IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.301
Volume 3, Issue 7, May 2023

A Review on Nanostructured Lipid Carrier in Cancer Therapy

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Abstract: *A set of illnesses known as cancer involve abnormal cell proliferation and can invade or spread to different bodily regions. In contrast to this, neoplasms do not spread. A lump, unusual bleeding, a persistent cough, unexplained weight loss, and a change in bowel habits are all potential warning signs and symptoms. These signs of cancer may be present, but there may be other causes as well. Humans are susceptible to over 100 different malignancies. It ranks as the second most frequent cause of mortality worldwide. Surgery, radiation, and chemotherapy are the mainstays of cancer treatment today, but each has several drawbacks and frequently fails to eradicate the disease. Due to their varied physical and chemical properties, nanomaterials have recently gained a lot of attention from scientists interested in cancer therapy.*

Keywords:Neoplasm, Organic Nanoparticles, Inorganic Nanoparticles, Nanomaterials.

I. INTRODUCTION

Cancer is a condition when a few of the body's cells grow out of control and spread to other bodily regions. In the millions of cells that make up the human body, cancer can develop practically anywhere. Human cells often divide (via a process known as cell growth and multiplication) to create new cells as the body requires them. New cells replace old ones when they die because of ageing or damage. Occasionally, this systematic process fails, causing damaged or aberrant cells to proliferate when they shouldn't. Tumors, which are tissue masses, can develop from these cells. Cancerous or non-cancerous (benign) tumors are both possible. Cancerous tumor can infect nearby tissues and spread to far-off locations in the body.[21].

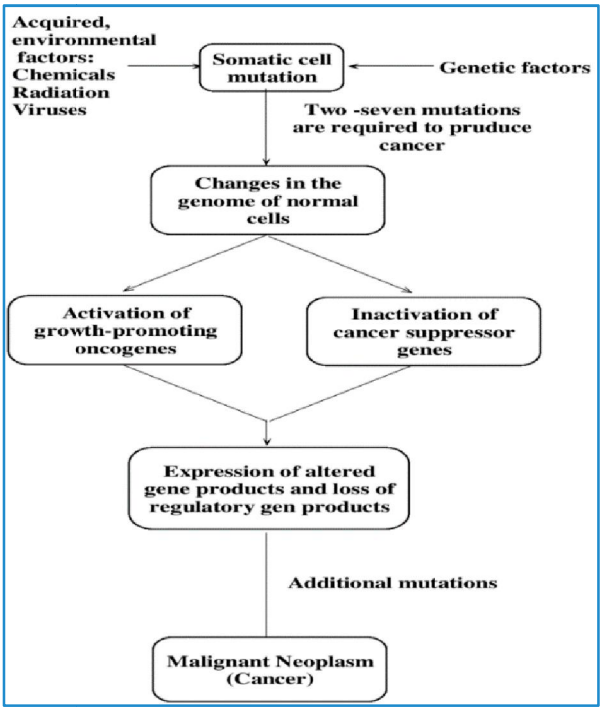

Fig:1 pathophysiology of cancer [22]

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Table 1- Examples of nanomaterials for cancer therapies and imaging.

Material	Type	Size	Main component	Main application
Organic	Polymeric micelles	20-200 nm	Polymer	Therapeutic and imaging agent carrier
	Polymeric NPs	10-1000 nm	Polymer	Therapeutic and imaging agent carrier
	Liposomes	10-1000 nm	Lipid	Therapeutic and imaging agent carrier
	Dendrimers	1-15 nm	Poly (amidoamine)	Therapeutic and imaging agent carrier
	Polymer-drug conjugates	5-50 nm	Polymer	Drug carrier
Inorganic	Silica NPs	20-100 nm	Silica	Therapeutic and imaging agent carrier
	Carbon nanotubes	0.4-2 nm	Carbon	Therapeutic and imaging agent carrier; Photodythermal therapy
	Nanographene	20-300 nm	Carbon	Drug carrier; photodythermal therapy
	Gold NPs	1-100 nm	Gold	Radiotherapy; imaging; drug carrier
	Magnetic NPs	10-50 nm	Iron oxide	Drug carrier; magnetic hyperthermia; MRI
	Quantum dots	2-100 nm	Metal compound	Fluorescence imaging; photodynamic therapy; drug carrier

Fig:2 examples of nanomaterials for cancer therapies and imaging

Due to their unique benefits, such as biocompatibility, less toxicity, more excellent stability, higher permeability and retention impact, and precision targeting, nanoparticles (1-100 nm) can be utilized to treat cancer. There are numerous major categories into which nanoparticles fall. The unique nanoparticle medication delivery technology makes use of features of the tumor and tumor environment. Nanoparticles not only circumvent multidrug resistance but also address the shortcomings of conventional cancer treatment. Additionally, nanoparticles are being aggressively researched as new multidrug resistance pathways are uncovered and analyzed. Different therapeutic implications of nano formulations have opened fresh prospects for the fight against cancer. [23].

Nanomaterials are broadly divided into two types:

- Organic nanomaterials
- Inorganic nanomaterials

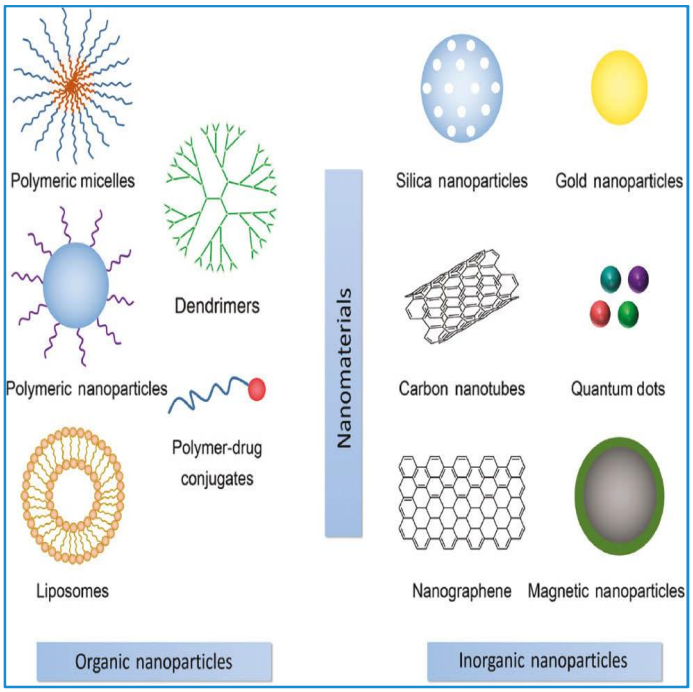

Fig:3 Types of nanomaterials

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1)Organic Nanomaterials for Cancer Therapies:

Due to its biological compatibility and degradability, natural or synthetic polymer-formed organic-based nanomaterials have been extensively used in the field of cancer therapies.

Application of nanoparticle in cancer treatment:

Polymeric Micelles:

When amphiphilic block copolymers are introduced to an aqueous solvent, they self-associate to generate nanosized molecules with a core-shell shape. Due to its intriguing properties, including biocompatibility, low toxicity, core-shell configuration, micellar association, shape, nano size, and relatively high stability, polymeric micelles are employed in drug administration [3]. They are used to treat a variety of illnesses, including cancer, estrogen therapy, and influenza. The core-shell structure of polymeric micelles determines their functionality; the hydrophobic core transports and protects the drug, while the hydrophilic shell supports and stabilizes the hydrophobic core in the aqueous medium and increases the polymers' water solubility, which is advantageous for drug administration [7].

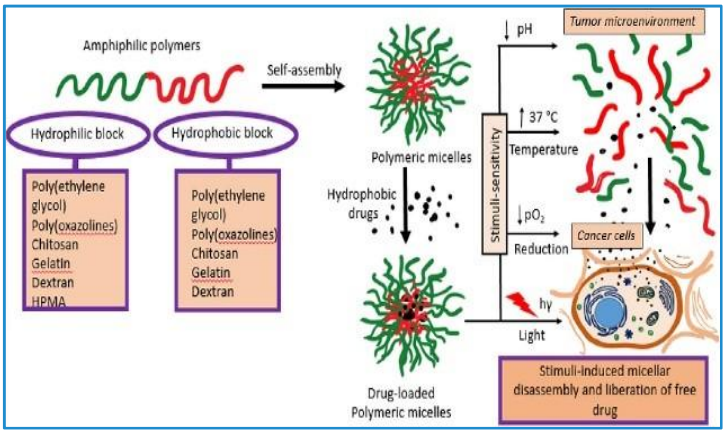

Fig: 4 Mechanisms of action of polymeric micelles in cancer treatments

Polymeric Nanoparticles:

Polymeric nanoparticles (NPs) are tiny particles with a size between 1 and 1000 nm with the ability to contain or have active substances surface-adsorbed onto the polymeric core. The morphological structure distinguishes nanospheres from nano capsules, which are both referred to as "nanoparticles". For the targeted delivery of medications used to treat a variety of disorders, polymeric NPs have demonstrated considerable promise. The polymeric NP-based delivery system for anticancer medications has drawn interest due to its excellent properties, including biodegradability, biocompatibility, and extended circulation.

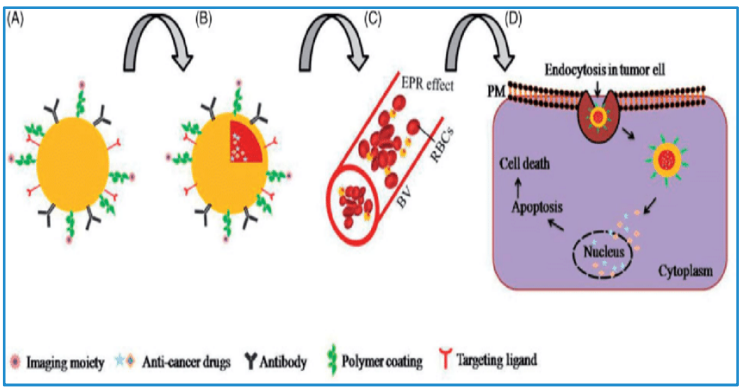

Fig:5 Mechanism action of polymeric nanoparticles in cancer therapy

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Liposomes

Drugs that are both hydrophilic and lipophilic can be enclosed in liposomes, which are vesicles made of phospholipid bilayer and are protected from deterioration. Since their discovery in the middle of the 1960s, liposomes have been thoroughly investigated and continue to generate significant interest in study. Since then, liposomes have established themselves as the most effective nanocarriers for drug delivery.[4] There are now several liposomal formulations available for the treatment of cancer, and many more are under development. This review examines the elements of liposomes, how they are made, how drugs are encapsulated, and any potential therapeutic uses for liposomes in the treatment of cancer. Cholesterol and phospholipids, which are important elements of natural bio membranes, make up most liposomes [8]. Two categories of drug encapsulation into liposomes are distinguishable.

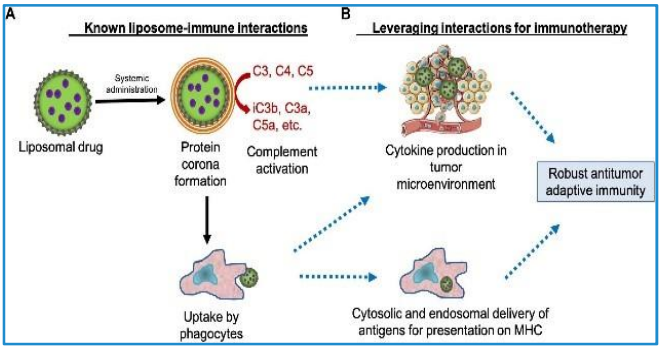

Fig:6 Mechanism of action of liposomes in cancer treatment.

Dendrimers:

Dendrimers represents a novel class of macromolecules, which are derived from branch upon branch type structural design. Dendrimers are emerging as promising drug-delivery molecules because of their extraordinary properties including membrane interaction, well-defined size, shape and molecular weight, etc. [16-17].

Drugs interact with dendrimers in three ways;

a) physical encapsulation,
b) electrostatic interactions, and
c) covalent conjugations.

Due to compact, globular structure and availability of interior cavity spaces and multiple surface functional groups, drug molecules can be encapsulated both in the interior of the dendrimers (physical encapsulation) as well as attached to the surface functional groups (covalent conjugations). Dendrimers may prolong the residence time of drug, increase the stability of bioactive, and protect it from biological environment [4].

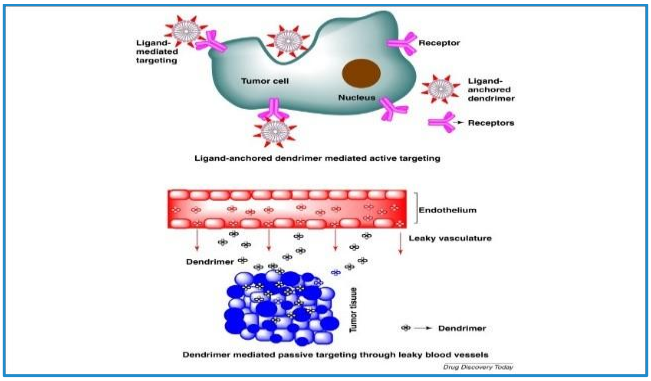

Fig: 7 Mechanism of action of dendrimers in cancer treatment.

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INORGANIC NANOPARTICLES IN CANCER THERAPIES:

Among these organic nanoparticles in cancer therapies some organic nanomaterials have also been used. They have unique chemical formulas and physical properties and are widely used for cancer treatment.

Application of inorganic nanoparticles in cancer treatment:

Carbon Nanotubes:

Due to their distinct physicochemical characteristics, carbon nanotubes (CNTs) are exploited as a novel carrier system for both tiny and big medicinal compounds. Carbon nanotubes can be functionalized (i.e., surface engineered) with certain functional groups to alter their physical or biological properties. They range in size from 0.4 to 2 nm [11–12]. Carbon nanotubes have been used in the photothermal death of cancer cells due to their extensive surface area, flexibility in manipulating their surfaces, and capacity to transport a wide variety of therapeutic chemicals. Almost all cancer therapeutic modalities, including drug delivery, lymphatic targeted chemotherapy, thermal therapy, photodynamic therapy, and gene therapy, have been investigated with carbon nanotubes.

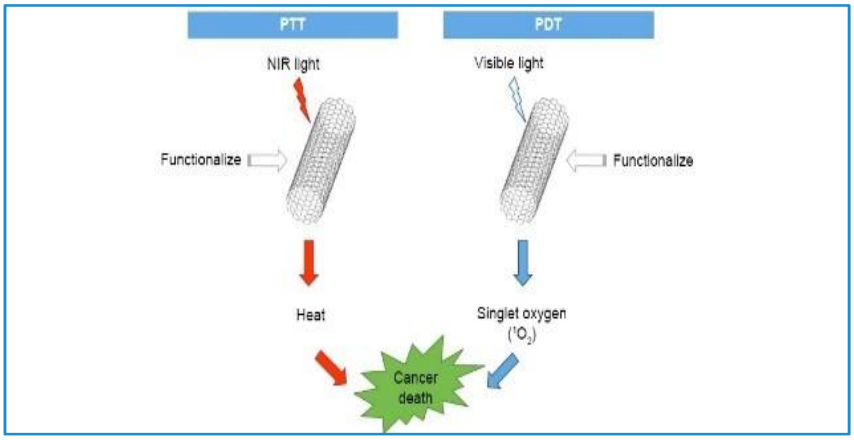

Fig: 8 Mechanism of action of carbon nanotubes.

Nanographene:

A multipurpose carbon nanomaterial called graphene might be used to create platform technologies for cancer treatments. To increase the effectiveness of treatment, its surface can be covalently and noncovalently functionalized with anticancer medications and functional groups that target cancer cells and tissue. Additionally, stimuli responsive therapies and drug administration can be made easier by utilizing its physicochemical qualities [7]. A one atom thick, tightly packed network of sp2-hybridized carbon atoms organized in a hexagonal crystal lattice makes up the 2D planar carbon nanostructure known as graphene. Due to some of its distinctive nanoscopic features, this nanomaterial has garnered a lot of interest. To enhance aqueous dispersibility and make cancer cell targeting easier, numerous amphiphilic functions can be covalently and noncovalently tethered to graphene thanks to its hydrophobic chemical structure.

Gold Nanoparticles:

Gold nanoparticles are incredibly small gold specks, measuring 1–100 nm in width, or 1,000th of the width of a human hair. When suspended in water, they typically have fantastic vibrant crimson hues. With an increase in size, gold nanoparticles' scattering cross section grows. Gold nanoparticles have a cross section that is more than 1 million times stronger than the emission from a fluorescent dye [14] and can scatter light. Dark-field scattering microscopy can be used to see gold nanoparticles larger than 10 nm in diameter. In contrast to a fluorescent dye, because gold nanoparticles are photostable, the light that they disperse does not flicker. Gold nanoparticles are desirable imaging probes for optical imaging because of these characteristics [20].

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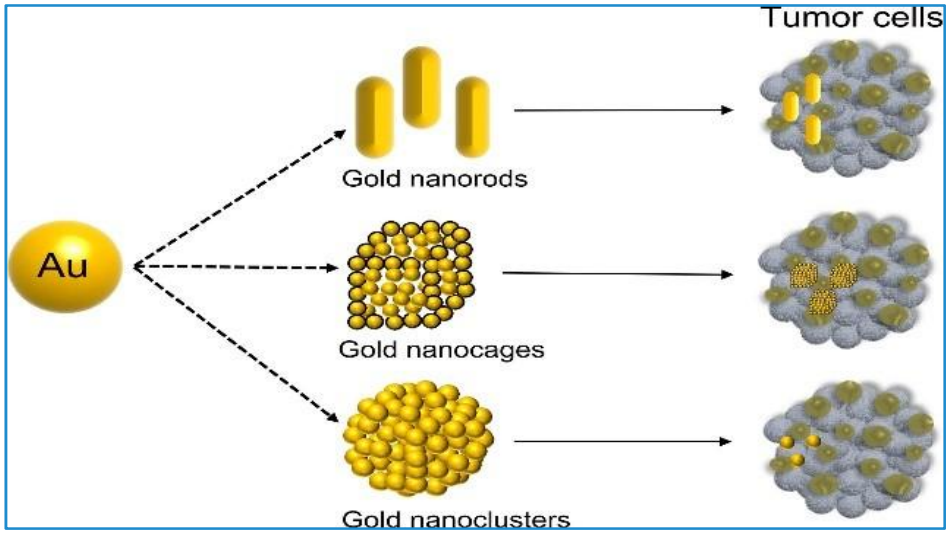

Fig.9: Gold nanoparticles in cancer treatment.

Quantumdots

A semiconductor nanocrystal with a diameter of 2 nm to 10 nm, quantum dots are made up of elements from groups II to VI or III to V. They are one of the most promising nanocrystals with unique optical and chemical properties due to their size and surface effect. They provide several advantageous qualities for spectroscopy, including strong fluorescence intensity, long lifetime, and good resistance to photobleaching, and they have many advantages over conventional organic fluorescent dyes. Due to their brightness, QD-based multifunctional probes enable simultaneous cancer molecular imaging and targeted therapy with great sensitivity. The sensitivity of QD-based molecular imaging can be two to three orders more sensitive than that of conventional fluorescent dyes for spectrum applications. The use of these in breast cancer and prostate cancer.

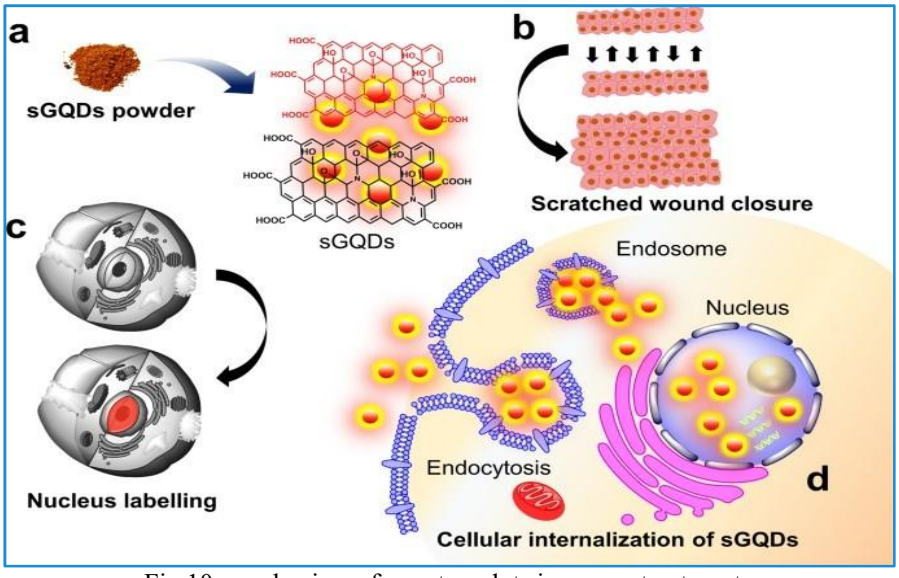

Fig.10- mechanism of quantum dots in cancer treatment.

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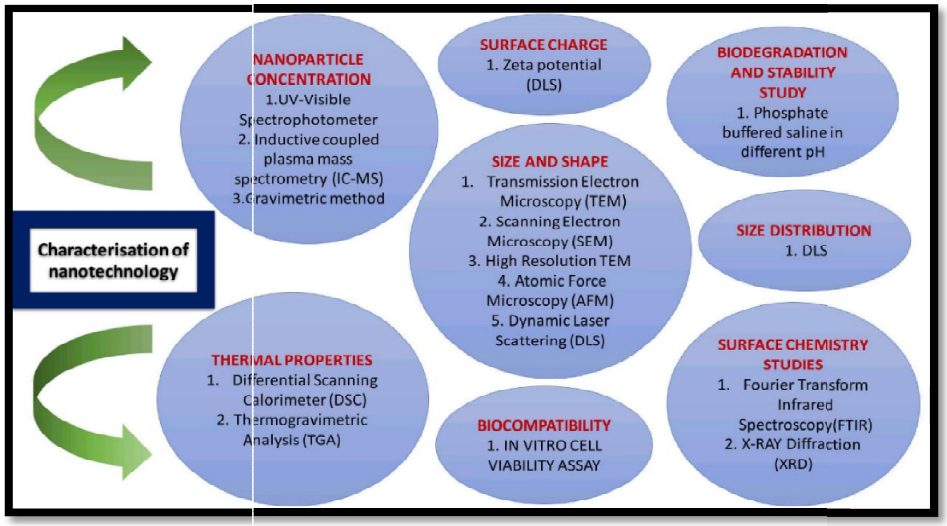
Characterization of lipid nanocarrier:



II. CONCLUSION

Nanostructured lipid carriers have gained attention as a possible cancer therapy tool and have a bigger variety of health advantages. Recently, several nanomaterials have been studied for cancer imaging, detection, and treatment due to their potential to demonstrate improved cellular absorption tumor site selectivity, longer circulation time, and surface modification. Due to the novel features that nanoparticles give materials; they have emerged as one of the most crucial research fields. There are several research in many different domains that are very concentrated. Due to its distinctive and superior qualities when compared to a material with bigger grain size, the same material manufactured in nanoscale has various advancements.

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