www.ijarp.com ISSN 2456-9992 Page: 01-06

International Journal Advanced Research Publications

Review Article

Volume: 02
Issue: 04

NOVEL DRUG DELIVERY SYSTEMS: A COMPREHENSIVE REVIEW

Mohammad Kaif Siddique*[1], Ranjan Kumar Singh[2], Tanya Sharma[3], Dhananjay Mistry[4], Noorul Huda[5], Kamalesh Mistry[6]

[1]Research Scholar, Faculty of Pharmaceutical Science, Mewar University, Gangrar, Chittorgarh 312901, Rajasthan, India.

[2]Associate Professor, Department of Pharmacy, Faculty of Pharmaceutical Science, Mewar University, Gangrar, Chittorgarh 312901, Rajasthan, India.

[3]Assistant Professor, Department of Pharmacy, Faculty of Pharmaceutical Science, Mewar University, Gangrar, Chittorgarh 312901, Rajasthan, India.

[4]Lecturer, Department of Pharmacy, Faculty of Pharmaceutical Science, Mewar University, Gangrar, Chittorgarh 312901, Rajasthan, India.

[5]Assistant Professor, Department of Pharmacy, Faculty of Pharmaceutical Science, Mewar University, Gangrar, Chittorgarh 312901, Rajasthan, India.

[6]Assistant professor, Dept. Of pharmaceutical Analysis, Nityananda college of pharmacy Balasore Odisha India - 756060

Article Received: 10 March 2026, Article Revised: 30 March 2026, Published on: 20 April 2026

***Corresponding Author: Mohammad Kaif Siddique**

Research Scholar, Faculty of Pharmaceutical Science, Mewar University, Gangrar, Chittorgarh 312901, Rajasthan, India.

DOI: https://doi-doi.org/101555/ijarp.1940

ABSTRACT

Recent advancements in pharmaceutical research have significantly focused on the development of novel drug delivery systems (NDDS) to overcome the limitations associated with conventional dosage forms. Traditional systems such as tablets and capsules often suffer from poor bioavailability, frequent dosing requirements, systemic side effects, and reduced patient compliance. NDDS aim to address these challenges by enhancing drug stability, improving therapeutic efficacy, and minimizing toxicity.

Innovative approaches such as orally disintegrating films, self-emulsifying drug delivery systems, nanoparticles, and targeted delivery carriers have demonstrated significant improvements in drug absorption and site-specific action. These systems are particularly beneficial for pediatric and geriatric patients due to ease of administration and improved

safety. Furthermore, NDDS help maintain drug concentration within the therapeutic range for extended periods, ensuring better treatment outcomes. This review discusses the design principles, classification, types, applications, and future perspectives of NDDS, emphasizing their role in modern therapeutics.

KEYWORDS: Drug delivery systems, Bioavailability, Nanoparticles, therapeutic agent, diseases, Specific target sites, body fluids, non- targeting tissues, drug etc.

1. INTRODUCTION

The field of pharmaceutical sciences has undergone substantial progress with the emergence of advanced drug delivery systems designed to enhance therapeutic outcomes. Novel drug delivery systems (NDDS) refer to innovative approaches that enable controlled and targeted delivery of drugs to specific sites within the body. These systems are developed to overcome the limitations of conventional drug administration methods such as oral and parenteral routes, which often result in non-specific distribution, systemic toxicity, and reduced drug efficacy.

NDDS utilize modern technologies including nanotechnology, liposomes, hydrogels, and stimuli-responsive materials to achieve precise drug targeting and controlled release. By improving pharmacokinetic and pharmacodynamic properties, these systems enhance drug performance and patient compliance. The concept of NDDS primarily focuses on delivering the right drug at the right place, in the right amount, and at the right time.

2. Overview of Drug Delivery Systems

Drug delivery systems are designed to regulate the rate, time, and location of drug release within the body. Conventional systems often face challenges such as poor bioavailability, rapid drug degradation, and inability to overcome biological barriers like the blood-brain barrier. Additionally, systemic distribution of drugs may lead to adverse effects on non-target tissues.

NDDS address these issues by improving drug solubility, stability, and targeting efficiency. They enable controlled drug release, reduce toxicity, and ensure optimal therapeutic levels. Advanced delivery systems such as nanoparticles, liposomes, dendrimers, and hydrogels are widely used to achieve these objectives.

3. Limitations of Conventional Drug Delivery Systems

Despite their widespread use, conventional drug delivery methods have several limitations. Poor bioavailability is a common issue, particularly for drugs with low water solubility. Non-specific distribution leads to systemic side effects, affecting both target and non-target tissues. Additionally, conventional systems often fail to deliver drugs precisely to the site of action, resulting in reduced therapeutic effectiveness.

Rapid drug elimination from the body necessitates frequent dosing, which may decrease patient compliance. These challenges have driven the development of NDDS, which offer improved targeting, sustained release, and enhanced therapeutic outcomes.

4. Need for Novel Drug Delivery Systems

The development of NDDS is essential to overcome the shortcomings of traditional drug delivery approaches. These systems enhance bioavailability by improving drug absorption and solubility. Targeted delivery ensures that drugs are directed specifically to diseased tissues, minimizing adverse effects on healthy cells. Controlled and sustained release mechanisms maintain drug concentrations within the therapeutic window for extended periods, reducing dosing frequency and improving compliance.

Moreover, NDDS enable drugs to cross complex biological barriers, such as the blood-brain barrier, which was previously difficult with conventional methods. The integration of personalized medicine further enhances the effectiveness of NDDS by tailoring treatments to individual patient needs.

5. Types of Novel Drug Delivery Systems

5.1 Nanoparticle-Based Drug Delivery

Nanoparticles are widely used in drug delivery due to their small size, large surface area, and ability to encapsulate both hydrophilic and hydrophobic drugs. They improve bioavailability, enable targeted delivery, and reduce side effects. Common types include polymeric nanoparticles, liposomes, and solid lipid nanoparticles.

5.2 Liposomes and Niosomes

Liposomes are vesicular structures composed of phospholipid bilayers that can encapsulate drugs and provide controlled release. Niosomes are similar structures formed from non-ionic surfactants and offer advantages such as improved stability and cost-effectiveness.

5.3 Hydrogels

Hydrogels are three-dimensional polymeric networks capable of absorbing large amounts of water. They are widely used for controlled and localized drug delivery, particularly in wound healing and chronic disease management. Their responsiveness to environmental stimuli allows controlled drug release.

5.4 RNA-Based Drug Delivery Systems

RNA-based therapeutics, including siRNA and mRNA, represent a promising area in drug delivery. These systems can regulate gene expression and are used in the treatment of genetic disorders, cancer, and viral infections. Nanocarriers are employed to protect RNA molecules and facilitate their delivery into target cells.

6. Applications of Novel Drug Delivery Systems

NDDS have a wide range of applications in modern medicine. They are extensively used for targeted drug delivery, ensuring precise action at the disease site while minimizing systemic exposure. Controlled release systems maintain consistent drug levels, improving therapeutic outcomes and patient compliance.

NDDS also support personalized medicine by tailoring treatments to individual patient needs. They play a crucial role in managing chronic diseases by providing long-acting formulations that reduce dosing frequency. Additionally, they enable combination therapies by delivering multiple drugs simultaneously, enhancing treatment efficacy.

These systems are also used in gene and cell therapies, where they facilitate the delivery of genetic material or therapeutic cells to specific sites. In vaccine delivery, NDDS improve antigen stability and immune response. Transdermal systems provide an alternative route for drug administration, bypassing the gastrointestinal tract and first-pass metabolism.

7. Future Perspectives

The future of NDDS lies in the integration of advanced technologies such as nanotechnology, personalized medicine, and smart delivery systems. Continued research is focused on developing biocompatible and biodegradable carriers with improved targeting capabilities. The use of artificial intelligence in drug design and delivery is expected to further enhance precision and efficiency.

As the understanding of disease mechanisms improves, NDDS will play a critical role in developing targeted therapies for complex diseases such as cancer and neurological disorders.

8. CONCLUSION

Novel drug delivery systems represent a significant advancement in pharmaceutical sciences, offering improved therapeutic efficacy, reduced toxicity, and enhanced patient compliance. By overcoming the limitations of conventional drug delivery methods, NDDS provide more effective and targeted treatment options.

Although challenges such as scalability, regulatory approval, and biocompatibility remain, ongoing research and technological advancements continue to address these issues. NDDS have the potential to revolutionize modern medicine by enabling precise, safe, and personalized treatment strategies.

REFERENCES

1. Vargason A.M., Anselmo A.C., Mitragotri S. The evolution of commercial drug delivery technologies. Nat. Biomed. Eng. 2021;5:951–967. doi: 10.1038/s41551-021-00698-w. [DOI] [PubMed] [Google Scholar]
2. Huang P., Wang X., Liang X., Yang J., Zhang C.N., Kong D.L., Wang W.W. Nano-, micro-, and macroscale drug delivery systems for cancer immunotherapy. Acta. Biomater. 2019;85:1–26. doi: 10.1016/j.actbio.2018.12.028. [DOI] [PubMed] [Google Scholar]
3. Abolfazl A., Rogaie R., Soodabeh D., Joo S.W., Zarghami N., Hanifehpour Y., Samiei M., Kouhi M., Nejati-Koshki K. Liposome: Classification, preparation, and applications. Nanoscale Res. Lett. 2013;8:102. doi: 10.1186/1556-276X-8-102. [DOI] [PMC free article] [PubMed] [Google Scholar]
4. Charman W.N., Chan H.-K., Finnin B.C. and Charman S.A., “Drug Delivery: A Key Factor in Realising the Full Therapeutic Potential of Drugs”, Drug Development Research, 46, 316-27, 1999.
5. Rosler A., Vandermeulen G. W. M., Klok H.-A., “Advanced drug delivery devices via self-assemply of amphiphilic block copolymers”, Advanced Drug Delivery Reviews, 53, 95-108, 2001.
6. Winterhalter M., Hilty C., Bezrukov S. M., Nardin C., Meier W., Fournier D., “Controlling membrane permeability with bacterial porins: applications to encapsulated enzymes”, Talanta, 55, 965-71, 2001.
7. Zhao Y., Hou X.X., Chai J.S., Zhang Z.Z., Xue X., Huang F., Liu J.F., Shi L.Q., Liu Y. Stapled liposomes enhance cross-priming of radio-immunotherapy. Adv. Mater. 2022;34:2107–2121. doi: 10.1002/adma.202107161. [DOI] [PubMed] [Google Scholar]

8. Wang X., Liu S., Sun Y.H., Yu X.L., Lee S.M., Cheng Q., Wei T., Gong J.Y., Robinson J., Zhang D., et al. Preparation of selective organ-targeting (sort) lipid nanoparticles (lnps) using multiple technical methods for tissue-specific mrna delivery. Nat. Protoc. 2023;18:265–291. doi: 10.1038/s41596-022-00755-x. [DOI] [PMC free article] [PubMed] [Google Scholar]
9. Yasukazu S., Atsushi Y., Nobuhiko M. Alpha-tocopheryl phosphate suppresses tumor invasion concurrently with dynamic morphological changes and delocalization of cortactin from invadopodia. Int. J. Oncol. 2009;35:1277–1288. doi: 10.3892/ijo_00000445. [DOI] [PubMed] [Google Scholar]
10. Saupe, Anne; Rades, Thomas (2006). "Solid Lipid Nanoparticles". Nanocarrier Technologies. p. 41. doi:10.1007/978-1-4020-5041-1_3. ISBN 978-1-4020-5040-4.
11. Roop k khar, s.p vyas, farhan J ahmed, gaurav k jain “the theory and practice of industrial pharmacy “4th edition lachman’s/lieberman’s cbs distributors, 2013; 872, 902, 905, 943.
12. Santini JT, Richards Ac, scheidt R, cima MJ and longer R. Microchips as controlled drug delivery devices angew chem. Int. Td, 2000; 39: 23, 96-407.