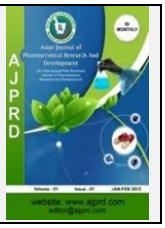
Available online on 15.04.2026 at http://ajprd.com

Asian Journal of Pharmaceutical Research and Development

Open Access to Pharmaceutical and Medical Research



Open Access

Case Study

Chitosan-Based Nanocarrier Systems for Enhanced Antidiabetic Activity of Linagliptin: A Review

Barewar Gauri*, Padole Nitin, Dhapke Pankaj, Dhoble Nilakshi, Baheti Jagdish

Kamla Nehru College of Pharmacy, Butibori Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur (Maharashtra) India

A B S T R A C T

Diabetes mellitus, particularly Type 2 diabetes mellitus (T2DM), remains a major global health challenge due to persistent hyperglycemia, progressive β-cell dysfunction, and limitations of conventional oral therapies. Linagliptin, a selective dipeptidyl peptidase-4 (DPP-4) inhibitor, offers effective glycemic control with minimal risk of hypoglycemia and weight gain; However, its therapeutic potential is restricted by low oral bioavailability caused by poor intestinal permeability, P-glycoprotein efflux, and first-pass metabolism. Chitosan-based nanocarrier systems have emerged as promising strategies to overcome these barriers. Chitosan, a biodegradable, biocompatible, and Mucoadhesive polymer, enhances drug absorption, protects against enzymatic degradation, and provides sustained drug release. Various preparation methods, including ionic gelation, polyelectrolytic complexation, and emulsification-solvent evaporation, have been utilized to develop efficient linagliptin-loaded nanocarriers with improved encapsulation efficiency and controlled release profiles. These advanced delivery systems significantly improve linagliptin's bioavailability, therapeutic efficacy, and patient compliance while reducing dosing frequency and systemic side effects. Additionally, targeted delivery approaches further optimize antidiabetic outcomes. This review highlights the formulation strategies, mechanisms, and therapeutic advantages of chitosan-based linagliptin nanocarriers, emphasizing their potential as innovative platforms for enhanced diabetes management and future clinical application.

Keywords: Chitosan Nanocarriers, Linagliptin, Type 2 Diabetes Mellitus, Drug Delivery System, Enhanced Bioavailability

A R T I C L E I N F O: Received 17 Dec.2025; Review Complete 21 Jan, 2026; Accepted 22 Feb. 2026; Available online 15 April. 2026

Cite this article as:

Barewar G, Padole N, Dhapke P, Dhoble N, Baheti J, Chitosan-Based Nanocarrier Systems for Enhanced Antidiabetic Activity of Linagliptin: A Review, Asian Journal of Pharmaceutical Research and Development. 2026; 14(2):203-207,
DOI: http://dx.doi.org/10.22270/ajprd.v14i2.1601

*Address for Correspondence:

Nitin Padole, Kamla Nehru College of Pharmacy, Butibori Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur (Maharashtra) India

INTODUCTION

Diabetes Mellitus (DM) is an ongoing metabolic disorder characterized by insulin resistance, inadequate secretion of insulin, and prolonged high levels of blood glucose in people who suffer from diabetes around the world. Many people living with T2DM fail to achieve glycemic control due to the progressive decline in β-cell function and due to the limitations of existing oral medications, including episodes of low blood sugar, weight gain, unwanted gastrointestinal side effects, and the need to take multiple oral medication or insulin therapy (1).

Type 2 diabetes mellitus accounts for the majority of diabetes cases worldwide. Type II diabetes makes up more than 90% of total diabetes prevalence. Diabetes mellitus is a long-term condition characterized by persistent elevated blood sugar levels as a result of insufficient insulin production by the pancreas (insulin deficiency) combined with an inability to properly use insulin (insulin resistance) (2,3).

Diabetes mellitus is one of the five leading causes of death internationally and in 2021 there were approximately 537 million individuals affected by diabetes (according to WHO GHO 2021). It is widely anticipated that diabetes prevalence will continue to grow over the next several years due to the lifestyles of most individuals (4, 42).

Challenges in current oral antidiabetic therapy

Type 2 diabetes mellitus is very common and associated with obesity and lifestyle, and has serious complications (micro-

vascular and macro-vascular) such as cardiovascular disease, renal failure, blindness (5, 35).

Patients on standard oral antidiabetic agents (metformin, sulfonylureas, thiazolidinediones, etc.) can develop hypoglycemia, gain weight, have gastrointestinal side effects and lose response to treatment as the function of beta cells diminishes over time. Dipeptidyl peptidase IV (DPP-4) Inhibitors (gliptins, e.g. Linagliptin) are associated with effective, weight-neutral glycemic control and a very low incidence of hypoglycemia; nonetheless, their cost and long-term durability are still a concern (6).

Introduction to Linagliptin

Linagliptin is an effective and specific inhibitor of DPP-4; as a result, linagliptin promotes the action of incretin hormones GLP-1 and GIP, resulting in decreased blood glucose levels during fasting and after meals. Hypoglycemia occurs infrequently during linagliptin treatment, and it does not cause any change in body weight (7).

Linagliptin exhibits non-linear pharmacokinetics with approximately 30% oral bioavailability; distributes widely to different body tissues; undergoes elimination mainly by non-renal routes; and may be administered at a fixed dose of 5 mg once daily regardless of renal or liver impairment (8).

Linagliptin, classified as a BCS class III drug, exhibits high solubility but low ability to cross cell membranes. It is also a substrate for P-glycoprotein (P-gp), which leads to intestinal efflux of linagliptin and reduced bioavailability of ~29 - 30%. The effects of first pass, the efflux of linagliptin via P-gp, and the intestinal degradation of linagliptin all lead to reduced exposure, which can affect efficacy or lead to increased frequency or higher doses of linagliptin (9).

Chitosan-Based Nanocarriers for Linagliptin

Chitosan is a natural biopolymer with anti-allergy properties, biocompatibility, is biodegradable, has low toxicity and has mucoadhesive characteristics. It is also straight forward to modify chemically (10, 36).

In diabetes treatment:

- Chitosan nanoparticles or nanocapsules can protect peptides (e.g., liraglutide) from digestion and provide sustained release over time due to their resistance to degradation in the GI tract (11).
- The Mucoadhesive properties of these nanoparticles or nanocapsules allow them to adhere well to the intestinal lining and thereby improving absorption from the intestine and oral cavity (12).
- Chitosan may be used as a flexible matrix to develop co-delivery systems of hypoglycemic drug combinations along with an antioxidant agent (e.g., pioglitazone + curcumin) that can address hyperglycemia, oxidative stress, and their complications at the same time (13, 39).
- Chitosan may either directly contribute to or assist in the production of environmentally friendly, natural nanostructures with the potential to prevent damage to β-cells of the pancreas, reduce blood glucose levels, and enhance the delivery of insulin, GLP-1, exendin-4, DPP-4 inhibitors, and genetic therapies (10,12).

Techniques for Preparation

Ionic gelation (cross-linking with Tripolyphosphate): Dissolve cationic chitosan in an aqueous solution containing anionic Tripolyphosphate and allow nanoparticle formation through spontaneous assembly and preparation using microfluidics, generally used to fabricate peptide or protein-containing nanoparticles (14).

Polyelectrolytic complexation: Chitosan with anionic or cationic polymers (such as alginate or carrageenan) or form colloidal polyelectrolyte complexes for encapsulation of drugs at low temperatures (15).

Emulsification-solvent evaporation / nanoemulsions:

Create nanocapsules or PLGA/Chitosan hybrids using water-in-oil or multiple emulsions containing chitosan in the aqueous phase; this method allows for high loading and controlled release (15).

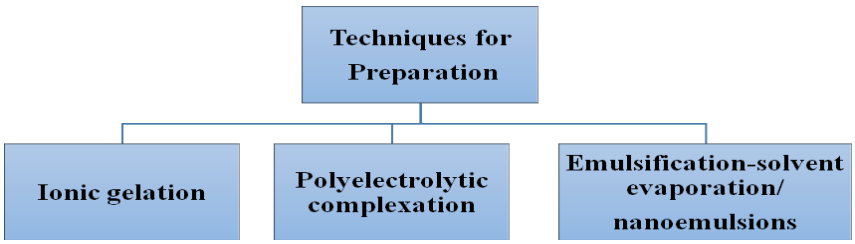


Figure: 1 Techniques for preparation of chitosan formulations.

Methods of Drug Entrapment

Achieving optimum Encapsulation Efficiency

Chitosan Nanoparticles (NP's) have less than 10-20% drug entrapment efficiency particularly for hydrophobic drugs (16, 41).

Methods of improving loading include:

Emulsion-based nanocapsules with high drug loading efficiencies (17).

Hybrid systems, such as chitosan coated alginate NPs, inside PLGA microcapsules increasing hydrophilic drug loading and reducing burst release (18, 43).

Optimising ratios of polymer: drug ratios, pH and degree of crosslinking; use of Design of Experiments for linagliptin nanosuspension (36% drug loading; 96% Encapsulation Efficiency) and PLGA-chitosan NPs (89% Encapsulation Efficiency) (19).

Mechanism of Enhanced Antidiabetic Activity

Improved Solubility and Dissolution

- Drugs that are poorly soluble (like curcumin and some orally administered drugs) can exhibit more pronounced antidiabetic properties in the form of nanosuspensions, micelles, or other nanoforms because these enhancements increase surface area, solubility, and the amount of drug uptake into cells. In addition to resulting in better blood glucose control, these enhancements may also produce improved metabolic markers (20).
- Another means of enhancing the solubility and stability of bioactive compounds (such as hesperidin or polyphenols) is through their encapsulation within nanocarriers, which provides enhanced antidiabetic activity (21).

Enhanced Intestinal Absorption via Mucoadhesion

- Chitosan and its derivatives (trimethyl, thiolated, PEG-conjugated, alginate-coated) bind to negatively charged mucosa, thus increasing the duration of contact with the epithelium and extending drug residence time (21).
- These systems induce openings (tight junctions), allowing paracellular transport of insulin and peptide products, resulting in an increase in plasma insulin levels and the duration of effect in vivo (22).
- Mucoadhesive buccal or intestinal films and nanoparticles (metformin buccal CS-NPs, for example) provide mucoadhesion and permeability enhancement to provide a route to bypass first-pass metabolism and increase drug bioavailability (23).

Sustained / Controlled Drug Release

- A number of nanomaterials (including PLGA, chitosan, alginate, porous silicon/polymer matrixes, and niosomes) have been found to be produced which can be used to achieve the pH-responsive and timed-release of drugs. These materials may release insulin or peptides through a biphasic pattern (i.e., both an initial and a sustained phase) or can be used for an extended release of oral medication for 12 to 14 hours, etc. (24, 38).
- Sustained intestinal delivery of antidiabetic peptides (i.e., RPP's from rapeseed, GLP-1, exenatide, etc.) improves glucose tolerance, raises levels of GLP-1, and enhances the duration of the hypoglycemic response in appropriate animal models (25).

Protection from Enzymatic Degradation

- Insulin and peptide encasement in chitosan, alginate, PLGA, or pH-sensitive matrices protects against acid and proteolytic enzymes. This provides significantly increased stability and bioavailability by mouth (26).
- Combination peptide + dipeptidyl-peptidase IV (DPP-IV) inhibitor dual systems in a multiphase nanocarrier protect GLP-1 from enzymatic degradation while improving permeability and providing additive antidiabetic activity in vitro (27).

Targeted Delivery Potential

- Surface ligands (folic acid, hyaluronic acid, vitamin B12) and polymers (fucoidan) facilitate receptor-mediated uptake or tissue targeting (intestinal receptors, CD44, folate receptors) resulting in higher concentrations of drug delivered locally and thus increased efficacy(28,37).

Some carriers deliver insulin/peptides with intrinsic antidiabetic activity (fucoidan has hypoglycaemic effect, hesperidin, polyphenols) and therefore provide multifunctional platforms that will address glucose, oxidative stress and their complications simultaneously (12, 21).

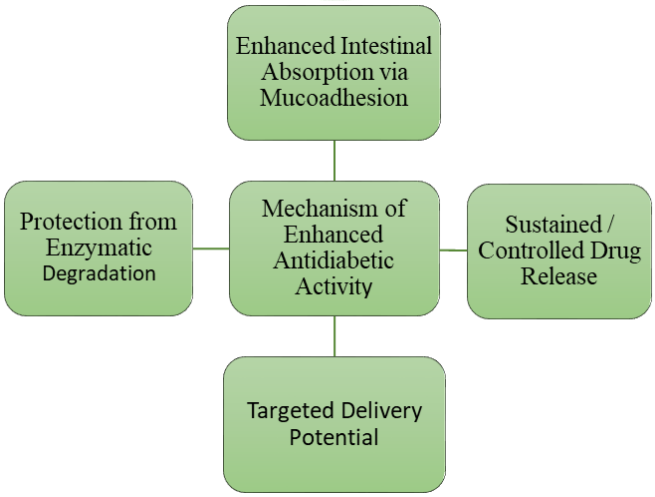


Figure: 2 Mechanism of enhanced antidiabetic activity

Advantages of Chitosan-Based Linagliptin Delivery

Improved Bioavailability

- Linagliptin nanocarrier delivery via buccal chitosan platforms (cubosomes or multi-layered nanosponge forms) provided an approximate increase of 2-fold in linagliptin AUC after administration to humans; thereby significantly improving systemic exposure relative to standard formulations (29, 40).

- The intranasal cationic chitosan-coated linagliptin nanosuspension achieved nearly complete entrapment (~96%), high drug loading (~36%) and significant increases in solubility, dissolution, and ex vivo permeation compared to uncoated linagliptin; therefore, making them suitable for reduced dosing frequency (30).
- Chitosan nanoparticles can also improve oral bioavailability of various compounds (typically by 2–3.5 fold), as they enhance absorption and protect against degradation during transit through the GI tract (31).

Reduced Dosing Frequency

- Platforms utilizing chitosan often achieve prolonged or controlled release, while CNPs have shown longer retention in both the stomach and intestines after sustained drug release; therefore, they greatly benefit bioavailability by decreasing the number of times that a patient has to take medication (32).
- Chitosan-modified PLGA linagliptin nanoparticles exhibited a clear first burst followed by 3 days of prolonged release - strong evidence of the ability to decrease the frequency of dosing (using a topical type model) (19).

Enhanced Therapeutic Efficacy

- The combination of chitosan-PVP buccal cubosomes containing the drugs linagliptin and empagliflozin resulted in increased area under the curves (AUCs) for both drugs (linagliptin: 2x; and empagliflozin: 3x) and was suggested to enhance their clinical efficacy in controlling diabetes (33).
- Multilayer nanosponge used to develop chitosan buccal films had similar effects with linagliptin exposure being double, and up to 10x higher for empagliflozin, as these products were designed to maximize dose efficiencies through improved clinical efficacies (29).
- Chitosan nanoparticles (NPs) generally result in enhanced stability, targeting, and cellular interaction, thereby providing higher therapeutic efficiencies with lower doses (17).

Reduced Side Effects

- The purpose of this research was to enhance the therapeutic effect of the intranasal chitosan-linagliptin nanosuspension while simultaneously aiming to decrease the dose and therefore side effects associated with the use of linagliptin; however, the cognitive effects were also sought to be improved upon as well (30).
- Chitosan nanocarriers have been reported in reviews to allow a decreased therapeutic dose and more localised delivery, which has been associated with reduced systemic adverse effects and improved safety profiles (34).

CONCLUSION

Chitosan-based nanocarrier systems represent a highly promising advancement in the delivery of linagliptin for the management of Type 2 diabetes mellitus. By addressing the major limitations of conventional linagliptin therapy, including low bioavailability, poor permeability, and rapid drug degradation, these nanocarriers significantly enhance therapeutic performance. The unique properties of chitosan, such as biocompatibility, biodegradability, mucoadhesion, and controlled-release capability, make it an ideal polymer for developing efficient drug delivery platforms. Through improved intestinal absorption, sustained release, protection from enzymatic degradation, and potential targeted delivery, chitosan formulations can increase drug efficacy, reduce dosing frequency, and minimize adverse effects. Current research highlights their ability to optimize glycemic control while improving patient compliance. Although further large-scale clinical studies are required to confirm long-term safety, efficacy, and commercialization potential, chitosan-based linagliptin nanocarriers offer a novel and effective strategy for future antidiabetic therapy, with strong potential to transform diabetes management through enhanced oral and alternative drug delivery approaches.

Acknowledgments: Authors are thankful to Principal Kamla Nehru College of Pharmacy Butibori for providing research facilities.

Conflicts of interest: Authors don't have conflicts of interest.

REFERENCE

1. Guedes EP, Hohl A, De Melo TG, Lauand F. Linagliptin: Phamacology, efficacy and safety in type 2 diabetes treatment. Diabetology& metabolic syndrome. 2013 May 22;5(1):25.
2. Galicia-Garcia, U.; Vicente, A.B.; Jebari, S.; Larrea-Sebal, A.; Siddiqi, H.; Uribe, K.B.; Ostolaza, H.; Martin, C. Pathophysiology of Type 2 Diabetes Mellitus. Int. J. Mol. Sci. 2020, 21, 6275. [CrossRef] [PubMed]
3. Roy, B.; Ehlert, L.; Mullur, R.; Freeby, M.J.; Woo, M.A.; Kumar, R.; Choi, S. Regional Brain Gray Matter Changes in Patients with Type 2 Diabetes Mellitus. Sci. Rep. 2020, 10, 9925. [CrossRef] [PubMed] Polymers 2024, 16, 1825 14 of 15
4. Sun, H.; Saeedi, P.; Karuranga, S.; Pinkepank, M.; Ogurtsova, K.; Duncan, B.B.; Stein, C.; Basit, A.; Chan, J.C.N.; Mbanya, J.C.; et al. Erratum to "IDF Diabetes Atlas: Global, regional and country-level diabetes prevalence estimates for 2021 and projections for 2045". Diabetes Res. Clin. Pract. 2023, 204, 110945.
5. Guedes EP, Hohl A, De Melo TG, Lauand F. Linagliptin: farmacology, efficacy and safety in type 2 diabetes treatment. Diabetology& metabolic syndrome. 2013 May 22;5(1):25.
6. Deacon CF, Holst JJ. Linagliptin, a xanthine-based dipeptidyl peptidase-4 inhibitor with an unusual profile for the treatment of type 2 diabetes. Expert opinion on investigational drugs. 2010 Jan 1;19(1):133-40.
7. Graefe-Mody U, Retlich S, Friedrich C. Clinical pharmacokinetics and pharmacodynamics of linagliptin. Clinical pharmacokinetics. 2012 Jul;51(7):411-27.
8. Abbas A, Eissa NG, El-Bassossy HM, Ghorab MM, El-Nahas HM. Polymeric linagliptin nanoparticles as a sustained release treatment for type 2 diabetes. Journal of Drug Delivery Science and Technology. 2024 Mar 1;93:105438.
9. Sarkar S, Das D, Dutta P, Kalita J, Wann SB, Manna P. Chitosan: A promising therapeutic agent and effective drug delivery system in managing diabetes mellitus. Carbohydrate polymers. 2020 Nov 1;247:116594.
10. Ziebarth J, Mainardes RM. Preparation, characterization and in vitro evaluation of chitosan nanoparticles for the oral delivery of GLP-1 analog liraglutide: J. Ziebarth, RM Mainardes. Journal of Thermal Analysis and Calorimetry. 2023 Mar;148(6):2443-55.
11. Taheriazam A, Entezari M, Firouz ZM, Hajimazdarany S, Heydargoy MH, Moghadassi AH, Motahhary M, Nashtifani AH, Zabolian A, Tabari T, Hashemi M. Eco-friendly chitosan-based nanostructures in diabetes mellitus therapy: Promising bioplatforms with versatile therapeutic perspectives. Environmental research. 2023 Jul 1;228:115912.

12. Ritthidej GC, Pichayakorn W, Kusonwiriyawong C, Lipipun V. Preparation of chitosan nanoparticles for protein delivery by w/o/w emulsion solvent evaporation and simple ionotropic gelation techniques. Solid State Phenomena. 2007 Mar 6;121:751-4.
13. Wu D, Zhu L, Li Y, Zhang X, Xu S, Yang G, Delair T. Chitosan-based colloidal polyelectrolyte complexes for drug delivery: a review. Carbohydrate polymers. 2020 Jun 15;238:116126.
14. Herdiana Y, Febrina E, Nurhasanah S, Gozali D, Elamin KM, Wathoni N. Drug loading in chitosan-based nanoparticles. Pharmaceutics. 2024 Aug 6;16(8):1043.
15. Jafernik K, Ładniak A, Blicharska E, Czarnek K, Ekiert H, Wiącek AE, Szopa A. Chitosan-based nanoparticles as effective drug delivery systems—a review. Molecules. 2023 Feb 18;28(4):1963.
16. Ryu S, Park S, Lee HY, Lee H, Cho CW, Baek JS. Biodegradable nanoparticles-loaded plga microcapsule for the enhanced encapsulation efficiency and controlled release of hydrophilic drug. International journal of molecular sciences. 2021 Mar 10;22(6):2792.
17. El-Tokhy FS, Helal DO, Mageed SS, Mahmoud AM, El-Gogary RI, El-Ghany EA, Abdel-Mottaleb MM. Re-purposing of linagliptin for enhanced wound healing and skin rejuvenation via chitosan-modified PLGA nanoplatforms. International Journal of Pharmaceutics. 2025 May 30;677:125664.
18. Liu M, Wang R, Hoi MP, Wang Y, Wang S, Li G, Vong CT, Chong CM. Nano-based drug delivery systems for managing diabetes: recent advances and future prospects. International Journal of Nanomedicine. 2025 Dec 31:6221-52.
19. Wang Q, Dong X, Castañeda-Reyes ED, Wu Y, Zhang S, Wu Z, Wang Z, Dai L, Xu B, Xu F. Chitosan and sodium alginate nanocarrier system: controlling the release of rapeseed-derived peptides and improving their therapeutic efficiency of anti-diabetes. International Journal of Biological Macromolecules. 2024 Apr 1;265:130713.
20. Caturano A, Nilo R, Nilo D, Russo V, Santonastaso E, Galiero R, Rinaldi L, Monda M, Sardu C, Marfella R, Sasso FC. Advances in nanomedicine for precision insulin delivery. Pharmaceuticals. 2024 Jul 15;17(7):945.
21. Kamble S, Rasala T, Meshram P, Barewar B, Deshmukh N. Design and Characterization of Chitosan-Based Mucoadhesive Nanoparticles for Buccal Delivery of Antidiabetic Drugs. Journal of Pharmaceutical Research and Integrated Medical Sciences. 2025 Aug 29:40-55.
22. Kaviani F, Baratpour I, Ghasemi S. The antidiabetic mechanisms of hesperidin: Hesperidin nanocarriers as promising therapeutic options for diabetes. Current Molecular Medicine. 2024 Dec;24(12):1483-93.
23. Yang JM, Wu LJ, Lin MT, Lu YY, Wang TT, Han M, Zhang B, Xu DH. Construction and evaluation of chitosan-based nanoparticles for oral administration of exenatide in type 2 diabetic rats. Polymers. 2022 May 27;14(11):2181.
24. Júnior FD, Pinheiro AC, Vicente AA, Cunha RL. Development of chitosan/navy bean extract-based nanocarriers for oral delivery of insulin. Food Research International. 2025 Oct 1;218:116876.
25. Shrestha N, Shahbazi MA, Araujo F, Mäkilä E, Raula J, Kauppinen EI, Salonen J, Sarmento B, Hirvonen J, Santos HA. Multistage pH-responsive mucoadhesive nanocarriers prepared by aerosol flow reactor technology: A controlled dual protein-drug delivery system. Biomaterials. 2015 Nov 1;68:9-20.
26. Pardhi E, Bhor Y, Singh PK, Mehra NK. An apprise on novel drug delivery systems for management of diabetes mellitus. Journal of Drug Delivery Science and Technology. 2024 Apr 1;94:105473.
27. Hammad RW, Sanad RA, Abdelmalak NS, Latif R. Architecting novel multilayer nanosponges for co-administration of two drugs managing high-risk type II diabetes mellitus patients suffering from cardiovascular diseases. International journal of biological macromolecules. 2022 Nov 1;220:1429-43.
28. Joshi D, Bhavna. Optimization of Chitosan-wrapped Linagliptin Nanosuspension for Cognitive Enhancement Through Intranasal Route. Nanoscience & Nanotechnology - Asia. 2022 Apr 1;12(2):56-73.
29. Grewal AK, Salar RK. Chitosan nanoparticle delivery systems: an effective approach to enhancing efficacy and safety of anticancer drugs. Nano TransMed. 2024 Dec 1;3:100040.
30. Stefanache A, Lungu II, Anton N, Damir D, Gutu C, Olaru I, PleseaCondratovici A, Duceac M, Constantin M, Calin G, Duceac LD. Chitosan nanoparticle-based drug delivery systems: advances, challenges, and future perspectives. Polymers. 2025 May 23;17(11):1453.
31. Hammad RW, Sanad RA, Abdelmalak NS, Latif R. Cubosomal functionalized block copolymer platform for dual delivery of linagliptin and empagliflozin: Recent advances in synergistic strategies for maximizing control of high-risk type II diabetes. Drug Delivery and Translational Research. 2024 Mar;14(3):678-95.
32. Sangnim T, Dheer D, Jangra N, Huanbutta K, Puri V, Sharma A. Chitosan in oral drug delivery formulations: A review. Pharmaceutics. 2023 Sep 21;15(9):2361.
33. Padole N, Avari J. Synthesis of silver nanoparticles for antibacterial activity against Staphylococcus aureus and Escherichia coli. Asian Journal of Pharmaceutical Research and Development. 2021 Oct 15;9(5):67-73.
34. Vyavahare S, Padole N, Avari J. A review: silver nanoparticles in wound healing. Eur. J. Pharm. Med. Res. 2021;8:212-8.
35. Padole NN, Padole NN. Fundamentals of Acoustics. InHandbook of Vibroacoustics, Noise and Harshness 2024 Dec 18 (pp. 915-950). Singapore: Springer Nature Singapore.
36. Firdous Z, Dhapake P, Padole N, Dhoble N, Baheti J. Different approaches for transdermal nano-carrier delivery system. Research Journal of Topical and Cosmetic Sciences. 2023 Nov 28;14(2):94-104.
37. Yugali C, Pankaj D, Nilakshi D, Nitin P, Jagdish B. Nanotechnology-Enabled Niosomal Nasal Sprays: Unlocking New Therapeutic Avenues for Alzheimer's Disease. Asian Journal of Pharmaceutical Research and Development. 2026 Apr 15;14(2):98-104.
38. Padole NN, Majgavali NV, Meshram MA, Padole NN. Synthesis and characterization of silver nanoparticles by chemical route for potential applications: a review. vol. 2022 Apr;31:2022.
39. Padole NN. Synthesis of silver nanoparticles for antibacterial activity against staphylococcus aureus and escherichia coli. Asian Journal of Pharmaceutical Research and Development. 2022 Apr 15;10(2):29-36.
40. Tijare LK, Deshmukh LT, Mohod AA, Bhandakkar VM, Hore S, Padole NN. Process validation of highly potent Antidiabetic tablets of Voglibose 0.2 Mg. Asian Journal of Pharmaceutical Research and Development. 2022 Apr 16;10(2):90-110.
41. Padole Nitin ,Avari Jasmine, Synthesis and characterization of cefixime loaded silver nanoparticles for antibacterial activity against staphylococcus aureus, Journal of Medical Pharmaceutical and allied sciences.2022 ISSN NO. 2320–7418.