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Overview on Osmotic Drug Delivery System

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ABSTRACT

The aim of the current review is to elaborate on the osmotic drug delivery system for controlled release of drugs. The oral route is the most conventional and acceptable route of drug administration. Osmotic drug delivery systems (ODDS) are gaining importance as these systems deliver the drug at specific times as per the functional needs of the disease, resulting in improved patient therapeutic efficacy and compliance.The osmotic drug delivery system serves as a tool for controlling drug release in these conditions and avoiding frequent administration, which is necessary for the treatment of chronic diseases that require repeated dose administration. To control drug delivery, they employ the osmotic pressure theory. To a significant extent, the drug's release is independent of GIT functional variables. This review paper highlights the Osmotic drug delivery system's structure, numerous unique osmotic technologies, various factors that affect the drug's release from the system, and the status of currently sold and in-progress products that use the system.

KEYWORD

Plasma concentration, controlled drug delivery, osmotic drug delivery, osmosis, osmotic pressure.

I. INTRODUCTION[1,19]

As the oral route provides the good active surface area of any drug delivery mechanism for administration of severaldrugs, oral drug delivery is the most admired and useful option. The entire scope of a drug's action is determined by its therapeutic function and how effectively it reaches the aid site.[1-5]The bioavailability of drugs from these formulations may differ significantly depending on factors such as the physicochemical properties of the drug, the presence of excipients, and various physiological factors such as the presence or absence of food, GI motility, and the pH of the GI tract.Controlled drug delivery systems' major goal is to increase the efficacy of drug therapies through prolonged or sustained drug release over a longer period. One essential field for drug research and development is novel drug delivery systems (NDDS).The NDDS's estimated launch time and cheap development costs ($20–50 million and 3–4 years, respectively) as compared to the new chemical molecule's ($500 million and 10–12 years, respectively) are the primary factors.[1]

The most reliable controlled drug delivery systems (CDDS) are osmotic systems, which can also be used for oral drug delivery. These systems release the drug in a controlled manner by using osmotic pressure as their driving mechanism. Osmotic pump tablets (OPT) generally consist of a core including the drug(s), an osmotic agent, other excipients, and a semipermeable membrane coat.[6-8] According to this system, osmotic drug administration produces superior outcomes than any other controlled release approach because it doesn't depend on the concentration of the drug. By preserving a largely constant, effective medication level in the body and minimizing negative side effects, controlled drug release systems try to maintain drug action at a predetermined rate.[6-10]

The administration of drugs to patients over an extended period is used to treat serious illnesses or chronic conditions. Osmotic drug delivery systems are distinctive in that they are flexible to a variety of drugs and may be designed to deliver drug(s) with just slight adjustments. This means that the drug(s) are not dependent on or impacted by physiological factors within the GIT. They are also known as GITS (gastrointestinal therapeutic system), and now different types of osmotic pumps for various drugs are available on the market to meet patients' needs and requirements.[12-13] Conventional medication administration techniques are effective for

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mostpharmaceuticals; however, some are toxic or less stable and offer fewer treatment alternatives. Some drugs have issues with solubility. To maintain optimal plasma levels in such circumstances, a technique of continuous consumption of the therapeutic substance is necessary, as shown in Fig 1.[1, 15-19]

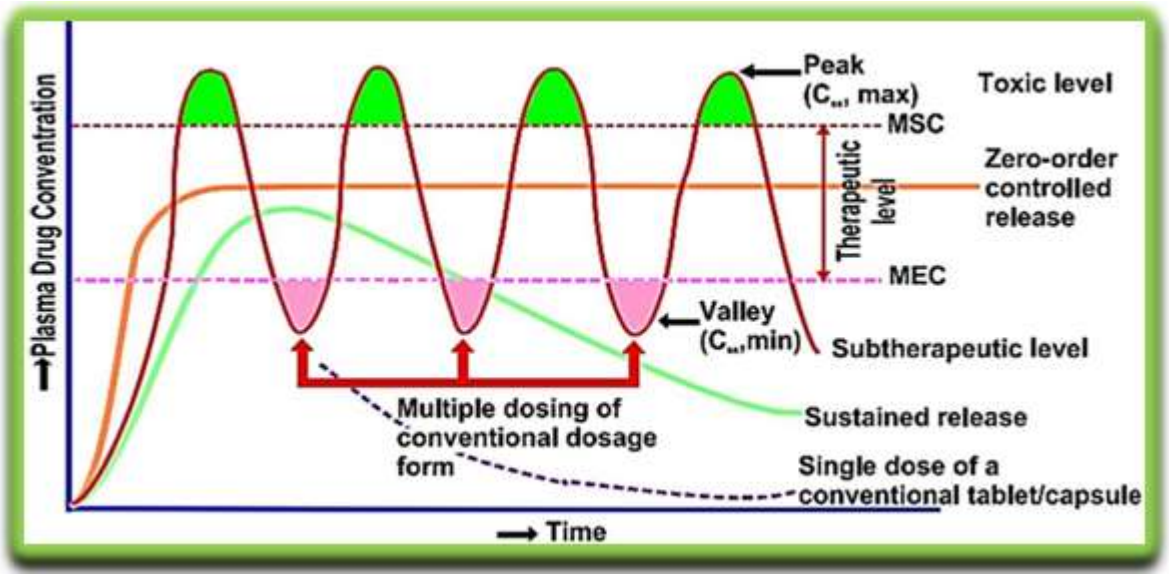

Fig. 1: Plasma drug concentration profiles for conventional various dosing Vs single dose of Zero order sustained release or controlled release dosage form.[1]

Benefits of osmotic drug delivery system:[18-24]

An osmotic drug delivery system for oral use suggests a distinct and functional advantage over other means of delivery. The following advantages contributed to the popularity of osmotic drug delivery systems:

- They give a zero-order release profile after an initial lag.
- The release mechanisms are independent of drug concentration.
- Sustained and consistent blood levels within the therapeutic window.
- Reduced side effects.
- Deliveries may be delayed or pulsed if desired.
- Drug release is independent of gastric pH and hydrodynamic condition.
- They are well characterized and understood.
- Delivery rate is independent of agitation outside, including GI motility.
- Enhanced bioavailability of drug.
- Reduced interpatient variability.
- Release rate of drug is highly predictable and programmable.
- Decrease dosing frequency.
- Improved patient compliance.
- Increased safety margin of high potency drugs.
- Drug release from the OCODDSs exhibits significant in vitro-in vivo correlation [IVIVC] within specific limits.
- Higher release rates can be achieved than with conventional diffusion-based drug delivery methods.

Drawback of osmotic drug delivery system:[18-24]

- High Expensive.
- If the coating process is not well controlled there is a risk of film defects, which results in dose dumping.
- Hole Size is critical in the case of elementary osmotic system.
- Drug release from the osmotic systems is affected to some extent by the presence of food.
- Retrieval of therapy is not possible in the case of unexpected adverse events.
- Rapid development of tolerance.

Alza Corporation of the USA (now affiliated with Johnson & Johnson, USA) was the first to make an oral osmotic pump, and even today, they are leaders in the industry with technology called OROSTM. Oral osmotic pumps have advanced significantly, as seen by the products on the market that are based on this technology and

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the number of patents issued in recent years. They are also known as the GITS (Gastrointestinal Therapeutic System). Osmotic drug delivery systems (ODDS) are different from matrix-based systems in that the delivery of active agents is driven by an osmotic gradient rather than a drug concentration in the device. They are among the most reliable novel drug delivery systems and can be used as oral delivery systems.

Osmosis and its principle

Osmosis: Osmosis describes the process of moving solvent molecules from a lower concentration to a higher concentration throughout a semipermeable membrane.

Osmotic pressure: The pressure applied to the higher-concentration side to inhibit solvent flow is called osmotic pressure. Osmotic pressure is a colligative property that depends on the concentration of the solute that contributes to osmotic pressure.

Principle: Solutions with the same solvent and solute system but varying concentrations display an osmotic pressure corresponding to their concentrations. Thus, a constant osmotic pressure and, thereby, a constant influx of water can be achieved by an osmotic drug delivery system. This results in a constant zero-order release rate of the drug.The rate of drug release from an osmotic pump depends on the osmotic pressure of the core and the drug's solubility; hence, these systems are suitable for the delivery of drugs with moderate water solubility. Osmotic pressure is symmetrical to temperature and concentration, and the relationship can be described by the following equation:

$\pi = n2\ RT$

Where, π = osmotic coefficient n2 = molar concentration of solute in the solution R = gas constant T = Absolute temperature.

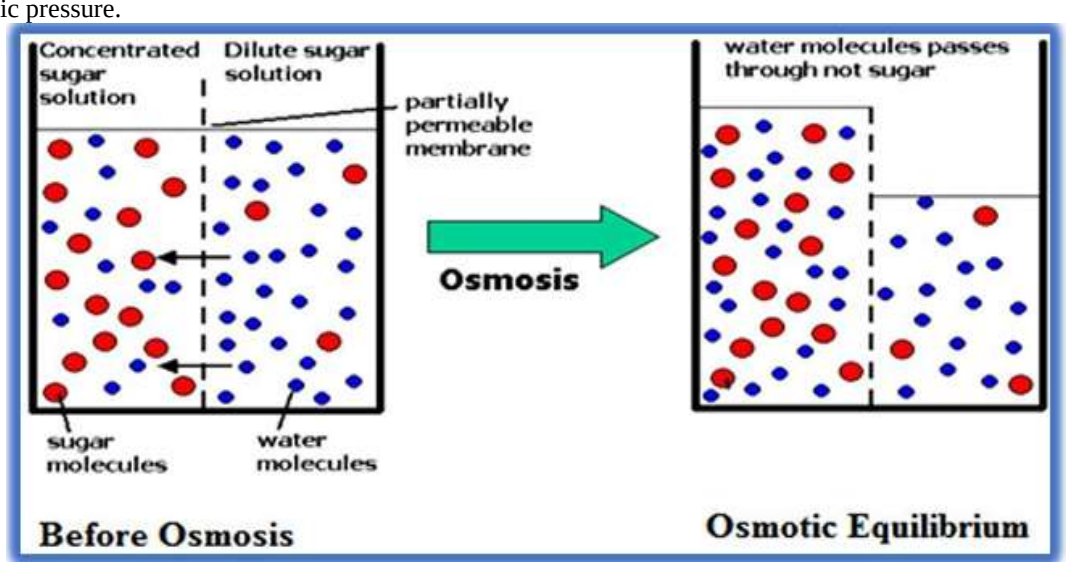

Fig2: A schematic diagram of osmotic flow and the attainment of osmotic equilibrium In a few years after, Van't Hoff has shown similarities between these results and the relevant gas laws with this statement.[1]

The Van't Hoff calculation presents excellent ways to calculate the osmotic pressures of the solute across the SPM (semi permeable membrane), and it is also accurate with a low solute concentration. But if the membrane cannot be completely semi permeable and allows the passage of solute and solvent, the osmotic pressure calculated by the above equation will be higher compared to the test value. Highly concentrated solutions also show differences in these relevant statistics.[1, 27-29]

Another way to find the right balance of osmotic pressure is to use vapor pressure measurements and an expression.

$$\pi = \frac{RT}{V}\ln\left(\frac{P_0}{P}\right)$$

Where, P0 is the vapour pressure of pure solvent, P is the vapour pressure of the solution, Vis the molar volume of the solvent.

II. CLASSIFICATION OF OSMOTIC DRUG DELIVERY SYSTEM[1,29-32]

They fallin two categories:

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1. **Implantable Osmotic Pump**
2. **Oralosmotic Pump**

1) Implantable Osmotic Pump:

A) TheRose-Nelson Pump

In 1955, two Australian physiologists, Rose and Nelson, reported the first osmotic pump. They were interested in the delivery of drugs to the guts of sheep and cattle.

- A drug chamber with an orifice.
- A salt chamber with an elastic diaphragm containing excess solid salt.
- A water chamber.

The drug and water chambers are separated by a rigid, semipermeable membrane. The difference in osmotic pressure across the membrane moves water from the water chamber into the salt chamber. The volume of the salt chamber increases because of this water flow, which distends the latex diaphragm, separating the salt and drug chambers and pumping drugs out of this device. The pumping rate of the Rose-Nelson pump is given by the equation:

dm/dt = dv/dt *c

Where: dm/dt = Drug release rate. dv/dt = Volume flow of water into salt chamber. c = Concentration of drug into drug chamber.

B) Higuchi Leeper pump

The design of the Higuchi Leeper pump described in the article represents the first simplified version of the Rose Nelson pump made by the Alza Corporation in the early 1970s. The benefit of this pump over the Rose Nelson pump is that it does not have a water chamber, and the device is activated by water absorbed from the surrounding environment. This means the pump is first prepared, then loaded with the drug, and then stored for weeks or months prior to use.

C) Higuchi- Theeuwes pump

In the early 1970 Higuchi – Theeuwes developed a similar form of Rose Nelson pump. The semipermeable wall itself acts as a rigid outer casing of the pump. The device is loaded with drug prior to use. When the device is put in an aqueous environment the release of the drug follows a time course set by the salt used in the salt chamber and the permeability of the outer membrane casing.

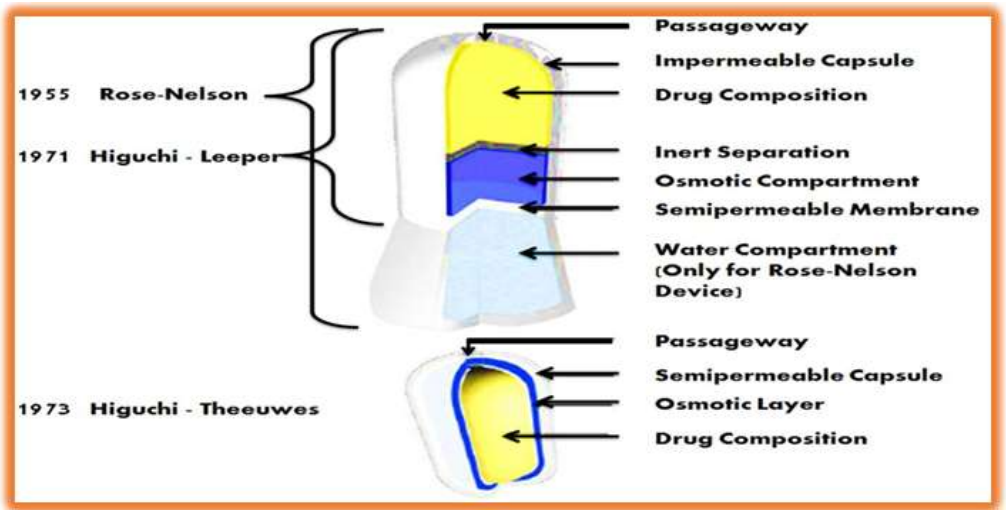

Fig3A:Schematic diagram of Osmotic Pump of Rose-Nelson, Higuchi Leeper and Higuchi – Theeuwes.[1]

D) Alzetosmotic pump

Alzet pumps (Fig 3B) operate due to the difference in osmotic pressure between the inner chamber of the pump, called the salt sleeves, and the area of tissue where the pump is implanted. The water fluxes into the tap through the SPM due to the high osmolality of the salt sleeve that forms the outer side of the pump. When water enters the salt sleeve, it compresses the flexible reservoir, removing the test solution from the pump at a controlled, predetermined rate. The limitation of pumps is that they are designed for single use only because compressed reservoirs cannot be refilled.

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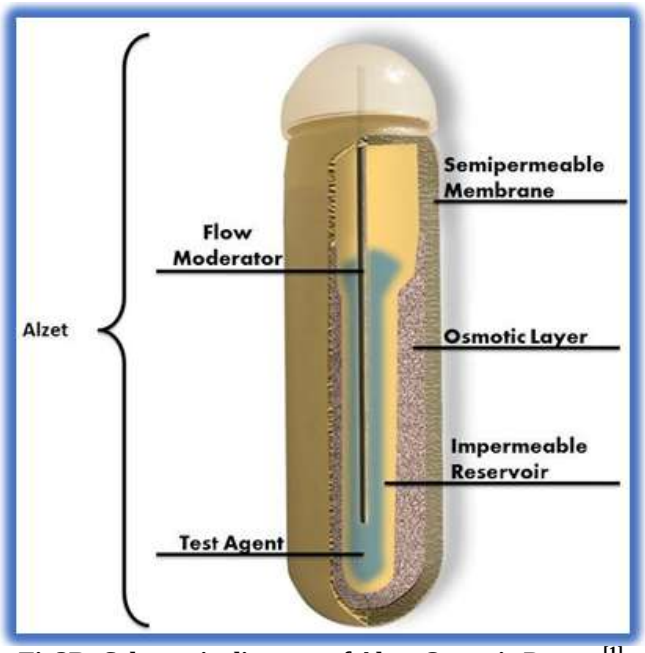

Fig3B: Schematic diagram of Alzet Osmotic Pump. [1]

2) Oral Osmotic Pump

1) Single Chamber Osmotic Pump

i. Elementary Osmotic Pump

An osmotic core (containing a drug with or without an osmogent) is coated with a semipermeable membrane (SPM), and a small orifice is created in the membrane. Imbibes water through the SPM because of the osmotic pressure gradient and forms a saturated solution inside the device. This increases the hydrostatic pressure inside the tablet and forces the saturated drug solution through the orifice present in the membrane. Advantage: Suitable for delivery of drugs having moderate water solubility.

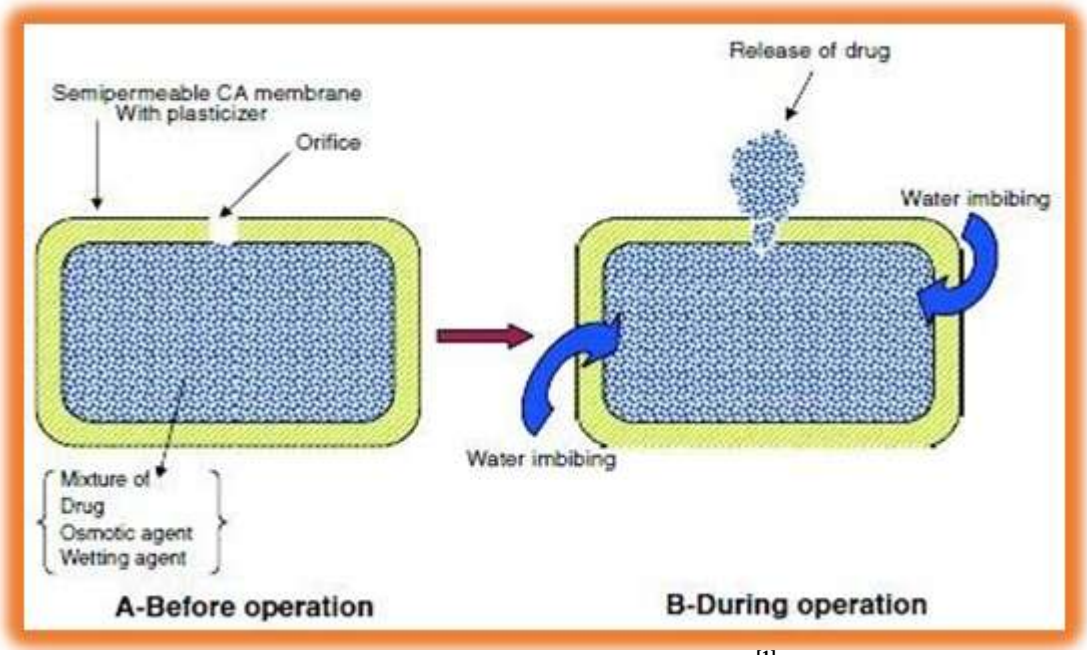

Fig4: Elementary Osmotic Pump(EOP).[1]

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2) Multi Chamber Osmotic Pump

i. Push Pull Osmotic Pump

Two compartments: The Upper compartment (the drug compartment) contains the drug along with osmotically active agents. The lower compartment (push compartment) contains the polymeric osmotic agents. When the dosage form meets the aqueous environment, both compartments imbibe water simultaneously. Because the lower compartment is devoid of any orifice, it expands and pushes the diaphragm into the upper drug chamber, thereby delivering the drug via the delivery orifice. Advantage: Deliver both highly water-soluble (oxybutynin hydrochloride) and practically water-insoluble (nifedipine, glipizide) drugs.

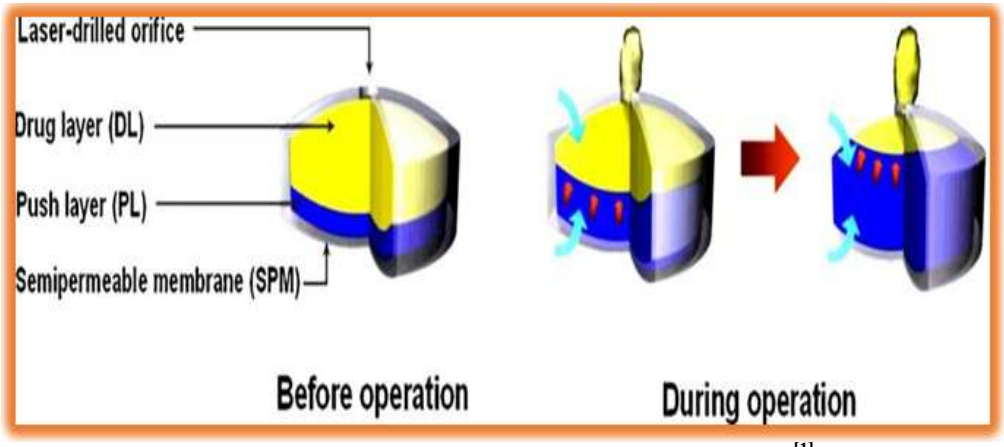

Fig5:Mechanism of Drug Delivery from a Push-Pull. [1]

ii. Osmotic Pump with Non-Expanding Second Chamber

Multi-chamber devices consist of systems containing a nonexpanding second Chamber. The purpose of the second chamber is either dilution of the drug solution leaving the device (particularly useful in handling drugs with a high incidence of GI irritation) or simultaneous delivery of two drugs. Advantage: Relatively insoluble drugs can also be delivered.

3) Modified Osmotic Pump

i) Controlled Porosity Osmotic Pump(CPOP)

CPOPs are similar to EOPs, with the only difference being that the delivery orifice from which the drug release takes place is formed by the incorporation of a water-soluble additive in the coating. After coming into contact with water, the water-soluble additives present in the coating dissolve, resulting in the in situ formation of a micro porous membrane as shown in Fig.The release of drugs takes place through this micro porous channel. Eliminates the need for a separate manufacturing step (creating an orifice using a laser drilling machine). Suitable for delivery of drugs having intermediate and extreme water solubility.

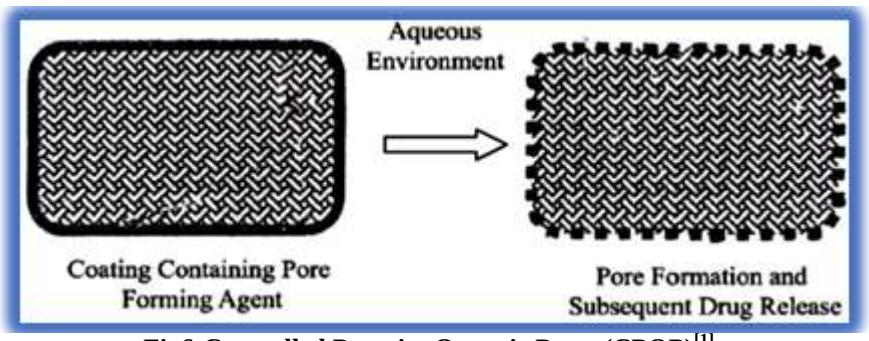

Fig6:Controlled Porosity Osmotic Pump(CPOP)[1]

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ii) Osmotically Rupturable Pumps

Another popular category is osmotic systems that release the active ingredient through an osmotic bursting device. The system was developed by Baker and consists of an osmotic core surrounded by an SPM. Water is osmotically attracted to this device when it is in a liquid environment, which results in the placement of the membrane within the device.This process continues until the internal pressure inside the device becomes greater than the cohesive force of the membrane and the membrane breaks down in a weak area, usually around the edges. When the membrane is raptured, the device becomes like an elementary osmotic pump, and the drug compound is pulled out of the cracked area with the mechanism of osmotic pumping.

Rapture time of SPM canbe controlled by:

a) Varying type, area, or thickness of SPM
b) Altering the osmotic agents embedded in the osmoticcore.

iii) Liquid Oral Osmotic System(L-OROS)

The various LOROS systems available to provide controlled delivery of liquid formulations include a L-OROS soft cap, a L-OROS hard cap, and a delayed liquid bolus delivery system. Each of these systems includes a layer of liquid drugs, an osmotic engine, or a Push layer, and a SPM (Fig 7). When this system meets water, the water penetrates inside the layer through SPM and activates an osmotic layer. The expansion of the osmotic layer leads to the formation of hydrostatic pressure within the system, thereby forcing the liquid formulation to extrude from the orifice at the delivery site. While L-OROS hard caps and L-OROS soft caps are designed to provide continuous drug delivery, the L-OROS delayed delivery of liquid bolus system is designed to deliver a pulse of liquid drug.

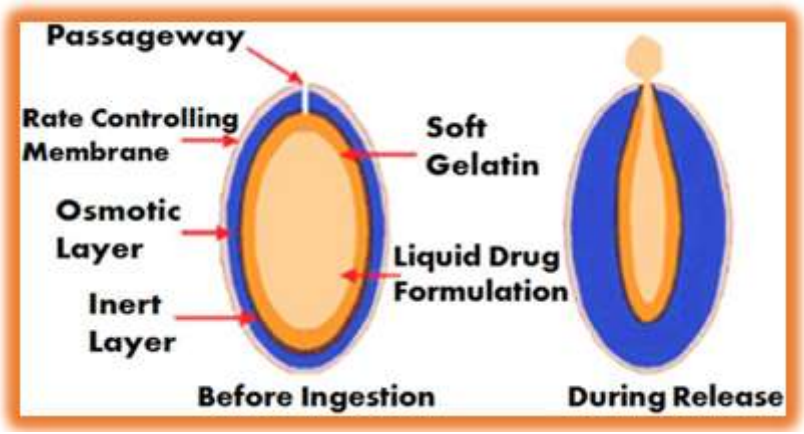

Fig7: Cross-sectional Diagram of Liquid Oral Osmotic System(L-OROS).[1]

iv) Colon Targeted Oral Osmotic System(OROS-CT)

OROS-CT is used to deliver drugs once or twice a day to the colon region. It comprises a hard gelatin capsule filled with 5–6 enteric-coated push-pull osmotic units for targeted drug delivery to the colon region. After contact with GI fluid, the gelatin capsule dissolves, but the enteric coating will prevent the entry of fluid from the stomach into the system (Fig 8).

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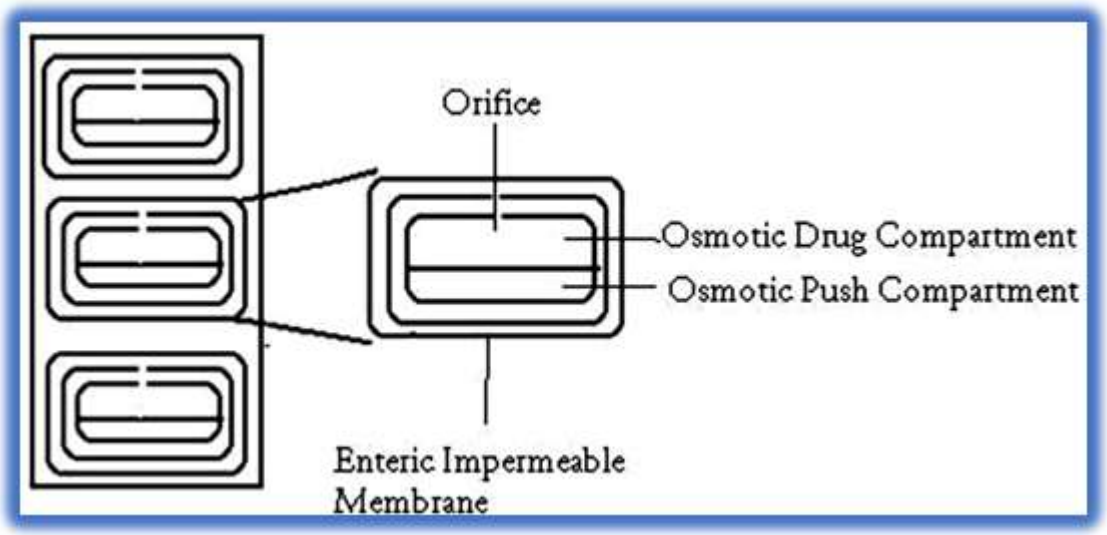

Fig8: Cross-sectional Diagram of OROS-CT Delivery System.[1]

v) Sandwiched Osmotic Tablets(SOTS)

It consists of a polymeric push layer sandwiched between two layers of the drug with two delivery orifices. When placed in a liquid environment (Fig 9), the central push layer containing the swellable polymer starts to swell, and the drug starts to release from the delivery orifice. The advantage of this type of system is that the drug is extruded from two opposite side layers of the tablet, and therefore SOTS may be suitable for drugs that tend to cause local irritation of the abdominal cord (gastric mucosa).

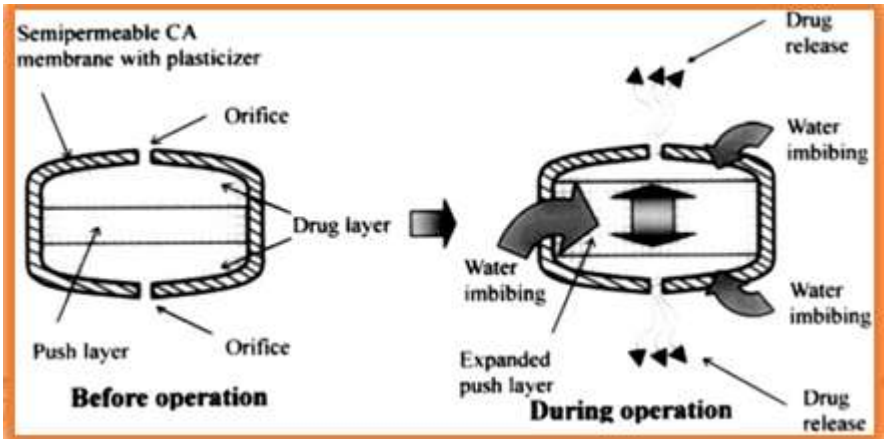

Fig9: Schematic Diagram of Sandwiched Osmotic Tablet(SOTS).[1]

vi) Osmotic Pump for Insoluble Drugs

It consists of coating the particles of the osmotic agent (osmogens) with a SPM. These particles are mixed with an insoluble drug substance and pressed into the form of a tablet, after which they are encased in a SPM and an orifice is formed on the membrane.

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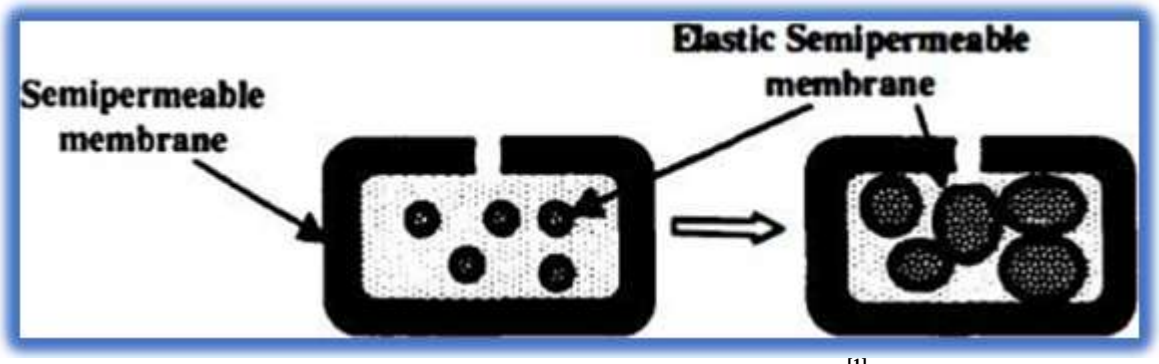

Fig10:Modified osmotic pump for insoluble drugs[1]

After its contact with the liquid, the water is drawn through both layers to the particles of the osmotic agent, which then swells and pushes the drug hydrostatically through a delivery orifice.

vii) Monolithic Osmotic Systems

It comprises a simple dispersion of a water-soluble substance in a polymeric matrix. When the system meets a liquid environment, the water uptake by the drug substance ruptures the polymer matrix, thereby releasing the drug into the external environment. Initially, this process takes place on the outer surface of the polymer matrix but gradually progresses to the inner surface in a consistent manner. However, this system fails if more than 20 to 30% of the active agent is incorporated into the osmotic system.

viii) Telescopic Capsule for Delayed Release

The device has two chambers: the first contains the delivery orifice and drug, and the second contains the osmotic engine. A wax-like layer separates the two chambers. To assemble the delivery device, the drug substance is placed in one of the chambers with a manual or automatic filling mechanism. A two-layer tablet with an osmotic engine is placed on the part of the capsule cap with a convex osmotic layer shown at the end of the cap and a barrier at the end of the closed cap, and a barrier layer is exposed at the opening of the cap.The filled vessel open end is fitted to the inner side of the cap open end, followed by compressing the two pieces together till the osmotic bilayer tablet, cap, and vessel fit tightly together. When fluid enters the housing of the dispensing device, it will expand the osmotic engine, exerting pressure on the slidingly connected sections of the second and first walls. Which leads to the flow of surrounding fluid driven by the pressure that enters the reservoir, is minimal, and consequently no agent will deliver during that period.

ix) Multi particulate Delayed-Release System

In this system, pellets comprising water-soluble drugs, optionally with osmotic agents, arecoated with a SPM. When it comes into contact with water, water enters the core and forms a saturated solution of drug substances. The osmotic pressure gradient causes fluid influx, leading to rapid fluid enlargement that causes membrane expansion and the formation of pores. The release of drug ingredients through these holes usually follows zero-order kinetics. In studies conducted by Schultz and Kleinebudde, it was found that lag times and release rates depend on the level of thickness of the coating layer and the osmotic pressure of the dissolution medium.

x) Osmotic Matrix Tablet(OSMAT)

It is an osmotically operated matrix system that uses hydrophilic polymer material to swell and gel into a liquid that makes it semi-permeable in situ. Release from such a matrix system containing osmogent; therefore, it can be modulated by phenomena of the osmosion. OSMAT thus follows both matrix and osmotic aspects, leading to quantum improvements in drug delivery from swellable matrix systems. Osmotic matrix tablets are very easy to produce and do not require SPM coating or an orifice for drug delivery. Therefore, it is a less expensive technology and can be utilized for a variety of drugs.

III. MAJOR COMPONENTS[1-19]

The following are the elements used in building anosmotically controlled system:

(1) Osmogents

Osmogents are the most important ingredient in an osmotic device. When biological

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fluid enters the osmotic pump through a semi permeable membrane, osmogent dissolves in the biological fluid, creating osmotic pressure inside the pump and pushing the drug out of the pump through an orifice. Various osmogents include inorganic salts and carbohydrates. Mostly, potassium chloride, sodium chloride, and mannitol are used as osmogens. Table 1 lists different osmogents along with their osmotic pressure.

Table 1
A list of various osmogens with their osmotic pressure

Osmotic pressures of saturated solution of commonly used osmogens	Osmotic pressure (atm)
Sodium chloride	356
Fructose 3	55
Potassium chloride	245
Sucrose	150
Xylitol	104
Sorbitol	84
Dextrose	82
Citric acid	69
Tartaric acid	67
Mannitol	38
Potassium sulphate	39
Lactose	23
Fumaric acid	10

(2) The Semi permeable membrane

An important part of the osmotic drug delivery system is the semipermeable membrane housing. Therefore, the polymeric membrane selection is important to the osmotic delivery formulation. The membrane should possess certain characteristics, such as

- Sufficient wet strength and water permeability.
- Should be biocompatible.
- Rigid and non-swelling.
- Should be sufficiently thick to withstand the pressure within the device.

Any polymer that is permeable to water but impermeable to solutes can be used as a coating material in osmotic devices.

(3) Plasticizers

Plasticizers lower the temperature of the second-order phase transition of the wall or the elastic modules of the wall and increase the workability, flexibility, and permeability of the fluids. Generally, from 0.001 to 50 parts of a plasticizer or a mixture of plasticizers are incorporated into 100 parts of wall-forming materials. Suitable polymers should have a high degree of solvent power for the materials, be compatible with the materials over both the processing and the temperature range, exhibit permanence as seen by their strong tendency to remain in the plasticized wall, impart flexibility to the materials, and be non-toxic.

(4) Coating Solvent

Solvents suitable for making polymeric solutions that are used for manufacturing the wall of the Osmotic device include inert inorganic and organic solvents that do not adversely harm the core, wall, or other materials. Mixtures of solvents 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), etc. can be used.

(5) Pore Forming Agents

These agents are particularly used in the pumps developed for poorly water-soluble drugs and in the development of controlled porosity or multiparticulate osmotic pumps. These pore-

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forming agents cause the formation of microporous membranes. The microporous material may be formed in situ by a pore former through its leaching during the operation of the system. The pore-formers can be inorganic or organic, solid or liquid in nature. Pores may also be formed in the wall by the volatilization of components in a polymer solution or by chemical reactions in a polymer solution that develop gases prior to application or during application of the solution to the core mass, resulting in the creation of polymer foams serving as the porous wall. The pore-formers should be non-toxic, and on their removal, channels should be formed. The channels become a transport path for fluid.

(6) Polymers

These polymers are used in the formulation of osmotic systems to constitute a drug layer. Highly water-soluble drugs can be trapped in hydrophobic matrices, and medium-soluble drugs can be added to hydrophilic matrices to obtain a more controlled release. Typically, a mixture of hydrophilic and hydrophobic polymers has been used in the formation of osmotic pumps for water-soluble drugs. The selection is based on the drug's solubility—the amount of drug and rate of drug release from the dosage form. Polyethylene Oxide and hydroxyethyl cellulose are the most widely used polymers for osmotic dosage forms. Other hydrophilic polymers such as carboxymethylcellulose, hydroxypropylmethyl cellulose, polyvinylpyrrolidone, and hydrophobic polymers such as ethylcellulose can be used for this purpose.

(7) Solubilizing Agents

In the osmotic delivery system, the most soluble drugs in the water can show a maximum release rate of about zero. Therefore, many drugs with low internal solubility have poor osmotic delivery. However, it is possible to increase the solubility of the drug within the dosage form by adding a solubility-enhancing agent. The addition of solubilizing agents to the main tablet significantly increases drug solubility.

(8) Wicking Agents

A wicking agent is defined as a material with the ability to draw water into the porous network of a delivery device. A wicking agent is of either a swellable or non-swellable nature. The function of the wicking agent is to carry water to surfaces inside the core of the tablet, thereby creating channels or a network of increased surface area.

IV. FACTOR AFFECTING THE RELEASE RATE OF DRUG FROM OSMOTICSYSTEM

Numerous process and formulation factors, including curing treatment, plasticization, and core characteristics, affect the drug release from an osmotic delivery device. Besides the water solubility of the drug, the solubility of the other core ingredients can also have a major influence on the drug release by generating an osmotic pressure gradient across the polymeric coating upon interaction with the dissolution medium. The rate of drug release fromosmotic pumpsis dependent on the total solubility and the osmotic pressure of the drug core. Various factor that affects thereleaseof drugfrom osmoticsystem arefollows.[1-24]

Thickness of Semi permeable Membrane

The factor that controls the rate of water infiltration is the circulation of the membrane. Proper and efficient selection of SPM sizes is one of the best ways to get regular dose release of drugs from the osmotic systems. As the tension increases, the resistance of the membraneto the water supply increases, the water level in the imbibing decreases, and, in turn, the absorption rate of the tablet's spine decreases, leading to a decrease in drug release. Usually the rate of drug release can be achieved by varying the membrane, while small changes up to 5 percent can be best achieved by varying the membrane size.

1. Drug Solubility

In the case of EOP, the solubility of the drug is one of the most important factors affecting the release of drug kinetics from osmotic pumps. Thus, the lower intrinsic solubility of drugs can preclude them from assembling an osmotic pump with an EOP design. The drug of choice for osmotic delivery should be soluble within a range of 50–300 mg/ml.

2. Delivery orificesize

The orifice is one of the most important components in the lining of the drug. The size of the orifice should be adjusted to control the release of the drug into the osmotic system. It was reported that there was an appropriate orifice size range for the osmotic system; this should be less than the

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maximum limit for the contribution to the level of delivery made by orifice distribution. Also, they should be larger than the minimum limit, reducing the hydrostatic pressure within the system.

3. Plasticizer Amount

Plasticizers were added to transform the visible structures and improve the film-forming properties of the polymers. Plasticizers can convert solid and thin polymers into softer, more flexible materials and make them more resistant to mechanical pressure. Polymer can affect the penetration of the polymer films, which can lead to a level of drug release from osmotic tablets.

4. Osmogent Amount

One of the key emissions controls to be developed is the osmotic pressure gradient between the room and the outside environment. Since the osmotic pressure in GIT remains relatively low, the osmogent that provides the highest osmotic pressure will have the power to drive water imbibition with tablet coverage. Therefore, the amount of osmotic agent also has a significant impact on drug release, and the rate of drug release has increased with the osmogent value due to the increase in fluid, which is why it increases the drug release capacity. This can be reversed by the appropriate selection of the delivery agent (the poreagent) to achieve the desired release profile.

V. MARKETED PRODUCTS

Table 2: Marketed oral osmotically driven products classified according to the rapeutic indication.

Product /BrandName	Active	Form	Strength(mg)	t1/2(h)	Developer/marketer
Cardiovasculardisorders					
UT-15C	Treprostinil diethanolamine	SEOP	1	4	UnitedTherapeutics
LCP-Lerc	Lercanidipine	DOEOP	20	3	Osmotica/Recordati
Cardura CR	Doxazosinmesylate	PPOP	4–8	15–22	Alza /Pfizer
DitropanXL Ditropan UD /Tavor	Oxybutyninchloride	PPOP SEOP	5–15	12–16	Alza /UCBPharma Osmotica/Phoenix
Teczem	EnalaprilDiltiazem	CPOP	2805	11	Merck/Aventis
Tiamate DilacorXR	DiltiazemHCl	CPOP SCOT	120–240	3–4.5	Merck/AventisAndrx
CoveraHS	VerapamilHCl	COER	180–240	2–5	Alza/Pfizer
DynaCircCR	Isradipine	PPOP	5–10	8	Alza/Novartis
MinipressXL orAlpressLP	Prazosin	PPOP	2.5–5	2–4	Alza/Pfizer
ProcardiaXL/ Adalat CCNifedSol	Nifedipine	PPOP DOEOP	30–90	2–5	Alza/Pfizer–Bayer Osmotica/Phoenix
Metabolic disorders					
Topamax	Topiramate	PSOP	25–175	21	Alza
AltoPlusXR	MetforminHCl PioglitazoneHCl	SCOT	500–85015	5.2	Andrx/Takeda
Fortamet	MetforminHCl	SCOT	500–1000	5.2	Andrx
Altoprev	Lovastatin	EOP	10–60	1.1–1.7	Andrx
GlucotrolXL	Glipizide	PPOP	2.5–10	2–4	Alza /Pfizer
Nervous and neuronal disorders					
FlexerilXL	Cyclobenzaprine	EOP	15–30	18	Alza

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Oxycontin	Oxycodone	PPOP	10	~3	Alza
Jusnista	Hydromorphone	PPOP	8–64	2–3	Alza/J&J
Invega	Paliperidone	PPOP	3–12	23	Xian–Janssen
ElafaxXR	VenlafaxineHCl	EOP	37.5–150	3–7	Osmotica/Phoenix
TegretolXL	Carbamazepine	SEOP	100–400	25	Alza /Novartis
Osmosin	Indomethacin	EOP	75	2.6–11.2	Alza/Merck
TeosonaSol	Theophylline	DOEOP	400	5–8	Osmotica/ Phoenix

Respiratory and Seasonal disorders					
AllegraD24h	PseudoephedrineHCl	DOEOP	240	9–15	Osmotica/Aventis
	FexofenadineHCl		180	14.4	
Loremex	PseudoephedrineHCl	DOEOP	240	5–8	Osmotica/Phoenix
	Loratadine		10	–	
MildugenD	PseudoephedrineHCl	DOEOP	240	5–8	Osmotica/Phoenix
	Astemizole		10	26	
Efidac24brompheniramine	PseudoephedrineHCl	EOP	240	5–8	Alza/NovartisOTC
	Brompheniramine		16	–	
Efidac 24chlorpheniramine	PseudoephedrineHCl	EOP	240	5–8	Alza/NovartisOTC
	Chlorpheniramine		16	21–27	
Efidac24 Sudafed24hMex:24	PseudoephedrineHCl	EOPEOP DOEOP	240	9–16	Alza / Novartis OTCAlza/J&JOsmotica /Phoenix
Volmax	Albuterol	EOP	4–8	2.7–6	GSK/Muro Pharmaceuticals
AcuSystemC	VitamineC	CPOP	n.p.	n.p.	Alza
Acutrim	Phenylpropanolamine	DOEOP	75	3–5	Alza
Gastrointestinaldisorders					
Osmoran300	RanitidineHCl	DOEOP	300	2–4	Osmotica/Phoenix

VI. CONCLUSION

Drug delivery systems have advanced in recent years. In this era of modern science and technology, Novel drug delivery systems have been an attractive and recognized drug delivery system for the pharmaceutical and health industries. The major advantages include precise control of zero-order release over an extended time period, and consistent release rates can be achieved irrespective of the environmental factors at the delivery site. Modifications implemented over time and many more possibilities for these systems indicate more promising drug delivery for nearly a decade. Osmotic drug delivery systems usually contain a drug compound containing Osmogent in the core, coated with a semipermeable membrane. This coating has one or more delivery holes through which the solution or suspension of the drug is released over time. In osmotic delivery systems, osmotic pressure depletes the ability to release drugs through the delivery hole in the dosage form. In the future, various efforts are being made to produce a successful osmotic system, such as pulsatile delivery in terms of an expandable orifice, a lipid osmotic pump, a telescopic capsule containing a small osmotic pump for delayed discharge, an osmotic bursting osmotic pump, and so on.

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Modified versions of conventional dosage forms have been introduced to overcome the limitations of traditional dosage forms. The revised versions are known as controlled-release drug delivery systems. Among the various controlled-release systems, osmotic pumps are widely accepted and employed to control drug delivery. As is discussed in this review, osmotic pressure is the principle of this system. The drug release pattern, which is independent of pH and physiological factors, is one of the significant benefits of this system, making predetermined drug release rates possible.

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