm to the viability of healthy tissues is therefore imperative[3]. It is well-known that by the time the drug hits the target, the efficacy of the anticancer drugs is significantly attenuated, which can make the medication ineffective and increase off-target effects. The efficacy of the treatment of anticancer drugs can be accomplished only if the administered drug is correctly dosed and displays optimum activity in cancer cells. Therefore, the nanomaterials used to target tumor cells should be able to increase the local drug concentration in and around tumor cells, reducing the possible toxicity to healthy cells[4].

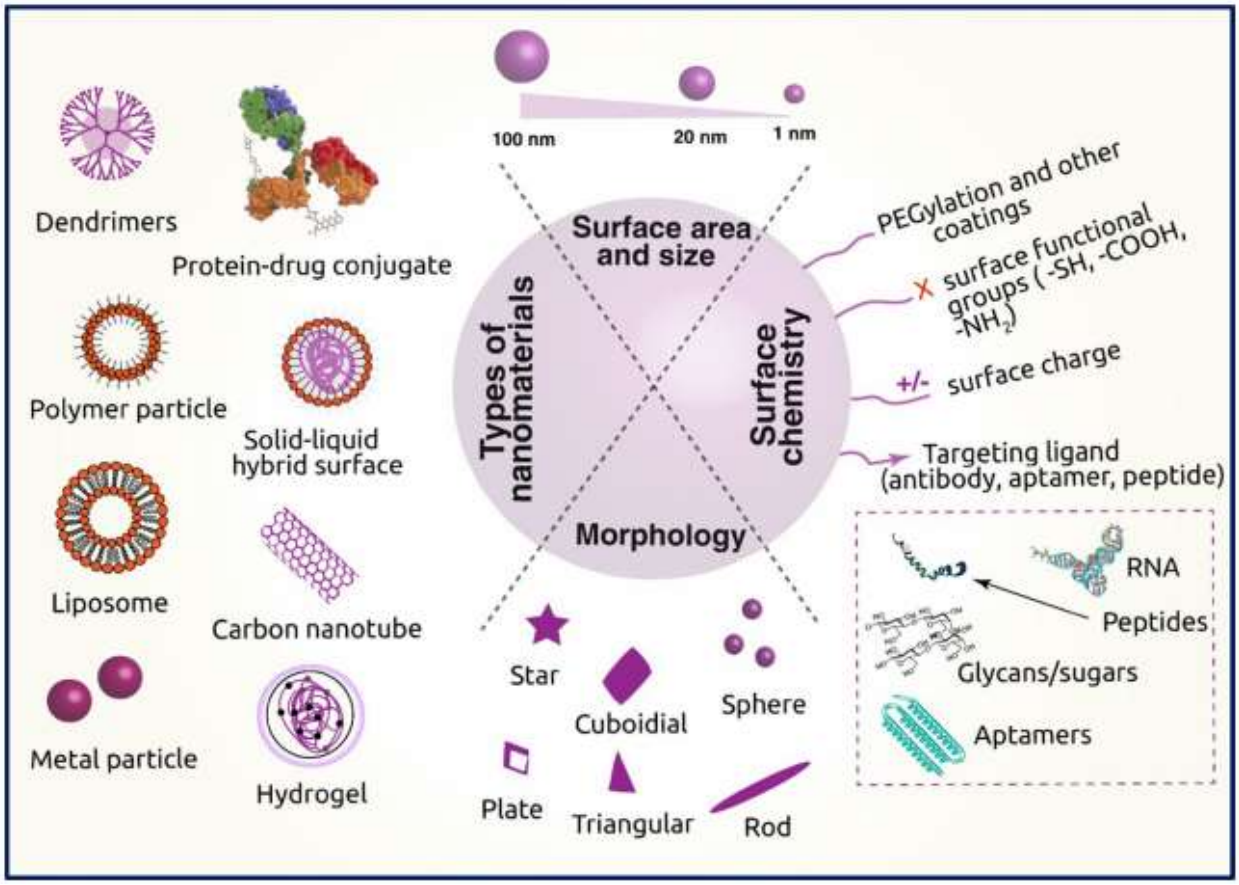

Fig. 1 Illustrates diverse kinds of nanomaterials working in cancer therapy[5].

Intravenous injection is the most common route of administration of nanomaterial-based anticancer drugs. The absorption phase through the intestinal epithelium needed after oral administration is bypassed by this approach. The vascular barrier is broken at tumor sites, which allows nanocarriers to accumulate in the tumor tissue, as shown in Figure 2. Depending on the tumor type, localization, and environment, the gaps between the endothelial cells in the tumor vasculature can vary from 200 to 2000 nm[6].

Furthermore, the nanoparticles are not easily cleared and accumulate in the tumor interstitium due to poor lymphatic function. This is referred to as the improved effect of permeability and retention (EPR), which is the basis of passive targeting. This deposition of the drug at the sites of the tumor is a passive process and requires prolonged drug circulation for adequate delivery of the drug[7].

II. DISCUSSION

Physicochemical properties such as scale, shape (morphology), surface charge, and surface chemistry are basically dependent on the aggregation of nanocarriers. The degree and kinetics of the aggregation of nanomaterials at the site of the tumor are influenced by their size.

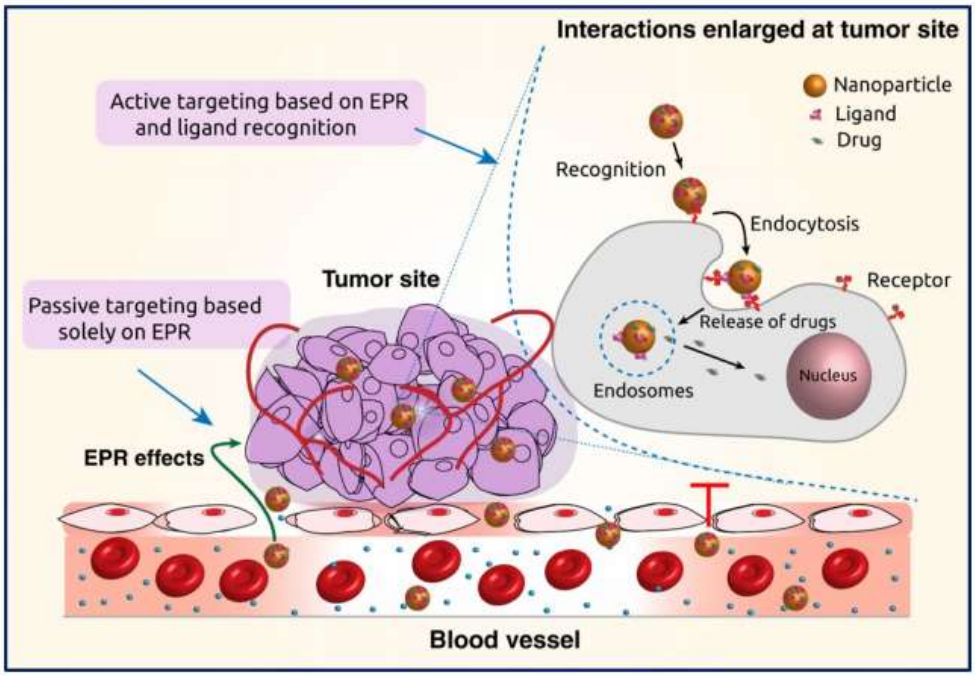

Fig. 2 Illustrates the nanoparticle types commonly used in the treatment of breast cancer[8].

Anticancer drug	Results
Tamoxifen	The R↔ and R↑ cells were 4.9- and 3.7-fold resistant respectively ($P<0.05$), to 1 μM of 4-OH tamoxifen, whereas the cells were 7- and 3.5-fold resistant respectively ($P<0.05$), to 10 μM tamoxifen at 72 h. The maximum cytotoxicity against R↔ cells was 72.6% whereas the highest cytotoxic effects on R↑ cell was 81.8% ($P<0.05$), with 10 μM tamoxifen-SLNs
Paclitaxel	Paclitaxel-SLNs showed remarkably enhanced anticancer activity in MCF-7/ADR compared to paclitaxel delivered in dimethyl sulfoxide (DMSO) and Cremophor EL-based vehicles. Verapamil increased 29.7% the cellular uptake of paclitaxel-SLNs into MCF-7/ADR
Docetaxel	Docetaxel-SLNs reduced cytotoxicity, arrested cell cycle progression in the G2/M stage and induced more apoptosis in MCF-7 cells at a low dose compared to the control
Doxorubicin	Doxorubicin-SLNs accumulated in MCF-7/ADR cells to a greater extent than did doxorubicin alone. The relative cellular uptake of doxorubicin-SLNs was 17.1-fold (60 min) and 21.6-fold (120 min) higher than that of free drug
Methotrexate, mitoxantrone, paclitaxel	In vitro cytotoxicity of mitoxantrone-SLNs (IC_{50}/72 h = 1.25 ± 0.19 μM vs. 2.13 ± 0.37 μM) and methotrexate-SLNs (IC_{50}/72 h = 93.80 ± 6.54 nM vs. 53.16 ± 11.54 nM) was higher than that of free drug formulations. In vitro cytotoxicity of paclitaxel-SLNs and free drug formulation IC_{50}/72 h were similar

Table 2 Illustrates anticancer drug delivery by solid lipid nanoparticles[9].

The problem of regulatory approval of nano drugs is another main question, as there are no clear standards set by the FDA for nano-material products. The requirements commonly used have been specifically copied from standards relating to bulk materials. The nano-formulated drug regulatory verdicts are focused on the individual assessment of paybacks and risks, rendering assessments a time-consuming affair that causes commercialization delays. Also, due to the advancement of multifunctional nano platforms, approval difficulties would appear to increase. Table 1 illustrates anticancer drug by polymeric nanoparticles to breast cancer cells. Table 2 illustrates anticancer drug delivery by solid lipid nanoparticles. Figure 1 illustrates diverse kinds of nanomaterials

working in cancer therapy. Figure 2 illustrates the nanoparticle types commonly used in the treatment of breast cancer.

III. CONCLUSION

Progress in materials science and nanotechnology has taken medical research to the forefront of nanomaterials-based formulations/drugs, emerging as potential tools for cancer treatment and management. For the success of cancer nano therapeutics, the smart design and synthesis of a library of nanomaterials, precise control over their physicochemical properties and the ease of their surface functionalization to increase specificity are indeed important. For cancer therapy and management, an understanding of nano-bio interfacial interactions and the targeting of nanoparticles to tumor cells is important. Development in materials science and nanotechnology has taken formulations/drugs based on nanomaterials to the forefront of medical research, emerging as future cancer treatment and management instruments. For the success of cancer nano therapeutics, the smart design and synthesis of a library of nanomaterials, accurate control over their physicochemical properties and ease of their surface functionalization to increase specificity are indeed important. For cancer therapy and management, an understanding of nano-bio interfacial interactions and the targeting of nanoparticles to tumor cells is important.

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