Crimson Publishers
Wings to the Research

Mini Review

Nanoparticles Drug Delivery for Cancer Therapy

Asmaa Abdelaziz Mohamed*

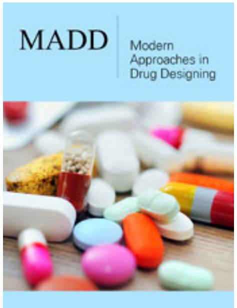
College of Pharmacy, Al-Zahraa University for Women, Iraq

Abstract

Complex etiology makes cancer a primary cause of death and morbidity. Traditional cancer treatments include chemo, radiation, targeted, and immunotherapy. Although non-specificity, cytotoxicity, and multi-drug tolerance limit cancer treatment. Nanotechnology has transformed cancer diagnosis and treatment. Biocompatibility, lowered toxicity, stability, permeability, retention, and targeted precision make nanoparticles (1-100nm) effective cancer treatments. Nanoparticle kinds vary. Patients' tumor and tumor environment characteristics determine the nanoparticle medicine delivery device. Nanoparticles revolutionize cancer treatment by reducing adverse effects and overcoming multidrug resistance. New multidrug resistance routes have spurred nanoparticle research. Nano formulations have opened new cancer treatment avenues. Fewer nanodrugs have been approved, and most research is in vitro and in vivo. Nanoparticles, targeting methods, and authorized nanotherapeutics are examined for cancer treatment. We conclude with clinical translation's pros and downsides.

Keywords: Cancer; Nanoparticles; Formulation

ISSN: 2576-9170



***Corresponding author:** Asmaa Abdelaziz Mohamed, College of Pharmacy, Al-Zahraa University for women, Karbala, Iraq

Submission: January 13, 2024
Published: February 08, 2024

Volume 4 - Issue 2

How to cite this article: Asmaa Abdelaziz Mohamed*. Nanoparticles Drug Delivery for Cancer Therapy. Mod Appro Drug Des. 4(2). MADD. 000584. 2024.
DOI: 10.31031/MADD.2024.04.000584

Introduction

In the world, cancer is the second largest cause of death after heart disease. Surgery, chemotherapy, radiation, immunotherapy, and hormone therapy are typical cancer treatments [1,2]. Chemotherapy and radiation therapy are cytostatic and cytotoxic, although they can cause severe side effects and relapse. Neuropathies, bone marrow suppression, gastrointestinal and dermatological problems, baldness, and fatigue are common side effects [3]. Deep tissue penetration of NPs Enhances Permeability and Retention (EPR). Additionally, surface features affect bioavailability and half-life by bridging epithelial fenestration [4]. NPs coated with Polyethylene Glycol (PEG) reduce immune system clearance [5]. Drug or active moiety release can be optimized by changing particle polymer properties. All in all, NPs' unique features regulate their cancer treatment effects.

Development of Nanoparticles

Bottom-up

This approach entails the construction of material starting from individual atoms, progressing to clusters, and ultimately forming nanoparticles. It is referred to as the constructive method due to its process of building up from simpler components. Several frequently employed techniques include spinning, chemical vapor deposition, plasma spraying synthesis, and biosynthesis [5].

Top-down

The process, sometimes referred to as the destructive method, involves reducing a large quantity of material or substance in order to synthesis nanoparticles. The process involves the breakdown or decomposition of a bigger molecule into smaller pieces, which are then transformed into NPs [6]. The techniques used in this process encompass mechanical milling, nanolithography, sputtering, electro-explosion, and thermal breakdown. Nanoparticles' size, shape, and charge are just a few of their physical properties that can be changed by tweaking the synthesis settings and reaction circumstances [7]. The chemical properties of nanoparticles are further determined by the growing method. If we want to make the required nanoparticles, we must understand the growth mechanism.

Nanoparticle Types

Inorganic nanoparticles

For targeted medication delivery, inorganic NPs have an inorganic core and organic shell [8]. Metallic nanoparticles, which range in diameter from 1 to 100nm, are usually made of metal oxides. They have exceptional physicochemical characteristics that potentially treat cancer. These systems have easy manufacturing and a functional surface that can enhance their attraction and specificity to target molecules from certain iron-based particles [9]. The metallic nanoparticles' surface can be readily modified to engage with targeted agents via different bonds [10]. Crucially, the metallic nanoparticles demonstrate enhanced durability and lifespan in the bloodstream, distribution throughout the body, and precise delivery to the intended location, which is significant for their use in medical treatment [11]. Silver NPs can enter the body through several routes, accumulate in organs, cross the Blood Brain Barriers (BBB), and reach the brain. After inhaling or subcutaneously injecting rats with silver-based NPs, silver NPs were found in the lungs, spleen, kidney, liver, and brain. They are more hazardous than others because they can affect cell viability and produce Reactive oxygen Species (ROS) [12].

Inorganic porous nanomaterials

Inorganic porous nanoparticles are attractive drug carriers due to their structural features. Due to their porous solid nature, particle units create consistent microporous and mesoporous pore structures [13]. Most porous materials have pores comprised of randomly aligned and repeated single units [14]. So, pores are utilized to embed molecules like medicines or antibodies. Porous materials with macroscopic channels that are unidirectionally orientated are crucial for controlling the destiny of implanted molecules. A Zeolite material's single unit is a tetrahedron comprised of Si and Al atoms linked together by oxygen atoms [15]. Such connected tetrahedra produce channels and holes, frequently including water, creating molecular sieves, adsorbents, and ion-exchangers. Thus, nanosized zeolites have been synthesized for industrial use [16]. They may be particularly useful in medicine and therapy. Zeolite nanocrystals can hold pharmaceuticals in their pores or cages [17]. Mesoporous silica NPs have improved pharmacokinetics, making them ideal medication carriers. They are often utilized in immunotherapy. A study found that colorectal cancer cells consume camptothecin-loaded mesoporous silica NPs [18].

Organic nanoparticles

There has been much interest in studying organic, biocompatible nanoparticles for cancer treatment purposes, in contrast to the inorganic nanoparticles due to their potential toxicity and the lack of regulations governing their safe in vivo use. Designed to be biodegradable and safe for cells and tissues, these organic nanoparticles pose no threat to living organisms. Polymers, nanogels, nanofibers, micelles, liposomes, and extracellular vesicles are all considered part of this class of molecules [19]. Non-biodegradable polymers like polyacrylamide and polystyrene can accumulate and produce toxicity through poor elimination [20]. Polylactic acid, poly(amino acids), chitosan, alginate, and albumin are biodegradable polymers that minimize toxicity and enhance release [21]. Since it hydrolyzes to biocompatible lactic acid and glycolic acid, poly-(D, L-lactide-co-glycolide)-based nanosystems are the least harmful [22].

Conclusion

Nanotechnology can provide tiny chemicals for cancer detection, diagnosis, and treatment, making it a promising field. Nanoparticle-based cancer therapies are widely used in clinical settings for numerous cancers due to their excellence. Nanoparticles have better pharmacokinetics, biocompatibility, tumor targeting, and stability than standard medications. Nanoparticles (NPs) also provide an efficient framework for combination therapy, which helps overcome multidrug resistance. Through considerable research, polymeric, metallic, and hybrid Nanoparticles (NPs) have improved medication delivery. Researchers must carefully evaluate nanoplatform and therapeutic medicine properties. However, there are limits, such as the cytotoxicity of nanoparticles. It is clear now that silver nanoparticles and non-biodegradable polymers are more toxic than other types of nanoparticles.

References

1. Gray J (2012) Henri Poincaré: A scientific biography. Princeton University Press, New Jersey, USA.
2. Oestreicher C (2007) A history of chaos theory. Dialogues in Clinical Neuroscience 9(3): 279-289.
3. Elabid Z, Chakraborty T, Hadid A (2022) Knowledge-based deep learning for modeling chaotic systems. 2022 21st IEEE International Conference on Machine Learning and Applications (ICMLA), pp. 1203-1209.
4. Chen Z, Liu Y, Sun H (2021) Physics-informed learning of governing equations from scarce data. Nature Communications 12(1): 6136.
5. Lai Q, Zhao XW, Liu F, Wang L (2022) Advances in chaotification and chaos-based applications. Frontiers in Physics 10: 996825.
6. Almazova N, Barmparis GD, Tsironis GP (2021) Analysis of chaotic dynamical systems with autoencoders. Chaos: An Interdisciplinary Journal of Nonlinear Science 31(10): 103109.
7. Churchill V, Xiu D (2022) Deep learning of chaotic systems from partially observed data. Journal of Machine Learning for Modeling and Computing 3(3): 97-119.
8. Raymond SJ, Camarillo DB (2021) Applying physics-based loss functions to neural networks for improved generalizability in mechanics problems. Arxiv Preprint Arxiv, pp. 1-9.
9. Wang H, Fu T, Du Y, Gao W, Huang K, et al. (2023) Scientific discovery in the age of artificial intelligence. Nature 620(7972): 47-60.
10. Ludwig J, Mullainathan S (2023) Machine learning as a tool for hypothesis generation. The Quarterly Journal of Economics, pp. 1-124.
11. Davies A, Veličković P, Buesing L, Blackwell S, Zheng D, et al. (2021) Advancing mathematics by guiding human intuition with AI. Nature 600(7887): 70-74.
12. Jumper J, Evans R, Pritzel A, Green T, Figurnov M, et al. (2021) Highly accurate protein structure prediction with AlphaFold. Nature 596(7873): 583-589.
13. Demszky D, Yang D, Yeager DS, Bryan CJ, Clapper M, et al. (2023) Using large language models in psychology. Nature Reviews Psychology 2(11): 688-701.

14. Hu Z, Feng Y, Luu AT, Hooi B, Lipani A (2023) Unlocking the potential of user feedback: Leveraging large language model as user simulator to enhance dialogue system. ArXiv.

15. Ozkaya I, Carleton A, Robert J, Schmidt D (2023) Application of Large Language Models (LLMs) in software engineering: Overblown hype or disruptive change? Software Engineering Research and Development.

16. Mandelbrot BB (1982) The fractal geometry of nature. Applied Mathematics 5(12).

17. Zhao WX, Zhou K, Li J, Tang T, Wang X, et al. (2023) A survey of large language models. Arxiv Preprint Arxiv pp.1-124.

18. Bâra A, Oprea SV, Băroiu AC (2023) Forecasting the spot market electricity price with a long short- term memory model architecture in a disruptive economic and geopolitical context. International Journal of Computational Intelligence Systems 16(1): 130.

19. Doan NAK, Polifke W, Magri L (2021) Short-and long-term predictions of chaotic flows and extreme events: a physics-constrained reservoir computing approach. Proceedings of the Royal Society A 477(2253): 20210135.

20. Yasuda H, Yamaguchi K, Miyazawa Y, Wiebe R, Raney JR, et al. (2020) Data-driven prediction and analysis of chaotic origami dynamics. Communications Physics pp. 1-8.

21. Barrio R, Lozano Á, Mayora Cebollero A, Mayora Cebollero C, Miguel A, et al. (2023) Deep learning for chaos detection. Chaos: An Interdisciplinary Journal of Nonlinear Science 33(7): 073146.

22. Mariño IP, Ullner E, Zaikin A (2013) Parameter estimation methods for chaotic intercellular networks. PloS One 8(11): e79892.

23. Bompas S, Georgeot B, Guéry Odelin D (2020) Accuracy of neural networks for the simulation of chaotic dynamics: Precision of training data vs precision of the algorithm. Chaos: An Interdisciplinary Journal of Nonlinear Science 30(11): 1-11.

24. Sprott JC (2022) Quantifying the robustness of a chaotic system. Chaos: An Interdisciplinary Journal of Nonlinear Science 32(3): 033124.

25. Stella F, Della Santina C, Hughes J (2023) How can LLMs transform the robotic design process? Nature Machine Intelligence 5(6): 561-564.