Proceedings of ICMMGH 2027 Symposium: Clinical OMICS for Drug Discovery and Personalized Medicine
DOI: 10.54254/2753-8818/2027.MB37715

Mechanisms and Biomedical Applications of Sustained- and Controlled-Release Drug Delivery Systems

Yinyi Zhang

Shenghua Zizhu Academy, Shanghai, China
idazyy1110@outlook.com

Abstract. Sustained-release and controlled-release drug carriers represent valuable pharmaceutical tools that help boost treatment outcomes while simplifying clinical medication schemes. Unlike conventional immediate-release tablets and capsules, these systems can moderate or adjust how active pharmaceutical ingredients get released inside organisms. Such features extend therapeutic action durations and lower daily dosing frequencies. This review sorts out core definitions and distinguishing traits of sustained-release and controlled-release dosage forms, alongside common product categories and their underlying release mechanisms. Three widely adopted technical solutions are discussed: matrix-type, membrane-coated and osmotic-pump tablet systems. The text addresses their clinical strengths including stable in-vivo drug levels, reduced dosing frequency and enhanced patient adherence. Real-world clinical applications covering cardiovascular illnesses, metabolic syndromes and pain management are also summarized. Collectively, sustained-release and controlled-release technologies offer feasible pathways to optimize drug delivery and therapeutic performance. Further research into novel excipient materials and delivery techniques is likely to achieve more accurate drug release behaviours and expand the scope of clinical use for such formulations.

Keywords: sustained drug release, controlled drug release, drug delivery systems, drug release profiles, matrix-type delivery constructs

1. Introduction

Usually, the oral immediate-release dosage forms release the potency of a drug quickly after administration, causing a sharp fluctuation in drug plasma concentration. Because of this, the drug level in the body may increase quickly and then decrease. Patients may need to take the medicine again when the drug level becomes too low. Sustained-release and controlled-release medicines were developed to improve this problem. Sustained-release systems can make the drug release more slowly and make the drug work for a longer time. Controlled-release systems can control the release of the drug more carefully. Studies have shown that these systems can reduce the number of times patients need to take medicine [1, 2]. In recent years, many new drug delivery methods have been developed. Some common methods include matrix systems, membrane-controlled systems, and osmotic pump systems. Therefore, this paper will introduce the basic concepts, release mechanisms,

© 2026 The Authors. This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (https://creativecommons.org/licenses/by/4.0/).

DOI: 10.54254/2753-8818/2027.MB37715

advantages, clinical applications, problems, and future development of sustained-release and controlled-release drug delivery systems.

2. Basic concepts of sustained-release and controlled-release drug delivery systems

2.1. Basic concept of sustained-release systems

A sustained-release system is a drug-delivery formulation designed to release active ingredients more slowly than conventional immediate-release dosage forms. Traditional fast-release tablets deliver most loaded drug components within a short window and cause sharp increases in in-vivo drug concentrations, followed by concentration drops driven by metabolism and excretion. Sustained-release products ease such drastic concentration shifts and maintain therapeutically effective drug levels for extended periods, cutting down how many times patients need to take medicines every day. Many sustained-release tablets contain specially selected functional excipients. Once swallowed, body fluids penetrate the dosage form gradually and trigger steady drug discharge. Multiple material choices and structural arrangements can slower release rates, for instance polymeric additives, surface coating films and matrix embedding techniques. It should be noted that sustained-release designs do not necessarily aim for absolutely constant release velocities. Their primary goal lies in prolonging release cycles and extending how long therapeutic effects can last [3].

2.2. Basic concept of controlled-release systems

Controlled-release carriers share certain similarities with sustained-release products, yet they place greater emphasis on predictable, well-defined drug-release rates. These properties help sustain blood-stream drug concentrations within valid therapeutic ranges over longer treatment periods and minimise drastic concentration swings. Some controlled-release formulations are engineered to liberate roughly equal drug quantities within fixed time intervals. Several technical routes can realise this objective, such as polymer thin-film barriers, matrix embedding, and osmotic-pump systems. Polymer material properties, dosage-form architecture, and drug solubility all exert influence over release patterns. For these reasons, controlled-release pharmaceuticals demand more thoughtful design work for delivery platforms [2, 4, 5]. In general, both categories of formulations can lengthen drug action periods and lower patient dosing frequency.

2.3. Core differences between sustained-release and controlled-release preparations

Many pharmaceutical textbooks treat sustained-release devices as one subclass falling under the broader controlled-release family; this review adopts a commonly-used comparative approach for introductory explanation. Even though both formulation types seek to improve drug delivery performance, clear practical differences can be observed. Their key distinction originates from divergent design priorities for drug-release behaviors. Sustained-release products mainly work by slowing drug output and extending treatment duration, reducing dosing frequency, and keeping therapeutic effects intact [4]. Even so their release rates do not need to stay completely unchanged. Controlled-release systems may be regarded as an advanced variant of sustained-release technology, focusing on precise tuning of release velocity and discharge patterns. Under ideal circumstances, they deliver drugs following highly foreseeable rhythms across preset timeframes. Formulation development workflows also show visible gaps. Sustained-release products can rely on relatively

DOI: 10.54254/2753-8818/2027.MB37715

simple technical solutions including polymer matrix mixing or surface coating to restrain drug discharge. In contrast, controlled-release preparations often require sophisticated structural designs such as membrane-wrapped reservoir compartments or osmotic-pump components to govern release kinetics [5].

3. Main types and drug release mechanisms

3.1. Mechanism of matrix sustained-release preparations

Matrix-based sustained-release dosage forms represent one mainstream branch of sustained-release delivery technology. In these structures, active ingredients get mixed and dispersed inside polymer substrate materials instead of being stored inside separate inner cavities. When exposed to water or physiological fluids, solvent molecules permeate the matrix and trigger polymer hydration and volume expansion. Hydrophilic polymers such as hydroxypropyl methylcellulose (HPMC) will form gel-type surface layers surrounding tablet bodies. Dissolved drug molecules pass slowly through this gel barrier and diffuse outward into surrounding body fluids. At the same time, gradual polymer erosion further facilitates drug leakage. In short, drug diffusion, polymer swelling and material degradation constitute the three core working mechanisms for matrix-type products. A variety of factors shape release characteristics: polymer types, applied loading amounts, viscosity grades, as well as drug solubility all play their part. Existing research indicates HPMC polymers of different viscosity specifications and dosages can alter release behaviours of matrix tablets, polymer swelling and degradation status are closely linked with drug liberation [6]. Proper polymer screening together with targeted matrix-structure adjustments enables slower drug output and extended therapeutic effects [7].

3.2. Mechanism of membrane-controlled preparations

Membrane-controlled delivery systems adjust drug-release rates through polymer barrier films. Under this structural setup, active substances sit within inner reservoir spaces and are fully enclosed by thin polymer membranes. When exposed to physiological fluids, liquid permeates the inner reservoir and dissolves stored drug substances. Solubilized ingredients then travel across polymer membranes and diffuse outward to external environments. Trans-membrane diffusion, therefore, acts as their primary release pathway. Researchers built reservoir-type delivery devices adopting poly(ε-caprolactone) as barrier layers and investigated multi-drug release behaviours under simulated physiological conditions. Experimental results demonstrated drug molecules pass through poly(ε-caprolactone) barriers via passive diffusion. Membrane thickness, polymer material traits, drug solubility, and molecular dimensions jointly determine release speeds. Thicker barrier layers usually raise diffusion resistance and slow down drug output. By tuning membrane-related parameters, membrane-controlled devices achieve long-lasting and relatively predictable drug release [8].

3.3. Mechanism of osmotic pump controlled-release preparations

Osmotic-pump controlled-release tablets make use of osmotic pressure gradients to achieve regulated drug discharge. Typical osmotic-pump tablets comprise drug-loaded inner cores, semi-permeable barrier membranes, and tiny outlet pores for substance release. After contacting physiological fluids, solvent molecules move across semi-permeable membranes and enter tablet

DOI: 10.54254/2753-8818/2027.MB37715

interiors. Solvent dissolves core-loaded drugs alongside osmotic excipients and builds up high internal osmotic pressure. Rising inner pressure pushes dissolved or suspended drug contents outwards through pre-manufactured small holes and realises prolonged drug liberation. Core osmotic activity, membrane thickness, membrane permeability, drug solubility, and outlet pore dimensions can change release velocities. Adjusting these parameters modifies solvent infiltration rates and overall drug-release performance. One major advantage of osmotic-pump systems lies in their low susceptibility to gastrointestinal environmental shifts including pH variations; certain variants maintain near-constant drug-release rates. This technical approach delivers predictable release profiles and stable therapeutic responses [4].

4. Advantages of sustained-release and controlled-release preparations

4.1. Stable drug concentration and better treatment safety

One major practical benefit brought by sustained-release and controlled-release formulations is stabilized drug concentrations inside blood circulation. Ordinary immediate-release tablets produce sharp concentration peaks after oral intake followed by subsequent declines. Regulated release modes mitigate such dramatic swings [1, 2]. This feature lowers adverse event risks caused by abrupt concentration rises and falls. Steady drug output accordingly improves overall therapeutic safety performance.

4.2. Fewer doses and better medication adherence

These dosage forms also reduce how many daily administrations patients require. Plenty of traditional medicines need multiple intakes every single day, whereas sustained-release options permit less frequent dosing. This benefit carries particular value for patients receiving long-term treatment courses. For antibacterial agents, stable and long-lasting drug concentrations provided by long-acting formulations may lower risks of generating drug-resistant bacterial strains [9].

4.3. Protecting the gastrointestinal tract and reducing local irritation

Massive rapid drug output from conventional tablets may trigger irritation effects on gastric and intestinal mucosal surfaces. Gradual drug discharge cuts instant drug exposure levels within gastrointestinal cavities. For this reason, several sustained-release formulations reduce local mucosal irritation risks [10]. Even so, such protective effects depend heavily on drug properties plus dosage-form architecture, people cannot assume every sustained-release tablet delivers gastrointestinal-protective outcomes.

5. Clinical applications of sustained-release and controlled-release preparations

5.1. Treatment of cardiovascular diseases

Sustained-release and controlled-release formulations possess considerable application value for cardiovascular disease management. Many cardiovascular disorders demand long-term medication, and certain therapeutic agents require repeated daily dosing. Frequent medication creates inconvenience and raises odds of missed doses among patients. Sustained-release technology addresses these practical difficulties through gradual drug discharge and sustained therapeutic effects, improving patient adherence and simplifying clinical treatment workflows. Ivabradine

DOI: 10.54254/2753-8818/2027.MB37715

serves as a typical example, this drug works to reduce heart rate for heart-failure patients. Researchers studied once-daily sustained-release ivabradine among patients diagnosed with reduced-ejection-fraction heart failure. Within a 32-week observation period, participants received either sustained-release ivabradine or placebo treatment. Trial data showed sustained-release ivabradine effectively lowered heart rates and improved selected cardiac-function indicators, relevant heart-failure clinical outcomes and patient quality-of-life metrics also saw improvements. Unlike the original immediate-release ivabradine which required twice-daily intake, this optimised formulation only calls for one daily dose and facilitates long-term patient care. This clinical case illustrates sustained-release technology offers more than simple drug-release deceleration, less frequent dosing, and sustained pharmacological activity, bringing tangible clinical benefits. Formulation development still demands careful fine-tuning, as release behaviours need to match therapeutic targets and patient requirements. On the whole, sustained-release delivery systems show promising prospects for cardiovascularar-disease interventions, especially illnesses requiring extended drug administration [11].

5.2. Treatment of metabolic diseases

Sustained-release delivery platforms show promising potential for managing metabolic illnesses including diabetes. Diabetes treatment generally requires long-term intervention. Repeated injections or frequent oral medication impose burdens and compromise patient adherence. Sustained-release strategies keep in-vivo drug concentrations stable over longer periods and cut down administration frequency. Research teams constructed double-layer sustained-release microneedle patches loaded with exenatide for type-2 diabetes patients (this microneedle device remains at pre-clinical research stage and has not entered routine clinical use). Calcium-alginate and sodium-alginate constitute the microneedle structural bodies. After skin insertion, outer matrix materials dissolve step-by-step, while drug-containing segments stay embedded underneath the skin and release exenatide slowly. Pharmacokinetic test results demonstrated detectable exenatide blood concentrations for roughly 48 hours after one single application, hypoglycemic effects lasted close to 24 hours. This research work demonstrates how sustained-release concepts support diabetes-related therapy. Instead of releasing drugs all at once upon administration, modified formulations achieve gradual substance output and extended therapeutic duration, easing burdens from repeated dosing. Additional research work remains necessary to enhance system stability, safety performance and long-term reliability before large-scale clinical translation [12].

5.3. Treatment with antipyretic, analgesic, and anti-inflammatory medicines

Sustained-release dosage forms also see practical use within antipyretic and analgesic drug categories. Such pharmaceutical substances relieve fever symptoms and physical pain. Ibuprofen acts as a well-known representative compound, delivering analgesic, antipyretic and anti-inflammatory effects. Standard ibuprofen gets absorbed quickly after oral intake, which forces repeated administration to sustain treatment effects. Sustained-release ibuprofen slows drug liberation, extends effective action windows and lowers dosing demands. Investigators compared two different sustained-release ibuprofen capsule products by recruiting healthy Chinese volunteer subjects, assessing their in-vivo absorption profiles and safety conditions. Forty-eight healthy volunteers took part in this trial. Test outcomes revealed both formulations generated comparable blood-concentration change patterns and met bioequivalence assessment standards, which means they produce equivalent in-vivo therapeutic responses. Subjects receiving sustained-release capsules

DOI: 10.54254/2753-8818/2027.MB37715

showed delayed peak-concentration times, reflecting slowed dissolution and absorption processes. No severe adverse safety events appeared throughout the observation phase. This trial validates sustained-release ibuprofen achieves gradual and prolonged drug output while retaining similar absorption characteristics, bringing practical convenience for users through fewer administrations. Nevertheless, this experiment collected data solely from healthy volunteers, further research needs to verify its performance among patient groups suffering from fever or pain symptoms [13].

5.4. Psychiatric and respiratory diseases

Sustained-release and controlled-release drug systems can also support psychiatric and respiratory-disease interventions. Many such medical conditions require long-term medication, and patients need stable drug exposure across extended periods. Regulated-release platforms stabilise in-vivo drug concentrations over longer timeframes and reduce dosing frequency to improve practical usability [4]. Within psychiatric-disease treatment, risperidone represents one suitable candidate for controlled-release formulation development. This antipsychotic compound treats clinical conditions such as schizophrenia. Research teams built lipid-liquid-crystal carriers designed for long-term risperidone release (this lipid-liquid-crystal risperidone preparation has only completed rabbit-animal testing and stays at pre-clinical exploration without formal clinical approval). Researchers ran in-vitro assessments plus rabbit-based animal trials. Optimised formulations maintained risperidone output for approximately 60 days and kept relatively steady blood-drug concentrations during this period, greatly outperforming traditional immediate-release medicines in release duration. This research suggests controlled-release platforms can reduce burdens from repeated medication and raise patient adherence. Mild-to-moderate organ-tissue changes were observed among rabbit-experiment subjects, so follow-up safety evaluation work remains essential. Controlled-release platforms targeting respiratory-system illnesses also attract research attention thanks to their capacity to prolong therapeutic effects and cut intervention frequency. Still more development work is required to build suitable formulations for various respiratory-targeted pharmaceutical substances. Taken together, controlled-release delivery systems hold bright application prospects for chronic-disease management by slowing drug output, extending treatment effects, and simplifying medication routines [14].

6. Current problems

6.1. Limitations in dosage form selection

Even with multiple practical strengths, sustained-release preparations cannot fully replace conventional tablets under all clinical scenarios. For example, certain sustained-release tablet varieties must not be crushed or split, such destructive operations will alter preset drug-release rates. Patients therefore ought to strictly observe medication instructions while using these special-purpose preparations. Despite their various advantages, sustained-release and controlled-release technologies cannot fit every therapeutic agent or delivery mode. Formulation development requires comprehensive evaluation of drug-intrinsic traits alongside dosage-form structural characteristics. Published studies point out drug properties, biomaterial types, administration approaches and compound stability all carry great importance when designing controlled-release delivery platforms. One formulation produces satisfactory outcomes for a particular drug may prove incompatible for other pharmaceutical substances. Careful dosage-form screening is likewise indispensable. Some chemical compounds work well with matrix-type tablet structures, while others require

DOI: 10.54254/2753-8818/2027.MB37715

membrane-wrapped or osmotic-pump-based delivery devices. Drug-related traits including solubility and stability determine whether successful sustained-release product development can be realised. Excessively fast release prevents formulations from delivering long-lasting therapeutic benefits. On the flip side, too-slow drug output leads to insufficient in-vivo drug exposure and fails to reach expected treatment endpoints. Developers need to establish proper matching relationships between active pharmaceutical ingredients and delivery carriers during sustained-release or controlled-release formulation design. Another practical drawback comes from more complex design workflows compared to conventional immediate-release medicines. Multiple raw-material choices and structural setups demand repeated testing to reach ideal release profiles. These factors raise manufacturing complexity as well as quality-control challenges. In summary, not all drug compounds are fit for sustained-release or controlled-release transformation, researchers must assess drug characteristics and dosage-form feasibility before launching formal development projects.

6.2. Individual differences in drug absorption

Drug-absorption behaviours show obvious discrepancies between different patients. Patient age, food intake conditions, and gastrointestinal physiological status can change how medicines get taken up by organisms. Due to such inter-individual variability, identical sustained-release preparations may yield inconsistent therapeutic effects for different subjects, which highlights the need for expanded clinical research. Variations in absorption between individuals constitute one major bottleneck for sustained-release and controlled-release pharmaceutical products. Even with equal administered drugs and identical dose sizes, quantities of substances absorbed into blood circulation differ across test subjects. Age gaps, physical conditions, dietary habits, gastrointestinal environments, and metabolic variations all contribute to such divergence. These variables alter absorption speeds and total absorbed drug amounts and reshape blood-drug concentration levels. This issue gains extra relevance for sustained-release formulations, because their whole design logic relies on extended-duration drug output. Whenever actual in-vivo absorption speeds deviate from pre-set theoretical expectations, real-world blood-drug values will drift away from design-oriented targets. Existing literature indicates drug features plus human physiological contexts influence practical delivery-system performance; the same formulation cannot guarantee fully uniform effects for every subject [4]. Separate research confirmed food consumption modifies sustained-release ibuprofen absorption patterns, blood-concentration magnitudes, and uptake speeds show differences between fasting and post-meal states. Such evidence proves factors outside formulation properties can change in-vivo performance of sustained-release products. Developers and clinical practitioners need to keep inter-subject variability and dietary influences in mind during product design and real-world application. Reasonable dose adjustment and targeted formulation fine-tuning are required to achieve satisfying treatment outcomes across diverse patient groups [13].

6.3. Relatively high production cost

Higher manufacturing costs represent another disadvantage of sustained-release and controlled-release pharmaceutical products. Compared to standard tablet products, these modified dosage forms often need specialised excipient materials and more complicated production workflows. Several formulations make use of polymer additives, custom-made surface-coating layers or functional barrier films to modulate drug output. These special raw materials plus complex processing steps push up overall manufacturing expenses. Product-development cycles also grow longer, research teams have to run repeated tests covering release profiles, shelf-life stability, and

DOI: 10.54254/2753-8818/2027.MB37715

safety indicators. Extra test equipment and experimental workflows further add economic burdens. For these reasons, finished sustained-release and controlled-release pharmaceutical goods generally carry higher market prices relative to ordinary dosage forms. Although these advanced preparations bring tangible merits such as extended therapeutic duration and reduced dosing frequency, their high-cost nature still creates real-world obstacles. Looking ahead, adopting low-cost raw-material sources alongside optimised production workflows may help lower relevant economic expenditures.

6.4. Risk of burst release

Sudden large-scale early-phase drug leakage counts as one critical hidden risk for sustained-release and controlled-release delivery devices. This phenomenon refers to scenarios where large quantities of active ingredients escape rapidly at the initial in-vitro or in-vivo stage, instead of being released gradually across extended time periods. Such occurrences trigger sharp rises in in-vivo drug concentrations and increase odds of adverse side effects. Premature drug discharge also shortens the time window where formulations sustain stable drug levels. Drug-substance dispersion status, polymer traits, material porosity, and manufacturing techniques all affect the emergence of burst-release risks. Regulating early-stage release kinetics therefore carries great significance for improving safety performance, storage stability, and therapeutic effectiveness of sustained-release drug carriers [15].

7. Conclusion

7.1. Research summary

This review covers fundamental definitions, release mechanisms, practical merits, clinical uses, and existing constraints of sustained-release and controlled-release pharmaceutical preparations. Sustained-release formulations focus on slowing drug-release rates and extending therapeutic durations, whereas controlled-release variants emphasise accurate tuning of release velocity and discharge patterns. Three typical delivery architectures have been illustrated: matrix-type, membrane-controlled, and osmotic-pump-based systems, each relying on distinct physicochemical mechanisms to govern drug output. Matrix-based devices mainly work through polymer swelling, substance diffusion and material erosion; osmotic-pump systems drive drug discharge by taking advantage of osmotic-pressure gradients. These modified pharmaceutical products deliver multiple practical advantages: prolonged therapeutic action, reduced dosing frequency, and stabilised blood-drug concentrations. Less-frequent medication also improves patient adherence. Under certain circumstances, they can mitigate mucosal-irritation risks brought by local high-concentration drug exposure. This paper also summarises their application within cardiovascular-disease therapy, metabolic-disorder management, fever-pain symptom treatment, and psychiatric-disease interventions. Even so multiple limitations remain. Not every pharmaceutical agent can be transformed into sustained-release or controlled-release products, inter-individual physiological differences interfere with real-world drug-absorption performance. Moreover, their production workflows turn out more complicated and cost-demanding compared with traditional immediate-release dosage forms. All things considered, sustained-release and controlled-release delivery systems hold huge development potential for optimising drug delivery and therapeutic outcomes. Their practical strengths make them well-suited for numerous chronic-disease-treatment scenarios, future product iterations still demand balanced consideration of safety guarantees, therapeutic reliability and manufacturing-cost constraints.

DOI: 10.54254/2753-8818/2027.MB37715

7.2. Future development

Real-world advances for next-generation sustained-release and controlled-release preparations will pursue higher release precision and better clinical practicality. One important research direction explores novel polymer excipients that support more subtle tuning of drug-release behaviours. Research teams are also working on stimulus-responsive delivery platforms that react to changes in internal physiological conditions including pH shifts or temperature fluctuations, releasing therapeutic substances when biological requirements actually arise. Another major development goal lies in enhancing release accuracy. Well-designed controlled-release systems ought to deliver appropriate drug quantities at suitable time points, lower blood-concentration swings, and improve clinical treatment effects. Innovative manufacturing technologies may simplify production procedures and cut total production costs. In addition, follow-up research should place more emphasis on safety evaluation and inter-individual-variability-related challenges. Since drug-absorption and bodily-response patterns differ across patient populations, delivery-system design will gradually incorporate individual-specific clinical requirements. On the whole, future technical progress for sustained-release and controlled-release drug-delivery frameworks will focus on improved release-regulation accuracy, strengthened safety performance, reduced production costs, and the realisation of individualised therapeutic schemes.

References

[1] Sun, L., Xie, B., & Xu, Y. (2024). Research progress of sustained and controlled release preparations of Chinese medicine. *Chinese Journal of Pharmacovigilance, 21*(8), 949–954. https://doi.org/10.19803/j.1672-8629.20240249

[2] Swarnalatha, K. M., Iswariya, V. T., Akash, B., Bhandari, S., Shirisha, R., & Ramarao, T. (2024). A comprehensive review of controlled drug release delivery systems: Current status and future directions. *International Journal of Pharmaceutical and Phytopharmacological Research, 14*(2), 24–30. https://doi.org/10.51847/d6pncGCouf

[3] Joshi, P., Rao, G. S. N. K., & Chatterjee, B. (2024). Scope and application of hot melt extrusion in the development of controlled and sustained release drug delivery systems. *Current Pharmaceutical Design, 30*(32), 2513–2523. https://doi.org/10.2174/0113816128299356240626114734

[4] Adepu, S., & Ramakrishna, S. (2021). Controlled drug delivery systems: Current status and future directions. *Molecules, 26*(19), 5905. https://doi.org/10.3390/molecules26195905

[5] Song, Q., Jiang, C., Wang, C., Zhou, L., Han, Z., Sun, N., Huang, P., & Wang, D. (2022). Preparation and in vitro evaluation of osmotic-pump lorcaserin-hydrochloride controlled-release tablets. *Chemical and Pharmaceutical Bulletin, 70*(3), 202–210. https://doi.org/10.1248/cpb.c21-00788

[6] Park, C., Lee, J. H., Jin, G., Ngo, H. V., Park, J.-B., Tran, T. T. D., Tran, P. H. L., & Lee, B.-J. (2022). Release kinetics of hydroxypropyl methylcellulose governing drug release and hydrodynamic changes of matrix tablet. *Current Drug Delivery, 19*(5), 520–533. https://doi.org/10.2174/1567201818666210820101549

[7] Hirun, N., & Kraisit, P. (2022). Drug-polymers composite matrix tablets: Effect of hydroxypropyl methylcellulose (HPMC) K-series on porosity, compatibility, and release behavior of the tablet containing a BCS class I drug. *Polymers, 14*(16), 3406. https://doi.org/10.3390/polym14163406

[8] Li, L., Lee, C., Cruz, D. F., Krovi, S. A., Hudgens, M. G., Cottrell, M. L., & Johnson, L. M. (2022). Reservoir-style polymeric drug delivery systems: Empirical and predictive models for implant design. *Pharmaceuticals, 15*(10), 1226. https://doi.org/10.3390/ph15101226

[9] Li, W., Tang, J., Lee, D., Tice, T. R., Schwendeman, S. P., & Prausnitz, M. R. (2022). Clinical translation of long-acting drug delivery formulations. *Nature Reviews Materials, 7*, 406–420. https://doi.org/10.1038/s41578-021-00405-w

[10] Drapińska, P., Skulmowska-Polok, K., Chałupka, J., & Sikora, A. (2025). Sustained-release oral delivery of NSAIDs and acetaminophen: Advances and recent formulation strategies—A systematic review. *Pharmaceutics, 17*(10), 1264. https://doi.org/10.3390/pharmaceutics17101264

[11] Ye, F., Wang, X., Wu, S., Ma, S., Zhang, Y., Liu, G., et al. (2022). Sustained-release ivabradine hemisulfate in patients with systolic heart failure. *Journal of the American College of Cardiology, 80*(6), 584–594. https://doi.org/10.1016/j.jacc.2022.05.027

DOI: 10.54254/2753-8818/2027.MB37715

[12] Liu, H., Zhang, S., Zhou, Z., Xing, M., & Gao, Y. (2022). Two-layer sustained-release microneedles encapsulating exenatide for type 2 diabetes treatment. *Pharmaceutics, 14*(6), 1255. https://doi.org/10.3390/pharmaceutics14061255

[13] Huang, C., Yin, Z., Yang, Y., Mo, N., Yang, H., & Wang, Y. (2023). Evaluation of pharmacokinetics and safety with bioequivalence of ibuprofen sustained-release capsules of two formulations, in Chinese healthy volunteers: Bioequivalence study. *Drug Design, Development and Therapy, 17*, 1881–1888. https://doi.org/10.2147/DDDT.S404756

[14] Rezaeian Shiadeh, S. N., Khodaverdi, E., Faal Maleki, M., Eisvand, F., Boujaran, H., Zarei, H., Vosooghi, R., Hadizadeh, F., & Kamali, H. (2022). Lipid-liquid crystals for 2 monthscontrolled risperidone release: In-vitro evaluation and pharmacokinetics in rabbits. *International Journal of Pharmaceutics, 618*, 121649. https://doi.org/10.1016/j.ijpharm.2022.121649

[15] Bhattacharjee, S. (2021). Understanding the burst release phenomenon: Toward designing effective nanoparticulate drug-delivery systems. *Therapeutic Delivery, 12*(1), 21–36. https://doi.org/10.4155/tde-2020-0099