VOLUME 11 ISSUE 1 2025

ISSN 2454 – 3055

INTERNATIONAL JOURNAL OF ZOOLOGICAL INVESTIGATIONS

Forum for Biological and Environmental Sciences

Published by Saran Publications, India

International Journal of Zoological Investigations Vol. 11, No. 1, 655-660 (2025)

International Journal of Zoological Investigations
Contents available at Journals Home Page: www.ijzi.net
Editor-in-Chief: Prof. Ajai Kumar Srivastav
Published by: Saran Publications, Gorakhpur, India

ISSN: 2454-3055

Formulation of Osmotic Drug Delivery Systems: A Review

Gaikwad Sanjana[1]*, Lonare Manish[2], Mahajan Renuka[1], Sharma Jay[3] and Diksha Gabhane[4]

[1]Nagpur College of Pharmacy, Wanadongri Nagpur 441110, Maharashtra, India
[2]Department of Chemical Engineering, Higher and Technical Education Department, Government of Maharashtra, Wardha 442201, Maharashtra, India
[3]Tayawade College of Pharmacy, Koradi Road, Nagpur 441111, Maharashtra, India
[4]Department of IT, Yeshwantrao Chavan College of Engineering Wanadongri Nagpur 441110, Maharashtra, India

**Corresponding Author*

Received: 2nd July, 2024; **Accepted:** 22nd November, 2024; **Published online:** 11th May, 2025
https://doi.org/10.33745/ijzi.2025.v11i01.070

Abstract: Oral drug delivery is the most predominant drug delivery system and for chronic diseases and dose related issues dose attainment osmotic drug delivery systems play keyrole in reduction of repeated administration. The osmotic delivery system consists of an osmotic core containing drug, an osmogen surrounded by a semipermeable membrane with or without an aperture. A system with constant internal volume delivers a volume of saturated solution equal to the volume of solvent uptake at any given time interval. Excess solid present inside a system ensures a constant delivery rate of solute. These parameters of osmotic drug delivery may prove beneficial in designing of dosage form for modification in drug release of various drugs who have limitations in conventional form.

Keywords: Osmotic drug delivery, Components, Formulation, Osmotic agents

Citation: Gaikwad Sanjana, Lonare Manish, Mahajan Renuka, Sharma Jay and Diksha Gabhane: Formulation of osmotic drug delivery systems: A review. Intern. J. Zool. Invest. 11(1): 655-660, 2025.

https://doi.org/10.33745/ijzi.2025.v11i01.070

Introduction

Novel drug delivery system is the prime area for industrial as well as academic research**.** Recently massive advances are in progress befitting the area of controlled drug delivery system. This in part is due to evolving disciplines of biopharmaceutics, pharmacokinetics and pharmacodynamics. In a particular therapeutic regimen, the drug dose and the dosing interval are optimized to attain required therapeutic window, drug efficacy and minimum toxic side effects. It is fact that daily dosing of two or more dosage units greatly affects the compliance by patient (Parmar *et al.*, 2004) Hence, the primary objective of system is to deliver a pharmacologically active agent in predetermined, predictable and reproducible manner and maintain drug concentration within therapeutic window, this would improve patient's compliance to dosage regimen. It would also

improve the efficacy with simultaneous reduction in toxic side effects (Jerzewski and Chien, 1992)

Many technologies have been appointed to get through the control of the systemic delivery of drug viz. extended drug delivery system, targeted drug delivery system, pulsatile drug delivery system etc, Majority of these drug delivery systems fall in category of matrix, reservoir and osmotic system. The matrix type embeds drug in polymer matrix and release occurs via partitioning of drug polymer matrix and release medium. While in reservoir systems the drug core is surrounded or coated with rate controlling membrane. There are several factors like pH, food and many physiological factors that affects the drug release from conventional controlled drug delivery system. This system depends on osmotic pressure for delivery of drugs. However, drug is released independent of pH and other physiological parameters (Verma and Garg, 2002).

The obvious advantage of osmotic pressure based delivery systems is the near ideal zero order release pattern of the drug candidate, which is due to the fact that osmotic pressure is a colligative property i.e. it depends on number of solute species (Martin *et al*., 1993) (neutral molecule or ionic species). In 1974, Theeuwes and Higuchi (1974) used this principle of osmotic pressure to formulate new generation of controlled drug delivery systems. These systems have some features in common but some of the features are exclusive to the design.

Formulation of osmotic drug delivery system:

The osmotic delivery system consists of an osmotic core containing drug, an osmogen surrounded by a semipermeable membrane with or without an aperture. A system with constant internal volume delivers a volume of saturated solution equal to the volume of solvent uptake at any given time interval. Excess solid present inside a system ensures a constant delivery rate of solute. The rate of delivery most of times follow the zero order kinetics and decreases when the solution concentration falls below saturation. The solute delivery rate from the system is controlled by solvent influx through the semipermeable membrane.

The osmotic delivery system includes following formulation ingredients:

- Drug candidate
- Osmotic agent
- Semipermeable membrane (coating polymer)
- Wicking agent
- Solublizing agent
- Coating solvent
- Flux regulating agents
- Plasticizer
- Pore forming agents

(i) *Drug*: The kinetics of osmotic release is directly related to solubility of drug within core table. Both highly soluble and poorly soluble drug are not good candidate for osmotic delivery (Verma and Garg, 2002).

(ii) *Osmotic agent* (*osmogen*): Ionic compounds consisting salts, sugar and hydrophilic polymers are used as osmogens (Fig.1). Table 1 enlists various osmogens with osmotic pressure values of their saturated solutions.

(c) *Semipermeable membrane* (*coating polymer*):

The polymeric membrane important for osmotic delivery formulation and should have following characteristics (Eckenhoff *et al.*, 1987):

- It should be stable with the outer as well as the inner environment of the device.
- Should be rigid for maintaining dimensional integrity
- Should be impermeable to the contents of dispenser to prevent get through of osmogen by diffusion.

Numerous polymers are currently available to form semipermeable membrane. One of its type includes cellulosic polymers such as cellulose

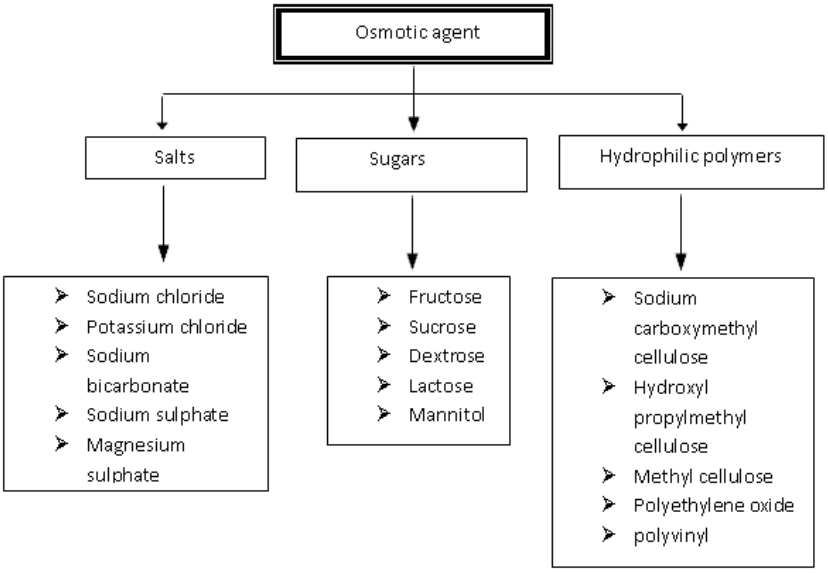

Fig.1: Classification of osmotic agents.

Table 1: Osmotic pressure values of saturated solutions of osmogens (Lakshminarayanaiah, 1969)

S. No.	Solute or Mixture	Osmotic pressure (atm)
1	Sodium phosphate monobasic	28
2	Sodium phosphate dibasic	31
3	Sodium phosphate tribasic	36
4	Mannitol	38
5	Potassium sulphate	39
6	Dextrose	82
7	Mannitol-lactose	130
8	Sucrose	150
9	Mannitol-sucrose	170
10	Dextrose-sucrose	190
11	Lactose-dextrose	225
12	Mannitol-dextrose	225
13	Potassium chloride	245
14	Lactose- sucrose	250
15	Fructose	355
16	Sodium chloride	356
17	Mannitol- fructose	415
18	Sucrose-fructose	430
19	Dextrose- fructose	450
20	Lactose –fructose	500

ethers, cellulose esters and cellulose ester-ethers. The cellulosic polymers have a degree of substitution (DS) of 0 to 3 on the anhydroglucose unit. The DS is number of hydroxyl groups present on the anhydroglucose unit being replaced by substituting group. Examples of this group include cellulose acylate, cellulose diacetylase, cellulose triacetylate, cellulose acetate, cellulose diacetate, and mono-, di-, and tri-cellulose alkynylates.

Cellulose acetate is available in different grades, such as cellulose acetate (DS of 1 to 2, an acetyl content of 21 to 35 %) or cellulose acetate (acetyl content of 32 to 39.8%). Other forms of cellulose polymers with a more specific

substitution are cellulose propionate with DS of 1.8, a propyl content of 39.2 to 45 % and a hydroxyl contact of 13 to15% and a butyrate content of 34 to 39 %. Moreover, the semipermeable membrane may consist of mixture of cellulose acetates, alkanylates, or acrylates with different degrees of substitution. Generally, in osmotic pumps, the semipermeable membrane must be 200-300 microns thick to withstand the pressure within the device (Santus and Baker, 1995).

Additional semipermeable membrane forming polymers are from the group consisting of acetaldehyde dimethyl cellulose acetate, cellulose acetate, cellulose acetate ethyl carbamate, cellulose dimethyl amino acetate, semipermeable polyamides, semipermeable polyurethanes, or semipermeable sulfonated polystyrenes. Semi-permeable cross-linked selectively permeable polymers formed by co-precipitation of poly anion and a poly cation also can be used for these purpose (Dong *et al.*, 1993). Numerous polymer materials like lightly cross-linked polystyrene derivative, semipermeable cross-inked poly (sodium styrene sulfonated), and semipermeable poly (viny benzyl triethyl ammonium chloride) may be considered (Loeb and Sourirajan, 1964).

Selection criteria for membrane polymen (*Singla, 2021*):

- The material whose reflection coefficient as close as possible to one.
- Relatively high water permeability for maintaining water flux (Table No.2)
- Sufficient wet strength and good dimensional stability is suitable as membrane
- Biocompatibility and biodegradability

(d) *Wicking agent*:

These are either swellable or non swellable porous materials with ability to draw water also known as physiosorption. Physiosorption is the form of absorption in which the solvent molecules can loosely adhere to surfaces of the wicking agent via Vander Waals interactions between the surface of the wicking agent and the absorbed molecule. The main role of the wicking agent is to carry water to the surfaces inside the core of the tablet and create channels or a network with increased surface area. For bioactive agents with low solubility in water, the wicking agent aids in the delivery of partially solubilized bioactive agent through the passageway in the semipermeable coating. Materials, which suitably act as wicking agents include colloidal silicon dioxide, kaolin, titanium dioxide, alumina, niacin amide, sodium lauryl sulfate, low molecular weight poly (vinyl Pyrrolidone), m-pyrol, bentonite.

(e) *Solubilizing agent*:

Non swellable solubilizing agents are classified into three groups:

- Substance which inhibit crystal formation of the drugs or which cause complexation with the drugs (e.g. PVP, PEG 8000, α, β, ɣ - cyclodextrin)
- A high HLB micelle-forming surfactant, particularly anionic surfactants (e.g. Tween 20, 60 and 80, poly oxyethylene or poly ethylene containing surfactants and other long chain anionic surfactants such as Sodium lauryl sulfate)
- Citrate esters and their combinations with anionic surfactants (e.g. alkyl esters particularly triethyl citrate)

(f) *Coating solvent*:

These are the solvents used for dissolution coating membrane polymer. They include inert inorganic and organic solvents that do not adversely harm the core, wall and other materials. The typical solvents are methylene chloride, acetone, methanol, ethanol, isopropyl alcohol, butyl alcohol, ethyl acetate, cyclohexane, carbon tetrachioride, water, etc. Moreover, the solvent mixtures such as acetone- methanol (80:20), acetone-ethanol (80:20), acetone-water (90: 10), methylene chloride-methanol (79:21), methylene chloride-methanol-water (75:22:3) can also be used.

(f) *Flux-regulating agent*:

Flux regulating agents are added to the coating membrane to assist regulation of fluid permeability of flux through the membrane. They also increase the flexibility and porosity of the membrane.[8] The examples are both hydrophilic (viz. Polyethylene glycols, polyhydric alcohols) and hydrophobic polymers (viz. diethyl phthalate).

(g) *Plasticizer*:

Lower temperature of the second order phase transition of the coating membrane or the elastic modulus of the membrane also increase the workability, flexibility and permeability of the fluids. For this, a plasticizer or mixtures of plasticizer (0.001-50 parts per 100 parts of membrane) are embibed in the membrane. They comprise of Phthalates (dibenzyl, dihutyl), triacetin, alkyl adipates, citrates and glycolates. They maintain flexibility of coating membrane.

(h) *Pore forming agent*:

Particularly used in the osmotic pumps developed for poorly water soluble drugs or for the development of controlled porosity or multi particulate osmotic pumps. They make channels for transport of fluids. They cause *in situ* formation of micro porous membrane due to their leaching during the operation of the system. The pores formation in the membrane be achieved by gas formation due to chemical reaction within the coating polymer solutions which results in voids in the film of membrane. Yet another technique involves volatilization of component of polymer solution before application or during application of core mass resulting in the creation of polymer foams serving as the porous wall. The pore formers ideally should be non-toxic. The examples include- (i) Organic-- Carbohydrates viz glucose, fructose, mannose, lactose, sorbitol, mannitol; and (ii) Inorganic-- Alkaline metal salt viz. such as sodium chloride, sodium bromide, potassium chloride. Alkaline earth metal viz. such as calcium chloride, calcium nitrate.

Conclusion

The osmotic drug delivery is a useful drug delivery for any crucial cases where in osmotic pressure plays important role. Expanding pressure inside the system from water imbibition makes the medication discharge of drug at a controlled rate from the framework irrespective of environmental factors with reduced side effect profile with wide use of different molecules. Further, with the disclosure of more up to date and powerful medications by the biotechnology business, the need to convey such rate constant drug delivery system unquestionably will make ready for osmotic delivery systems to assume a key role. The products and patents available till date proves its effectiveness and success rate.

Ethical Statement

This is a review article hence no Ethical Approval needed.

Author Contributions

Gaikwad Sanjana and *Lonare Manish* developed the idea for the topic of the review. *Gaikwad Sanjana, Lonare Manish, Mahajan Renuka* and *Sharma Jay* conducted literature survey for the review. *Gaikwad Sanjana* wrote the manuscript with the support of *Lonare Manish*, *Mahajan Renuka*, *Sharma Jay* and *Diksha Gabhane*. All authors have read and agreed to the published version of the manuscript.

Acknowledgements

Authors express thanks to Dr Naresh Gaikwad and Mr. Jiten Das.

Conflict of Interest

The authors declare no conflicts of interest.

References

Dong LC, Dealey MH, Burkoth TL, Inventors; ALZA corporation, Palo Alto, CA, Assignee (1993) Process for lessening irritation caused by drug. US patent 5 254 349.

Eckenhoff B, Theeuwes F and Urquhart J. (1987) Osmotically actuated dosage forms for rate-controlled drug delivery. Pharm Technol. 11: 96-105.

Jerzewski RL and Chien YW. (1992) Osmotic drug delivery. In: Treatise on controlled drug delivery: Fundamentals, optimization application, (ed.) Kydonieus A.F., CRC Press, Boca Raton, pp. 225-253.

Lakshminarayanaiah N. (1969) Transport phenomena in Membrane. New York: Academic Press, New York, pp. 517.

Loeb S and Sourirajan S. (1964) High flow porous membranes for separating water from saline solutions. https://patentimages.storage.googleapis.com/84/02/7d/b78345f0d595d0/US3133132.pdf

Martin A, Bustamante P and Chun AHC. (1993) Physical pharmacy: Physical chemical principles in the pharmaceutical science. 4th edn., Lea and Febiger, Philadelphia, pp. 116-117.

Parmar NS, Vyas SK and Vyas N. (2004) Osmotic pump-A novel drug delivery system. In: Advances in controlled and novel drug delivery, (ed.) Jain N.K., CBS Publishers and Distributors, New Delhi, pp. 18-37.

Santus G and Baker RW. (1995) Osmotic drug delivery: A review of the patent literature. J Controlled Release 35(1): 1-21.

Singla C. (2021) Recent advances in pharmaceutical sciences. AkiNik Publications. https://doi.org/10.22271/ed.book.1318

Theeuwes F and Higuchi T. (1974) ALZA Corporation, Palo Alto, CA, Assignee. Osmotic dispensing device for releasing beneficial agent. US patent 3845770.

Verma RK and Garg S. (2002) Formulation aspects in the development of osmotically controlled oral drug delivery. J Controlled Release 79: 7-27.

Wong PSL, Edgen DE, Dong LC and Dove CP. (2003) Inventors; ALZA Corporation, Palo Alto, CA, Assignee. Controlled release liquid active agent formulation dosage forms. US patent. 6: 596 314.