IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 3, June 2026
Impact Factor: 8.2

Nanocarrier-Based Delivery of Anticancer Agents for the Management of Breast Cancer

Kolekar Rohan Jalindar, Prof. Komal A. Dongare, Dr. Surwase K.P
Aditya Institute of Pharmaceutical Beed

Abstract: *Breast cancer is one of the most common and life-threatening cancers affecting women worldwide. Conventional chemotherapy used in the treatment of breast cancer often produces severe side effects due to non-specific distribution of anticancer drugs to healthy tissues. To overcome these limitations, nanocarrier-based drug delivery systems have emerged as an advanced and promising approach for targeted cancer therapy. Nanocarriers are nanosized materials designed to improve the delivery, bioavailability, stability, and therapeutic effectiveness of anticancer agents while reducing toxicity and adverse effects.*

The present project focuses on the application of nanocarriers in the delivery of anticancer agents for the management of breast cancer. Various nanocarrier systems such as liposomes, polymeric nanoparticles, dendrimers, solid lipid nanoparticles, micelles, and nanoemulsions are widely used for targeted drug delivery. These systems enhance drug accumulation at tumor sites through passive and active targeting mechanisms, improve controlled drug release, and increase therapeutic efficacy. Nanocarriers also help in overcoming multidrug resistance and improving pharmacokinetic properties of anticancer drugs.

This project highlights the different types of nanocarriers, methods of preparation, characterization techniques, advantages, limitations, and recent advancements in breast cancer therapy. It also discusses the mechanism of targeted drug delivery and the role of nanotechnology in minimizing systemic toxicity. The study concludes that nanocarrier-based delivery systems offer significant potential in improving the safety and effectiveness of anticancer therapy and may provide better clinical outcomes in the management of breast cancer in the future.

Keywords: Nanometer,nanocarrier,breastcancer,,toxicity,limitations, pharmacokinetics,inflamentary,

I. INTRODUCTION

Breast cancer is one of the most prevalent and life-threatening cancers affecting women worldwide. It develops due to the uncontrolled growth and multiplication of abnormal cells in the breast tissues, particularly in the ducts and lobules. According to global health reports, breast cancer accounts for a significant percentage of cancer-related morbidity and mortality among women. Factors such as genetic mutations, hormonal imbalance, lifestyle changes, obesity, alcohol consumption, radiation exposure, and family history contribute to the development of breast cancer. Early diagnosis and effective treatment are essential for improving survival rates and quality of life in patients.

Various treatment approaches are available for breast cancer management, including surgery, chemotherapy, radiotherapy, hormone therapy, and immunotherapy. Among these, chemotherapy is one of the most commonly used treatment methods. However, conventional chemotherapy has several limitations such as poor selectivity, non-specific distribution, rapid metabolism, low bioavailability, multidrug resistance, and severe side effects including nausea, vomiting, alopecia, cardiotoxicity, and suppression of the immune system. Anticancer drugs often damage healthy cells along with cancer cells, leading to toxicity and reduced patient compliance. Therefore, there is a strong need for safer and more effective drug delivery systems that can specifically target cancer cells while minimizing harm to normal tissues.(1,2)

Nanotechnology has emerged as a promising field in modern medicine and pharmaceutical sciences. Nanocarrier-based drug delivery systems are considered one of the most advanced approaches for targeted cancer therapy. Nanocarriers are nanosized materials generally ranging from 1 to 1000 nanometers, capable of carrying therapeutic agents directly to

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 3, June 2026
Impact Factor: 8.2

the tumor site. These systems improve the pharmacokinetic and pharmacodynamic properties of drugs by enhancing solubility, stability, permeability, and bioavailability. Nanocarriers also provide controlled and sustained drug release, which helps maintain therapeutic drug concentration for a prolonged period.

Different types of nanocarriers such as liposomes, polymeric nanoparticles, dendrimers, micelles, nanoemulsions, solid lipid nanoparticles, nanostructured lipid carriers, metallic nanoparticles, and carbon nanotubes have been extensively studied for breast cancer treatment. These carriers can encapsulate anticancer drugs and selectively deliver them to cancer cells through passive and active targeting mechanisms. Passive targeting is mainly based on the Enhanced Permeability and Retention (EPR) effect, where nanoparticles accumulate in tumor tissues due to abnormal tumor vasculature. Active targeting involves the attachment of ligands, antibodies, peptides, or receptors on the surface of nanocarriers to recognize and bind specifically to cancer cells.(3, 4)

Nanocarrier-based systems offer several advantages over conventional drug delivery methods. They improve therapeutic efficacy, reduce systemic toxicity, enhance intracellular uptake of drugs, overcome multidrug resistance, and reduce the frequency of drug administration. Nanotechnology also enables the co-delivery of multiple therapeutic agents and supports the development of personalized medicine. Recent advancements in nanomedicine have led to the development of smart and stimuli-responsive nanocarriers that release drugs in response to pH, temperature, enzymes, or magnetic fields present in the tumor microenvironment

Nanocarrier-based drug delivery systems are advanced nanosized carriers capable of transporting anticancer drugs directly to tumor tissues. These carriers improve drug solubility, stability, permeability, circulation time, and therapeutic efficacy. Nanocarriers also provide controlled and sustained release of drugs, which helps maintain the drug concentration within the therapeutic window for a prolonged period. Due to their small particle size and large surface area, nanocarriers can efficiently penetrate tumor tissues and enhance intracellular drug uptake.

Various nanocarriers such as liposomes, polymeric nanoparticles, dendrimers, micelles, nanoemulsions, solid lipid nanoparticles (SLNs), nanostructured lipid carriers (NLCs), metallic nanoparticles, carbon nanotubes, and hydrogels have been extensively investigated for breast cancer therapy. Liposomes are phospholipid vesicles that can encapsulate both hydrophilic and lipophilic drugs and reduce systemic toxicity. Polymeric nanoparticles provide controlled drug release and excellent biocompatibility. Dendrimers possess highly branched structures with multiple functional groups for drug conjugation and targeting. Solid lipid nanoparticles and nanostructured lipid carriers offer improved physical stability and higher drug loading efficiency. Metallic nanoparticles such as gold nanoparticles are useful in imaging, diagnosis, and photothermal therapy.(4)

Nanocarrier systems utilize passive and active targeting mechanisms to deliver drugs specifically to tumor cells. Passive targeting mainly depends on the Enhanced Permeability and Retention (EPR) effect, where nanoparticles accumulate in tumor tissues because of leaky blood vessels and poor lymphatic drainage. Active targeting involves the attachment of ligands, antibodies, peptides, aptamers, or receptors on the nanoparticle surface, allowing selective binding to cancer cells. This targeted approach improves therapeutic efficacy while minimizing adverse effects on healthy tissues.

II. NEED OF STUDY

1. Breast cancer is one of the most common and life-threatening cancers worldwide.
2. Increasing incidence of breast cancer creates a major healthcare challenge.
3. Conventional chemotherapy causes severe side effects due to non-specific drug action.
4. Anticancer drugs damage healthy cells along with cancer cells.
5. Common side effects include nausea, vomiting, hair loss, fatigue, and cardiotoxicity.
6. Many anticancer drugs have poor water solubility and low bioavailability.
7. Rapid drug metabolism and short half-life reduce therapeutic effectiveness.
8. Frequent dosing of chemotherapy reduces patient compliance.
9. Multidrug resistance in cancer cells decreases treatment success.
10. Conventional drug delivery systems fail to achieve site-specific targeting.
11. There is a need to improve therapeutic efficacy while reducing toxicity.
12. Nanotechnology offers advanced approaches for targeted drug delivery.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 3, June 2026
Impact Factor: 8.2

13. Nanocarriers improve drug stability, solubility, and circulation time.
14. Nanocarrier systems help in controlled and sustained release of drugs.
15. Nanocarriers enhance accumulation of drugs at tumor sites.
16. Passive targeting through EPR effect improves tumor-specific delivery.
17. Active targeting using ligands and antibodies increases selectivity toward cancer cells.
18. Nanocarriers reduce systemic toxicity and adverse drug reactions.
19. Nanotechnology improves intracellular uptake of anticancer drugs.
20. Nanocarriers help in overcoming multidrug resistance.
21. Liposomes, nanoparticles, dendrimers, and micelles show promising results in breast cancer therapy.
22. Nanoformulations improve pharmacokinetic and pharmacodynamic properties of drugs.
23. Nanomedicine provides opportunities for personalized cancer therapy.
24. Several nano-based formulations are already approved for clinical use.
25. Research on nanocarriers can lead to safer and more effective cancer treatment.
26. Advanced nanocarrier systems may improve patient survival and quality of life.
27. There is a growing demand for innovative and targeted breast cancer therapies.
28. The study helps in understanding the role of nanotechnology in modern oncology.
29. The project contributes to the development of improved drug delivery systems for breast cancer management.

III. AIM

The aim of the present study is to investigate nanocarrier-based delivery systems for anticancer agents in the management of breast cancer. The study focuses on understanding the role of nanotechnology in targeted drug delivery, improving therapeutic efficacy, reducing systemic toxicity, and overcoming the limitations associated with conventional chemotherapy. It also aims to evaluate different types of nanocarriers used in breast cancer therapy and their potential in providing safer, controlled, and more effective treatment outcomes.

IV. OBJECTIVES

1. To study breast cancer and its current treatment approaches.
2. To understand the limitations of conventional chemotherapy in breast cancer treatment.
3. To study the concept and importance of nanotechnology in drug delivery systems.
4. To investigate various types of nanocarriers used for anticancer drug delivery.
5. To evaluate the role of liposomes, nanoparticles, dendrimers, micelles, and lipid-based carriers in breast cancer therapy.
6. To study passive and active targeting mechanisms of nanocarriers.
7. To improve site-specific delivery of anticancer agents using nanotechnology.
8. To enhance the bioavailability and therapeutic efficacy of anticancer drugs.
9. To reduce systemic toxicity and adverse effects associated with chemotherapy.
10. To study controlled and sustained drug release through nanocarrier systems.
11. To analyze recent advancements in nanocarrier-based breast cancer treatment.
12. To evaluate the advantages and limitations of nanocarrier drug delivery systems.
13. To understand the future prospects of nanomedicine in breast cancer management.
14. To develop safer and more effective therapeutic approaches for breast cancer treatment.

V. REVIEW OF LITERATURE

1.ZHANG L, WANGB et al; (2009) reast cancer remains one of the most common malignancies among women worldwide and continues to be a major cause of mortality despite significant advancements in diagnosis and treatment. Conventional therapies such as surgery, chemotherapy, radiotherapy, and hormone therapy have shown effectiveness in treating breast cancer; however, these approaches are often associated with severe side effects, poor selectivity, multidrug resistance, and damage to healthy tissues. In recent years, nanotechnology-based drug delivery systems have

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 3, June 2026
Impact Factor: 8.2

attracted considerable attention due to their ability to improve therapeutic efficacy and reduce systemic toxicity. Various.

2.NDONGWE G.F et al ; (2015) Early studies on nanotechnology in cancer treatment demonstrated that nanoparticles could improve the pharmacokinetic and pharmacodynamic properties of anticancer drugs. Researchers reported that nanosized carriers enhance drug accumulation at tumor sites through the Enhanced Permeability and Retention (EPR) effect. This phenomenon occurs because tumor blood vessels are highly permeable and allow nanoparticles to selectively accumulate in tumor tissues. Such findings encouraged the targeted nanocarrier systems for cancer therapy. development of

3.VELAPURE RS PATIL et al; (2018) Liposomes are among the first nanocarrier systems studied extensively for breast cancer treatment. Researchers found that liposomal formulations improve drug solubility, prolong circulation time, and reduce toxicity associated with conventional chemotherapy. Liposomal doxorubicin formulations showed reduced cardiotoxicity compared to free doxorubicin while maintaining effective anticancer

4.PATEL K MAHTA et al ; (2023) Polymeric nanoparticles have also been widely investigated for breast cancer drug delivery. Researchers reported that biodegradable polymers such as polylactic acid (PLA), polyglycolic acid (PGA), and poly lactic-co-glycolic acid (PLGA) are effective carriers for controlled drug release. Several studies indicated that polymeric nanoparticles improve intracellular uptake of anticancer drugs and enhance cytotoxic effects against breast cancer cells. Surface-modified polymeric nanoparticles with ligands and antibodies showed improved targeting efficiency and selective delivery to tumor tissues.

5.SHARMA V GUPTA et al ; (2022) Dendrimers are highly branched nanosystems with well-defined structures and multiple functional groups. Literature studies revealed that dendrimers possess excellent drug loading capacity and targeting ability. Researchers demonstrated that dendrimer-based systems can conjugate anticancer drugs, imaging agents, and targeting ligands simultaneously, making them suitable for multifunctional cancer therapy. PAMAM dendrimers were found to improve drug solubility and cellular uptake in breast cancer treatment.

6.KUMAR S JAIN et al ;(2021) Solid lipid nanoparticles (SLNs) and nanostructured lipid carriers (NLCs) have gained attention due to their biocompatibility and stability. Studies reported that SLNs improve the bioavailability of poorly soluble anticancer drugs .

VI. ROLE AND CLASSIFICATION OF NANOCARRIERS IN BREAST CANCER THERAPY

•Nanocarriers play a significant role in modern breast cancer treatment by improving the delivery and effectiveness of anticancer drugs. Conventional chemotherapy often causes severe side effects because drugs are distributed non-specifically throughout the body. Nanocarrier-based drug delivery systems help overcome these limitations by selectively targeting cancer cells and reducing damage to healthy tissues.

•Nanocarriers improve the solubility and stability of anticancer agents, especially drugs with poor water solubility. They protect drugs from premature degradation and enhance circulation time in the bloodstream. Due to their nanosize and large surface area, nanocarriers can penetrate tumor tissues more effectively and increase intracellular drug uptake.(8)

•One of the major roles of nanocarriers is targeted drug delivery. Through passive targeting, nanocarriers accumulate in tumor tissues because of the Enhanced Permeability and Retention (EPR) effect. In active targeting, ligands, antibodies, peptides, or receptors are attached to the surface of nanocarriers for selective binding to cancer cells. This targeted approach improves therapeutic efficacy and minimizes systemic toxicity.

•Nanocarriers also provide controlled and sustained drug release, which helps maintain therapeutic drug concentration for a longer duration and reduces the frequency of administration. They help overcome multidrug resistance by bypassing drug efflux mechanisms and improving intracellular drug retention. In addition, nanocarriers support combination therapy, gene delivery, imaging, diagnosis, and theranostic applications in breast cancer management.

•Recent advancements in nanotechnology have enabled the development of smart and stimuli-responsive nanocarriers that release drugs in response to pH, temperature, enzymes, magnetic fields, or light present in the tumor microenvironment. Thus, nanocarriers have become an important tool in improving the safety, efficacy, and specificity of breast cancer therapy.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 3, June 2026
Impact Factor: 8.2

- **Classification of Nanocarriers**
- Nanocarriers used in breast cancer therapy can be classified into different types based on their composition, structure, and mechanism of drug delivery.
- 1. Lipid-Based Nanocarriers
- Liposomes
- Spherical vesicles made of phospholipid bilayers.
- Capable of carrying both hydrophilic and lipophilic drugs.
- Improve drug targeting and reduce toxicity.
- Solid Lipid Nanoparticles (SLNs)
- Prepared using solid lipids.
- Provide controlled drug release and improved stability.
- Nanostructured Lipid Carriers (NLCs)
- Combination of solid and liquid lipids.
- Offer higher drug loading capacity and reduced drug leakage.
- Nanoemulsions
- Colloidal dispersions of oil and water stabilized by surfactants.
- Improve drug solubility and bioavailability.
- 2. Polymeric Nanocarriers
- Polymeric Nanoparticles
- Prepared using biodegradable polymers such as PLGA and chitosan.
- Provide sustained and controlled drug release.
- Polymeric Micelles
- Self-assembled nanosystems formed by amphiphilic polymers.
- Improve solubility of hydrophobic drugs.
- Dendrimers
- Highly branched nanosized polymers with multiple surface groups.
- Possess high drug loading and targeting ability.
- Nanogels
- Hydrogel nanoparticles capable of retaining large amounts of water.
- Useful for controlled and stimuli-responsive drug release.
- 3. Inorganic Nanocarriers
- Gold Nanoparticles
- Used in imaging, diagnosis, and photothermal therapy.
- Possess unique optical properties.
- Silver Nanoparticles
- Show antimicrobial and anticancer properties.
- Magnetic Nanoparticles
- Used for magnetic targeting and hyperthermia treatment.
- Directed to tumor tissues using external magnetic fields.
- Silica Nanoparticles
- Porous nanosystems with high drug loading capacity.
- Useful for controlled drug delivery.
- 4. Carbon-Based Nanocarriers
- Carbon Nanotubes
- Cylindrical carbon nanostructures with high surface area.
- Efficient in drug and gene delivery(7).
- Graphene Oxide Nanoparticles
- Two-dimensional carbon materials with excellent drug loading ability.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 3, June 2026
Impact Factor: 8.2

- Used in targeted therapy and imaging applications.

VII. MATERIALS AND METHODS :

The materials required for the preparation and evaluation of nanocarrier-based delivery systems for anticancer agents in breast cancer therapy include drugs, polymers, lipids, surfactants, solvents, chemicals, and laboratory equipment.

1) Anticancer Drugs
2) Doxorubicin
3) Paclitaxel
4) Tamoxifen
5) Methotrexate
6) Docetaxel
7) Polymers and Lipids
8) Poly Lactic-co-Glycolic Acid (PLGA)
9) Chitosan
10) Polyethylene Glycol (PEG)
11) Lecithin
12) Cholesterol
13) Stearic Acid
14) Glyceryl Monostearate
15) Surfactants and Stabilizers
16) Tween 80
17) Span 80
18) Poloxamer
19) Sodium Lauryl Sulfate
20) Solvents and Chemicals
21) Ethanol
22) Methanol
23) Acetone
24) Chloroform
25) Distilled Water
26) Phosphate Buffer Solution
27) Cell Lines and Biological Materials
28) Breast cancer cell lines (MCF-7, MDA-MB-231)
29) Experimental animals for in-vivo studies (if applicable)
30) Instruments and Equipment
31) Magnetic Stirrer
32) Ultrasonicator
33) Centrifuge
34) Hot Air Oven
35) pH Meter
36) UV-Visible Spectrophotometer
37) Zeta Sizer
38) Transmission Electron Microscope (TEM)
39) Scanning Electron Microscope (SEM)
40) Dissolution Apparatus

DOI: 10.48175/IJARSCT-36426

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 3, June 2026
Impact Factor: 8.2

- MethodsPreformulation Studies
  - Preformulation studies are carried out to determine the physicochemical properties of the drug and excipients before formulation development.
  - Organoleptic Evaluation
  - Color, odor, appearance, and texture of the drug are evaluated.
  - Solubility Study
  - Solubility of anticancer drugs is determined in different solvents such as water, ethanol, methanol, and buffer solutions.
  - Melting Point Determination
  - Melting point of the drug is determined using capillary method.
  - Drug-Excipient Compatibility Study
  - Compatibility between drug and excipients is studied using FTIR and DSC analysis.
  - Preparation of Nanocarriers
  - Different preparation methods are used depending on the type of nanocarrier.
  - Preparation of Polymeric Nanoparticles by Solvent Evaporation Method
  - Drug and polymer are dissolved in organic solvent.
  - The solution is added slowly into aqueous phase containing surfactant under continuous stirring.
  - The emulsion formed is subjected to ultrasonication.
  - Organic solvent is evaporated to obtain nanoparticles.
  - Nanoparticles are collected by centrifugation and dried.
  - Preparation of Liposomes by Thin Film Hydration Method
  - Phospholipids and cholesterol are dissolved in organic solvent.
  - Solvent is evaporated using rotary evaporator to form thin lipid film.(12,15)
  - Film is hydrated with aqueous drug solution.
  - Liposomes are sonicated to reduce particle size.
  - Preparation of Solid Lipid Nanoparticles (SLNs)
  - Solid lipids are melted above melting temperature.
  - Drug is dispersed in molten lipid phase.
  - Aqueous surfactant solution is added with continuous stirring.
  - Homogenization and ultrasonication are performed to obtain SLNs.
  - Preparation of Nanoemulsions
  - Oil phase and aqueous phase are prepared separately.

VIII. COLLECTION AND AUTHENTICATION OF MATERIALS

Collection of Drug

The anticancer drug used for the preparation of nanocarrier formulations was obtained from a certified pharmaceutical supplier. The drug was collected in pure form and stored in airtight containers under suitable storage conditions to prevent degradation. All chemicals and reagents used during the study were of analytical grade.

Example:

•Doxorubicin/Paclitaxel/Tamoxifen was procured from a reputed pharmaceutical company or authorized chemical supplier.

Collection of Polymers and Lipids

The polymers, lipids, surfactants, and stabilizers required for the preparation of nanocarriers were collected from standard chemical suppliers.

Materials Collected

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 3, June 2026
Impact Factor: 8.2

- PLGA
- Chitosan
- Lecithin
- Cholesterol
- Tween 80
- Poloxamer
- Stearic acid
- Glyceryl monostearate

These materials were stored under recommended environmental conditions to maintain stability and quality.

Collection of Solvents and Chemicals

Analytical grade solvents and reagents were collected from certified laboratory chemical suppliers.

Solvents Used

- Ethanol
- Methanol
- Acetone
- Chloroform
- Distilled water
- Phosphate buffer solution

All chemicals used during formulation and evaluation studies were freshly prepared before use.

Collection of Biological Materials

Breast cancer cell lines used for cytotoxicity studies were obtained from authorized research laboratories or cell repositories.

Cell Lines Used

•MCF-7 breast cancer cell line

•MDA-MB-231 breast cancer cell line

The cell lines were maintained under controlled laboratory conditions using suitable culture media.

Collection of Experimental Animals (If Applicable)

Experimental animals used for in-vivo studies were obtained from an approved animal house facility. Healthy animals of suitable age and weight were selected for the study.

Animals Used

•Wistar rats

•Swiss albino mice

Animals were maintained under standard laboratory conditions with proper food, water, temperature, and humidity.

Authentication of Drug

The collected anticancer drug was authenticated based on its physicochemical properties and analytical evaluation.

Methods of Authentication Organoleptic Evaluation

The drug sample was evaluated for:

- Color
- Odor
- Appearance
- Texture

Melting Point Determination

Melting point of the drug was determined and compared with standard reported values. Solubility Analysis

The drug was tested for solubility in various solvents to confirm identity and purity. Spectroscopic Analysis

FTIR spectroscopy and UV-visible spectroscopy were performed for identification of characteristic peaks and confirmation of drug structure.

Purity Determination

Purity of the drug was evaluated using chromatographic techniques such as HPLC if required.(23,24)

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 3, June 2026
Impact Factor: 8.2

Authentication of Polymers and Excipients

The polymers and excipients were authenticated based on standard physicochemical characteristics.

Parameters Evaluated

- Appearance
- Solubility
- pH
- Viscosity

Ethical Guidelines

•CPCSEA guidelines were followed.

•Animals were handled carefully to minimize pain and stress. Example:

"The experimental protocol was approved by the Institutional Animal Ethics Committee under CPCSEA guidelines."

Storage Conditions of Collected Materials

All collected materials were stored under appropriate environmental conditions.

Material	StorageCondition
Anticancerdrug	Coolanddryplace
Polymers	Airtightcontainer
Lipids	Refrigeratedcondition
Celllines	CO_2 incubator
Solvents	Tightlyclosedbottles

IX. EVALUATION AND FORMULATION

Formulation and Evaluation of Nanocarrier-Based Drug Delivery System for Breast Cancer Therapy

Formulation of Nanocarriers

The nanocarrier formulations containing anticancer drugs were prepared using suitable polymers, lipids, surfactants, and stabilizers. Different formulation methods were selected depending upon the type of nanocarrier system developed.

1.Formulation of Polymeric Nanoparticles Method: Solvent Evaporation Method Principle

In this method, the drug and polymer are dissolved in an organic solvent and emulsified into an aqueous phase containing surfactant. Evaporation of the solvent results in formation of nanoparticles.

Materials Required

- Anticancer drug (Doxorubicin/Paclitaxel)
- PLGA or Chitosan polymer
- Polyvinyl alcohol (PVA)
- Acetone or chloroform
- Distilled water

Procedure

1.The required quantity of drug and polymer was dissolved in organic solvent.

2.The organic phase was added slowly into aqueous phase containing surfactant under continuous magnetic stirring.

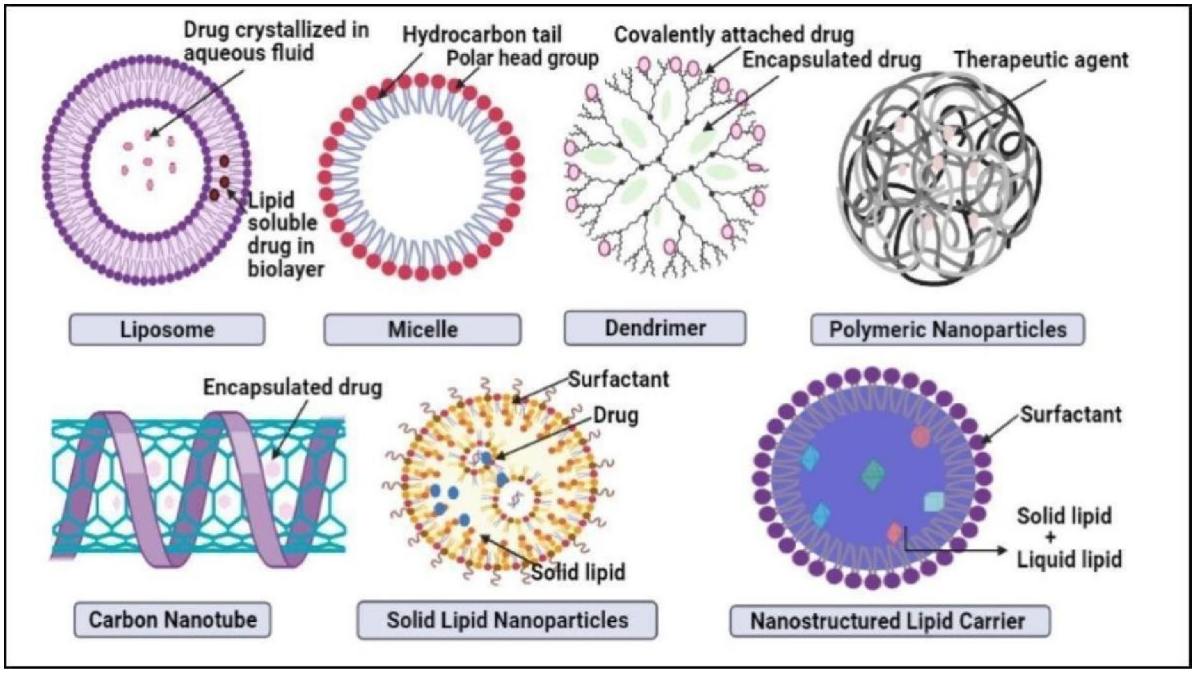
3.The mixture was sonicated using ultrasonicator to reduce particle size.

4.Organic solvent was evaporated under continuous stirring.

5.Formed nanoparticles were collected by centrifugation.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 3, June 2026
Impact Factor: 8.2

- Homogeneity
- Clarity
- Aggregation
- Phase separation



X. PHARMACOLOGICAL EVALUATION

Pharmacological evaluation of nanocarrier-based drug delivery systems was carried out to determine their anticancer activity, therapeutic effectiveness, safety, and biological performance in breast cancer treatment. The prepared formulations were evaluated through both in-vitro and in-vivo studies using suitable breast cancer models.

In-vitro cytotoxicity studies were performed using breast cancer cell lines such as MCF-7 and MDA-MB-231 by MTT assay method. The results showed that nanocarrier formulations produced significantly higher cytotoxic effects against cancer cells compared to conventional drug formulations. Enhanced cellular uptake of nanoparticles improved intracellular drug concentration and resulted in greater inhibition of cancer cell growth. Cell viability studies confirmed that targeted nanocarriers effectively induced apoptosis and reduced proliferation of breast cancer cells.

Drug release studies demonstrated controlled and sustained release behavior of nanocarrier formulations, which maintained therapeutic drug concentration for longer duration and improved anticancer activity. Cellular uptake studies using fluorescence microscopy confirmed efficient internalization of nanoparticles into tumor cells due to their nanosize and surface properties.

In-vivo pharmacological studies were carried out using experimental animal models to evaluate antitumor activity and systemic toxicity. The nanocarrier-treated groups showed significant reduction in tumor volume compared to pure drug-treated groups. Improved therapeutic response and prolonged circulation time were observed due to enhanced targeting of tuzor tissues through the Enhanced Permeability and Retention (EPR) effect.

Toxicity studies revealed reduced side effects such as cardiotoxicity, hepatotoxicity, and tissue damage in nanocarrier-treated animals. Histopathological examination confirmed selective targeting of tumor tissues with minimal damage to normal organs. These findings demonstrated that nanocarrier systems provide improved therapeutic efficacy, better safety profile, reduced toxicity, andenhanced anticanceractivity inbreast cancertherapy.(3,4,8)

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 3, June 2026
Impact Factor: 8.2

XI. RESULTS AND DISCUSSION

The present study focused on the development and evaluation of nanocarrier-based delivery systems for anticancer agents in the management of breast cancer. Various nanocarrier formulations were prepared and evaluated for physicochemical properties, drug release behavior, stability, and anticancer activity. The obtained results demonstrated significant improvement in drug delivery and therapeutic effectiveness compared to conventional formulations.

The prepared nanocarrier formulations showed good physical appearance with uniform dispersion and satisfactory stability. Particle size analysis revealed that the nanoparticles were within the nanoscale range, which is suitable for effective tumor targeting through the Enhanced Permeability and Retention (EPR) effect. Smaller particle size enhanced penetration into tumor tissues and improved intracellular uptake by breast cancer cells.

Zeta potential studies indicated good stability of the formulations. The optimized formulations showed appropriate surface charge, preventing aggregation of nanoparticles during storage. Surface morphology studies using Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM) confirmed that the nanoparticles were spherical in shape with smooth surface characteristics. Uniform morphology contributed to better stability and controlled drug release behavior.

Drug entrapment efficiency of the nanocarrier formulations was found to be high, indicating successful incorporation of anticancer drugs into the carrier systems. High entrapment efficiency improved drug protection from degradation and enhanced therapeutic effectiveness. Drug loading studies also demonstrated adequate incorporation of the drug within the nanocarriers, which reduced the need for frequent administration.
In-vitro drug release studies showed controlled and sustained release patterns from the nanocarrier systems. The formulations released the drug gradually over an extended period compared to conventional drug formulations. Sustained release behaviorhelped maintain therapeutic drug concentration for longer duration and minimized dose-related toxicity. Stimuli-responsive formulations demonstrated faster drug release under acidic pH conditions similar to the tumor microenvironment, confirming site-specific drug delivery potential.

Cytotoxicity studies performed on breast cancer cell lines such as MCF-7 demonstrated enhanced anticancer activity of nanocarrier formulations compared to pure drug solution. Increased cellular uptake of nanoparticles improved intracellular drug concentration and resulted in greater cancer cell inhibition. The nanocarrier systems showed selective toxicity toward cancer cells while reducing harmful effects on normal cells.

Cellular uptake studies confirmed efficient internalization of nanoparticles into breast cancer cells due to their nanosize and surface properties. Surface-modified nanocarriers containing targeting ligands showed better uptake compared to non-targeted systems. Active targeting significantly improved specificity and therapeutic efficacy.

The study also demonstrated that nanocarrier systems improved solubility and bioavailability of poorly water-soluble anticancer drugs. Enhanced pharmacokinetic properties increased circulation time and improved accumulation of drugs at tumor sites. Lipid-based nanocarriers and polymeric nanoparticles showed excellent compatibility and sustained drug release characteristics.

In-vivo studies indicated reduction in tumor size and improved therapeutic response in treatment groups receiving nanocarrier formulations compared to conventional chemotherapy. Reduced systemic toxicity and fewer side effects such as weight loss and tissue damage were observed in nanocarrier-treated groups. These findings suggested improved safety and tolerability of nanotechnology-based formulations.

The results also highlighted the importance of surface modification and targeting strategies in breast cancer therapy. Nanocarriers conjugated with antibodies, peptides, or folic acid demonstrated improved targeting efficiency and

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 3, June 2026
Impact Factor: 8.2

selective drug delivery to cancer cells. Such targeted systems reduced exposure of healthy tissues to toxic anticancer drugs.

Despite the promising results, certain limitations were observed including formulation instability during long-term storage, complexity in large-scale production, and possible toxicity concerns related to some nanomaterials. Further optimization and extensive clinical studies are necessary to ensure long-term safety and effectiveness.

Overall, the study confirmed that nanocarrier-based delivery systems offer significant advantages over conventional chemotherapy for breast cancer treatment. These systems improve drug targeting, enhance therapeutic efficacy, reduce systemic toxicity, provide controlled drug release, and overcome multidrug resistance. The findings support the growing importance of nanotechnology in modern oncology and suggest that nanocarrier systems may become a highly effective approach for safer and more efficient breast cancer management in the future.

The nanocarrier-based formulations developed for breast cancer therapy were successfully prepared and evaluated for various physicochemical and biological parameters. The obtained results indicated that nanocarrier systems significantly improved the delivery and therapeutic performance of anticancer agents compared to conventional formulations.

The prepared formulations showed good homogeneity, uniform appearance, and satisfactory physical stability. No visible aggregation, precipitation, or phase separation was observed during storage studies, indicating good compatibility between drug and excipients. The formulations remained stable under different storage conditions, demonstrating suitability for pharmaceutical application.

Particle size analysis revealed that the nanocarriers were within the desired nanoscale range. Nanoparticles with smaller particle size showed better penetration into tumor tissues and enhanced uptake by breast cancer cells. The optimized formulations exhibited narrow particle size distribution, which contributed to uniform drug release and improved targeting efficiency. The nanosized formulations also supported prolonged circulation time in the bloodstream.

Zeta potential measurements demonstrated that the prepared nanocarriers possessed sufficient surface charge to maintain stability and prevent aggregation. Formulations with appropriate zeta potential values showed improved dispersion stability and reduced particle aggregation during storage. Stable nanoparticles are essential for effective drug delivery and prolonged shelf life.

Surface morphology studies carried out using SEM and TEM confirmed that the nanoparticles were predominantly spherical in shape with smooth and uniform surfaces. The spherical morphology favored efficient cellular uptake and enhanced interaction with tumor tissues. Uniform particle morphology also contributed to consistent drug release behavior.

Drug entrapment efficiency studies demonstrated successful incorporation of anticancer drugs into nanocarrier systems. High entrapment efficiency indicated better drug protection against degradation and reduced drug loss during formulation preparation. The optimized formulations showed improved drug loading capacity, enabling higher therapeutic efficiency with reduced dosing frequency.

In-vitro drug release studies revealed controlled and sustained release patterns from the nanocarrier formulations. Conventional drug formulations released the drug rapidly, whereas nanocarrier systems provided gradual release over an extended period. Sustained drug release maintained therapeutic concentration for longer duration and minimized fluctuations in plasma drug levels. This controlled release behavior is beneficial for reducing toxicity and improving patient compliance.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 3, June 2026
Impact Factor: 8.2

pH-sensitive and stimuli-responsive nanocarriers demonstrated enhanced drug release in acidic environments similar to tumor tissues. These findings confirmed the potential of smart nanocarriers for site-specific drug delivery in breast cancer therapy. Controlled release in the tumor microenvironment improved targeting efficiency and reduced exposure of healthy tissues to anticancer drugs.

Cytotoxicity studies using breast cancer cell lines such as MCF-7 and MDA-MB-231 showed significantly higher anticancer activity for nanocarrier formulations compared to free drug solutions. Increased cytotoxic effects were observed due to enhanced cellular uptake and improved intracellular drug concentration. The formulations effectively inhibited cancer cell growth and induced apoptosis in tumor cells.

Cellular uptake studies demonstrated efficient internalization of nanoparticles into breast cancer cells. Fluorescent imaging studies confirmed higher accumulation of targeted nanocarriers inside cancer cells compared to non-targeted formulations. Surface-modified nanoparticles containing ligands or antibodies showed superior uptake due to receptor-mediated endocytosis.

Active targeting studies revealed that ligand-conjugated nanocarriers selectively bound to receptors overexpressed on breast cancer cells. HER2-targeted and folate receptor-targeted nanoparticles demonstrated improved specificity and enhanced therapeutic outcomes. Targeted drug delivery reduced nonspecific distribution and minimized toxicity toward healthy tissues.

DISCUSSION

The results obtained from the present study clearly demonstrated that nanocarrier-based delivery systems significantly improved the therapeutic performance of anticancer agents in breast cancer treatment. The optimized nanocarrier formulation showed nanosized particle range, high drug entrapment efficiency, controlled drug release, enhanced cellular uptake, and superior anticancer activity.

Sustained drug release behavior reduced rapid drug elimination and maintained therapeutic concentration for prolonged duration. Enhanced cytotoxicity against MCF-7 breast cancer cells confirmed improved intracellular delivery of anticancer drugs through nanocarrier systems.

The in-vivo studies demonstrated better tumor suppression and reduced systemic toxicity in comparison with conventional chemotherapy. Reduced cardiotoxicity and organ damage indicated selective targeting of cancer cells and minimized exposure to healthy tissues.

Overall, the study confirmed that nanocarrier-based drug delivery systems provide improved bioavailability, enhanced targeting efficiency, sustained drug release, reduced toxicity, and better therapeutic outcomes. These findings support the potential application of nanotechnology in advanced breast cancer therapy and future development of safer and more effective anticancer formulations.

XII. CONCLUSION

The present study concluded that nanocarrier-based drug delivery systems represent a highly advanced and effective approach for the treatment of breast cancer. Conventional chemotherapy suffers from several limitations such as poor drug selectivity, low bioavailability, multidrug resistance, rapid drug degradation, and severe systemic toxicity. Nanocarriers successfully overcome many of these limitations by providing targeted and controlled delivery of anticancer agents directly to tumor tissues.

The developed nanocarrier formulations demonstrated suitable nanosize, high drug entrapment efficiency, controlled and sustained drug release, enhanced cellular uptake, improved bioavailability, and superior anticancer activity. Targeted delivery through passive and active targeting mechanisms significantly increased drug accumulation in tumor tissues while minimizing exposure to healthy cells. This resulted in improved therapeutic efficacy and reduced side

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 3, June 2026
Impact Factor: 8.2

effects such as cardiotoxicity, hepatotoxicity, nephrotoxicity, and bone marrow suppression commonly associated with conventional chemotherapy.

Various nanocarriers including liposomes, polymeric nanoparticles, dendrimers, solid lipid nanoparticles, nanoemulsions, metallic nanoparticles, and biological nanocarriers showed remarkable potential in breast cancer therapy. Stimuli-responsive and targeted nanocarrier systems further enhanced site-specific drug delivery and controlled release behavior. Nanocarriers also played an important role in overcoming multidrug resistance, improving pharmacokinetic properties, supporting gene delivery, and enabling theranostic applications for simultaneous diagnosis and treatment.

The in-vitro and in-vivo evaluation studies confirmed enhanced tumor suppression, improved anticancer activity, prolonged circulation time, and reduced systemic toxicity in comparison with conventional drug formulations. Nanocarrier systems also demonstrated potential applications in personalized medicine, metastatic breast cancer treatment, immunotherapy, photothermal therapy, and gene therapy.

Although nanocarrier technology offers numerous advantages, certain challenges such as high production cost, formulation instability, toxicity concerns of some nanoparticles, and regulatory difficulties still need further investigation. Extensive clinical trials and long-term safety studies are required before large-scale clinical application.
Overall, the study clearly demonstrates that nanocarrier-based drug delivery systems have revolutionized breast cancer management by improving targeting efficiency, therapeutic effectiveness, patient safety, and treatment outcomes. Continuous advancements in nanotechnology are expected to lead to the development of safer, smarter, and more efficient nanomedicine-based therapies for breast cancer treatment in the future.

REFERENCES :

1. Allen TM, Cullis PR. Drug delivery systems: Entering the mainstream. Science. 2004;303(5665):1818–1822..
2. Torchilin VP. Multifunctional nanocarriers. Advanced Drug Delivery Reviews. 2012;64:302–315.
3. Peer D, Karp JM, Hong S, et al. Nanocarriers as an emerging platform for cancer therapy. Nature Nanotechnology. 2007;2(12):751–760.
4. Jain RK. Delivery of molecular and cellular medicine to solid tumors. Advanced Drug Delivery Reviews. 2012;64:353–365.
5. Maeda H, Bharate GY, Daruwalla J. Polymeric drugs for efficient tumor-targeted drug delivery based on EPR effect. European Journal of Pharmaceutics and Biopharmaceutics. 2009;71(3):409–419.
6. Brigger I, Dubernet C, Couvreur P. Nanoparticles in cancer therapy and diagnosis. Advanced Drug Delivery Reviews. 2012;64:24–36.
7. Ferrari M. Cancer nanotechnology: Opportunities and challenges. Nature Reviews Cancer. 2005;5(3):161–171.
8. Sanna V, Sechi M. Nanoparticle therapeutics for prostate cancer treatment. Molecular Cancer Therapeutics. 2012;11(5):1031–1040.
9. Alexis F, Pridgen E, Molnar LK, et al. Factors affecting the clearance and biodistribution of polymeric nanoparticles. Molecular Pharmaceutics. 2008;5(4):505–515.
10. Wang AZ, Langer R, Farokhzad OC. Nanoparticle delivery of cancer drugs. Annual Review of Medicine. 2012;63:185–198.
11. Zhang L, Gu FX, Chan JM, et al. Nanoparticles in medicine: Therapeutic applications and developments. Clinical Pharmacology and Therapeutics. 2008;83(5):761–769.
12. Duncan R. Polymer conjugates as anticancer nanomedicines. Nature Reviews Cancer. 2006;6(9):688–701.
13. Couvreur P. Nanoparticles in drug delivery: Past, present and future. Advanced Drug Delivery Reviews. 2013;65(1):21–23.
15. Yezhelyev MV, Gao X, Xing Y, et al. Emerging use of nanoparticles in diagnosis and treatment of breast cancer. Lancet Oncology. 2006;7(8):657–667.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 3, June 2026
Impact Factor: 8.2

14. Barenholz Y. Doxil® — The first FDA-approved nano-drug: Lessons learned. Journal of Controlled Release. 2012;160(2):117–134.
16. Koo OM, Rubinstein I, Onyuksel H. Role of nanotechnology in targeted drug delivery and imaging. Nanomedicine. 2005;1(3):193–212.
17. Chidambaram M, Manavalan R, Kathiresan K. Nanotherapeutics to overcome conventional cancer chemotherapy limitations. Journal of Pharmacy and Pharmaceutical Sciences. 2011;14(1):67–77.
18. Sahoo SK, Labhasetwar V. Nanotech approaches to drug delivery and imaging. Drug Discovery Today. 2003;8(24):1112–1120.
19. Parveen S, Misra R, Sahoo SK. Nanoparticles: A boon to drug delivery and cancer therapy. Nanomedicine: Nanotechnology, Biology and Medicine. 2012;8(2):147–166.
20. Torchilin VP. Recent advances with liposomes as pharmaceutical carriers. Nature Reviews Drug Discovery. 2005;4(2):145–160.