Available online on http://www.ijhacr.com

International Journal of Health Advancement and Clinical Research (tz) 2024; 2(4); 24-28

Review Article

Sustained Release Matrix Tablets: A Comprehensive Review

Chandan Kumar [1], Vijay Sharma [2], N Ravindra [3], Virender Singh [4]

[1] Research Scholar, Goenka College of Pharmacy, Lachhmangarh, Sikar.
[2] Professor, Goenka College of Pharmacy, Lachhmangarh, Sikar.
[3] Principal and Professor, Goenka College of Pharmacy, Lachhmangarh, Sikar.
[4] Assistant Professor, Goenka College of Pharmacy, Lachhmangarh, Sikar.

Received: 05-10-2024 / Revised: 07-11-2024 / Accepted: 06-12-2024
Corresponding author: Chandan Kumar
Conflict of interest: Nil

Abstract:

Sustained release matrix tablets have emerged as a reliable drug delivery system designed to achieve controlled and prolonged therapeutic effects. By regulating drug release over an extended period, these formulations improve patient compliance, reduce dosing frequency, and maintain stable plasma drug concentrations. The matrix system, often composed of hydrophilic, hydrophobic, or inert materials, serves as the backbone for modulating release rates. This review explores the need for sustained release systems, various preparation methods, different polymers that can be used like hydrophilic polymers, hydrophobic polymers, inert polymers and natural polymers and materials used in formulating sustained release matrix tablets. It also discusses challenges, future prospects, and the potential role of advanced technologies in improving drug delivery efficiency.

Keywords: Sustained release matrix tablets, prolonged therapeutic effects, plasma drug concentrations, hydrophilic polymers, hydrophobic polymers.

Introduction

In pharmaceutical sciences, the goal is to develop formulations that provide optimal therapeutic outcomes while minimizing side effects. Sustained release (SR) formulations, including matrix tablets, are engineered to maintain steady drug levels in the systemic circulation, overcoming the limitations of conventional immediate-release forms. Matrix tablets are among the simplest and most cost-effective approaches for sustained drug delivery, leveraging physical and chemical properties of polymers to control drug diffusion. [1]

Need for Sustained Release Systems

The primary objective of sustained release systems is to overcome the drawbacks of conventional dosage forms, such as:

Frequent Dosing: Immediate-release formulations often require multiple doses daily, which can reduce patient adherence.

Fluctuating Plasma Levels: Traditional forms may cause peaks and troughs in plasma drug concentration, leading to suboptimal therapeutic effects or side effects. [2]

Improved Efficacy and Safety: Sustained release systems maintain drug levels within the therapeutic window for extended periods, enhancing efficacy and reducing toxicity.

Enhanced Patient Compliance: Reduced dosing frequency improves patient adherence, particularly for chronic diseases.

Minimized Side Effects: Controlled

release ensures gradual drug absorption, minimizing abrupt side effects. [3,4]

Polymers Used in Sustained Release Matrix Tablets

Polymers play a critical role in formulating sustained release matrix tablets, as they govern the release rate and mechanism of the drug. The choice of polymer depends on the physicochemical properties of the drug, the desired release profile, and the intended route of administration. Polymers can be classified into three main categories: hydrophilic, hydrophobic, and inert.

Hydrophilic Polymers

Hydrophilic polymers are widely used for sustained release formulations due to their ability to form a gel-like barrier upon contact with gastrointestinal fluids. This barrier regulates the diffusion of the drug, providing controlled release. Common hydrophilic polymers include hydroxypropyl methylcellulose (HPMC), carbopol, sodium alginate, and guar gum. HPMC is particularly popular for its versatility, as different grades can be used to achieve varying release rates. Sodium alginate, derived from seaweed, is biodegradable and forms a viscous gel in aqueous media, making it suitable for sustained release applications. Hydrophilic polymers are typically used in drugs that require prolonged release in aqueous environments. [5]

Hydrophobic Polymers

Hydrophobic polymers act by forming an insoluble matrix that slows down drug release primarily through diffusion. These polymers are particularly useful for drugs that are highly water-soluble, as they prevent rapid dissolution and burst release. Examples include ethyl cellulose, polyvinyl acetate, and carnauba wax. Ethyl cellulose is a versatile polymer that can be used in both matrix and coating systems for sustained release. Carnauba wax, a natural polymer, is used in melt granulation techniques to form a hydrophobic barrier around drug particles. The release rate in hydrophobic systems can be modulated by varying the polymer concentration or combining it with other polymers.

Inert Polymers

Inert polymers, also known as non-erodible polymers, maintain their structure throughout the release period, relying on diffusion for drug release. These polymers do not dissolve or degrade in the gastrointestinal tract. Polyethylene oxide (PEO) and polymethacrylate derivatives (e.g., Eudragit) are commonly used inert polymers. Eudragit polymers offer a wide range of functionalities, such as pH-dependent release, which allows site-specific drug delivery. These polymers are particularly useful in formulating tablets that need to remain intact in acidic environments while releasing the drug in the intestines. [6]

Natural Polymers

Natural polymers like xanthan gum, chitosan, pectin, and locust bean gum have gained attention due to their biocompatibility, biodegradability, and low toxicity. Xanthan gum and pectin are used in hydrophilic matrix systems, while chitosan, a cationic polymer, is suitable for pH-sensitive drug delivery. Natural polymers are often combined with synthetic polymers to improve mechanical strength and control release profiles. [7]

The choice of polymer and its concentration directly influence the drug release mechanism, which could be diffusion-controlled, erosion-controlled, or a combination of both. By optimizing the polymer type and formulation technique, sustained release matrix tablets can be designed to meet therapeutic needs and enhance patient compliance.

Different Methods to Prepare Sustained Release Matrix Tablets

Several approaches are employed in developing sustained release matrix tablets, depending on the drug properties and

desired release profile:

Direct Compression

Direct compression is a straightforward and cost-effective method for preparing sustained release matrix tablets. In this process, the active pharmaceutical ingredient (API) is mixed with excipients, primarily polymers, which form the matrix. The mixture is then directly compressed into tablets using a tablet press. This method is suitable for drugs with good flow and compressibility properties. Polymers such as hydroxypropyl methylcellulose (HPMC), ethyl cellulose, and polyvinyl alcohol are commonly used as matrix-forming agents. Direct compression avoids the use of solvents or heat, making it ideal for moisture-sensitive and thermolabile drugs. However, achieving uniform drug distribution and maintaining tablet hardness can sometimes be challenging, requiring precise formulation optimization. [8]

Wet Granulation

Wet granulation involves blending the drug and excipients with a liquid binder to form granules, which are then dried and compressed into tablets. This method enhances the flowability and compressibility of the drug-polymer mixture, ensuring uniform drug content in the matrix tablets. The binder, such as povidone, starch paste, or hydroxypropyl cellulose, plays a crucial role in binding the particles together. The polymers used in wet granulation can include hydrophilic or hydrophobic materials, depending on the desired release profile. While wet granulation provides better mechanical strength to the tablets, it requires additional steps and equipment, making it a more time-consuming and cost-intensive process compared to direct compression. [9]

Melt Granulation

Melt granulation is a solvent-free technique in which a polymeric binder is melted and mixed with the drug and excipients to form granules. The molten binder acts as a granulating agent, eliminating the need for water or organic solvents. Hydrophobic polymers such as glyceryl monostearate, carnauba wax, or polyethylene glycol (PEG) are commonly used. The granules are then cooled, sieved, and compressed into tablets. Melt granulation is particularly useful for preparing sustained release formulations with hydrophobic matrix systems. It also avoids issues related to solvent removal, making it a relatively eco-friendly method. However, the use of heat can limit its application for thermolabile drugs. [10]

Spray Drying

Spray drying is a method that involves dissolving or dispersing the drug and polymer in a suitable solvent, followed by atomization of the solution into a heated drying chamber. The solvent rapidly evaporates, leaving behind fine granules or powder containing the drug encapsulated within the polymer matrix. These granules are subsequently compressed into tablets. Spray drying offers precise control over particle size and distribution, which is critical for achieving a consistent release profile. Polymers like polyvinyl alcohol, cellulose derivatives, and acrylic resins are commonly used. Despite its advantages, spray drying is a resource-intensive method requiring specialized equipment and careful handling of solvents.

Hot-Melt Extrusion

Hot-melt extrusion (HME) is a process where the drug and polymers are melted and mixed under heat and pressure to form a homogenous dispersion. The mixture is then extruded into a desired shape, cooled, and milled into granules for tablet compression. This method is particularly suitable for poorly water-soluble drugs, as it can improve their solubility and bioavailability. Polymers such as ethyl cellulose, polyethylene oxide, and HPMC are commonly used. HME provides uniform drug distribution and eliminates the need for solvents, making it

environmentally friendly. However, its application is limited by the high temperatures involved, which can degrade heat-sensitive drugs. [11,12]

Coating Techniques

Coating techniques involve applying a polymer layer over an immediate-release core tablet to control drug release. The coating material can be hydrophilic, hydrophobic, or pH-sensitive, depending on the intended release profile. Techniques such as fluidized bed coating, dip coating, or pan coating are commonly used. Polymers like ethyl cellulose, Eudragit, or HPMC are frequently employed. Coated matrix tablets are especially useful for achieving delayed or pulsatile drug release. However, the coating process requires specialized equipment and precise control of parameters to ensure uniformity and reproducibility, which can increase manufacturing costs. [13]

Ion Exchange Resins

In this method, the drug is bound to ion-exchange resins to create a drug-resin complex. The drug is released in response to changes in the ionic environment, such as pH or electrolyte concentration, during its passage through the gastrointestinal tract. The resins act as a matrix system, ensuring sustained drug release. This approach is particularly advantageous for drugs that are sensitive to enzymatic degradation or have narrow absorption windows. While ion-exchange systems offer precise release control, they require thorough formulation optimization to ensure stability and reproducibility.

Future Aspects

The future of sustained release matrix tablets is intertwined with advancements in material sciences, computational modeling, and nanotechnology:

Smart Polymers: Development of stimuli-responsive polymers that release drugs in response to specific triggers like pH, temperature, or enzymes. [14]

3D Printing: Customizable drug formulations using 3D printing to produce matrix tablets with complex geometries and layered designs for precise drug release.

Nanotechnology Integration: Incorporating nanocarriers within matrix systems to improve bioavailability and target-specific delivery.

Green Manufacturing: Use of eco-friendly and sustainable materials, along with solvent-free preparation techniques, to minimize environmental impact.

Artificial Intelligence (AI) in Formulation Design: Predictive algorithms to optimize drug release profiles and accelerate the development process.

Personalized Medicine: Tailoring sustained release formulations to meet individual patient needs based on genetic, metabolic, or disease-specific factors. [15]

Conclusion

Sustained release matrix tablets represent a cornerstone in modern pharmaceutical formulations, addressing the challenges of conventional drug delivery systems. By enabling prolonged and controlled drug release, these systems enhance therapeutic efficacy, improve patient compliance, and minimize side effects. While challenges such as scaling up production and polymer compatibility remain, advances in technology and materials hold immense potential to refine and expand their applications. As the field evolves, sustained release matrix tablets will continue to play a pivotal role in achieving precision and efficiency in drug delivery systems.

References

1. Ravi Sharma, Mayank Bansal, Alok Garg, Vikas Agarwal, & Deeksha Sharma. (2023). Formulation and Evaluation of Sustain Release Matrix Tablet of Aceclofenac. International Journal of Health Advancement and Clinical Research (tz), 1(1), 6-11.
2. Ashwani Singh, Mayank Bansal, Vikas,

Rakesh Kumar Gupta, & Deeksha Sharma. (2023). Formulation and Evaluation of Enteric Coated Tablet of Aceclofenac. International Journal of Health Advancement and Clinical Research (tz), 1(1).01-05.

3. Kumar, M., Singh, D. and Chaudhary, V., 2022. Formulation and Characterization of Sustained Release Matrix Tablet of Pantoprazole. EAS J. Pharm. Pharmacol., 990, pp.64-69.
4. Lachman L, Lieberman H, Kanig J. The Theory and
5. Practice of Industrial Pharmacy.3rd ed. Verghese
6. publishing house.Bombay; 1990.141.
7. Rao NG, Raj K, Nayak BS. Review on Matrix Tablet as Sustained Release. International Journal of Pharmaceutical Research & Allied Sciences. 2013 Jul 1;2(3).
8. Dikshit MK, Sharma V, Singh V. A Review on Sustained Release Matrix Tablets. International Journal of Health Advancement and Clinical Research (tz). 2023 Oct 30;1(4):76-9.
9. Bhagat VC, Awate PB, Kardile DP, Pawar OP, Shete RV, Bichukale AD, Raut JM, Mane SR. A Review on Sustained Release Drug Delivery and Sustained Release Matrix Tablets. Journal of Coastal Life Medicine. 2023 May 29;11:1174-90.
10. Kumar Sampath, K. P., Bhowmik, D., & Srivastava, S. (2010). Sustained release drug delivery system potentials. International Journal of Pharmaceutics, 2, 751–754.
11. Andrade C. Sustained-release, extended-release, and other time-release formulations in neuropsychiatry. The Journal of clinical psychiatry. 2015 Aug 26;76(8):20558.
12. Alhalmi A, Altowairi M, Saeed O, Alzubaidi N, Almoiliqy M, Abdulmalik W. Sustained release matrix system: an overview. World J Pharm Pharm Sci. 2018 Apr 17;7(6):1470-86.
13. Ratilal D and Priti DG: An overview on sustained release drug delivery system. International Journal of Research and Applied Pharmaceutics 2011; 1701-08.
14. Kumar P and Kijjal R: Novel oral sustained release drug technology: a concise review. International Journal of Research and Development Pharmaceutical Sciences 2013; 2: 262-69.
15. Wadher, G., Satish, B., & Tukaram, M. K. (2013). Recent (Aspects) trend on Sustained drug delivery system. International Journal of Chemical and Pharmaceutical Sciences, 4, 1–7.