A REVIEW: OSMOTIC DRUG DELIVERY SYSTEM

Patil P. B.1*, Uphade K. B.1, Saudagar R. B.2

1Department of Pharmaceutics, R.G.Sapkal College of Pharmacy, Anjaneri - 422213, Nasik, Maharashtra, India.
2Department of Pharmaceutics Chemistry, R.G.Sapkal College of Pharmacy, Anjaneri - 422213, Nasik, Maharashtra, India.

ABSTRACT

Conventional oral drug delivery systems supply an instantaneous release of the drug and effective concentration at the target site. This kind of dosing pattern may result in constantly changing, unpredictable plasma concentrations. This results in the development of various controlled drug delivery system. Among which the pulsatile drug delivery systems (PDDS)/osmotic drug delivery system (ODDS) are gaining importance as these systems deliver the drug at specific time as per the path and physiological need of the disease, resulting in improved patient therapeutic efficacy and compliance. They work on the principle of osmotic pressure for controlling the delivery of the drug. The release of the drug is independent of physiological factors of the GIT to a large extent. These systems can be utilized for systemic as well as targeted delivery of drugs. This review ‘highlights’ the theoretical concept of drug delivery, types of oral osmotic drug delivery systems, factors affecting the drug delivery system, advantages and disadvantages of this delivery systems, basic component of osmotic system, evaluation parameter, marketed status and last but not the least the recent development.

KEYWORDS: plasma concentration, controlled drug delivery, osmotic drug delivery, osmotic pressure.

INTRODUCTION [1, 2]:

Oral drug delivery is the most preferred and convenient choice as the oral route provides maximum active surface area among all drug delivery system for administration of various drugs. In conventional oral drug delivery systems, there is instantaneous release of the drug and effective concentration at the target site can be achieved by irregular administration of excessive doses. This kind of dosing pattern result is fluctuation in therapeutic plasma concentrations, leading to marked side effects in some cases. Moreover, the rate and extent of absorption of drug from conventional dosage forms may vary greatly depending on factors such as presence of excipients, physicochemical properties of the drug, various physiological factors such as presence or absence of food, pH of gastro intestinal tract, gastro intestinal motility and so on. Uncontrolled rapid release of drug may cause local gastro intestinal or systemic toxicity. Hence, various approaches are made in designing the formulations, which will overcome the disadvantages of conventional dosage forms, which include sustained/controlled drug delivery...
system. There are three main classes of controlled-release drug delivery system; transdermal, intravenous, and oral systems. Oral osmotically controlled release (CR) delivery systems exploit osmotic pressure for controlled delivery of active agents. Drug release from these systems is independent of pH and other physiological parameters to a large extent and it is possible to modulate the release characteristics by optimizing the properties of drug and system. Alza Corporation R of USA was the first to develop an oral osmotic pump.

Advantages:

1) They typically give a zero order release profile after an initial lag.
2) The release mechanisms are independent on drug concentration.
3) Sustained and consistent blood levels within the therapeutic window.
4) Reduced side effects.
5) Deliveries may be delayed or pulsed if desired.
6) Drug release is independent of gastric pH and hydrodynamic condition.
7) They are well characterized and understood.
8) Delivery rate is independent of agitation outside, including GI motility.
9) Enhanced bioavailability of drug.
10) Reduced inter patient variability
11) Decrease dosing frequency.
12) Improved patient compliance
13) Increased safety margin of high potency drugs
14) Drug release from the OCODDSs exhibits significant in vitro-in vivo correlation [IVIVC] within specific limits.
15) It is possible to attain better release rates than those obtained with conventional diffusion based drug delivery systems.

Disadvantage:

1) Expensive.
2) If the coating process is not well controlled there is a risk of film defects, which results in dose dumping.
3) Hole Size is critical in case of Elementary osmotic
4) System.
5) Drug release from the osmotic systems is affected to some extent by the presence of food.
6) Retrieval of therapy is not possible in the case of unexpected adverse event.
7) Rapid development of tolerance.

**Osmosis and its principle** [2, 3]

**Osmosis**: Osmosis refers to the process of movement of solvent molecules from lower concentration to higher concentration across a semipermeable membrane.

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

**Principle:**

Solutions of different concentrations having the same solvent and solute system show an osmotic pressure proportionate 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 a constant zero order release rate of drug. The rate of drug release from osmotic pump depends on the osmotic pressure of the core and the drug solubility; hence, these systems are suitable for delivery of drugs with moderate water solubility. Osmotic pressure is proportionate to temperature and concentration and the relationship can be described by following equation:

\[ \pi = n_2 \cdot RT \]

Where,

\( \pi \) = osmotic coefficient  
\( n_2 \) = molar concentration of solute in the solution  
R = gas constant  
T = Absolute temperature

**CLASSIFICATION OF OSMOTIC DRUG DELIVERY SYSTEM** [4-8]:

**Implantable:**

1. The Rose Nelson pump  
2. Higuchi Leeper pump  
3. Higuchi-Theeuwes pump  
4. Mini Osmotic Pumps

**Oral Osmotic pump:**

1. Single chamber osmotic pump.  
   i) Elementary osmotic pump.  
2. Multi chamber osmotic pump.
i) Push pull osmotic pump.
ii) Osmotic pump with non-expanding second chamber.

3. Specific types
   i) Controlled porosity osmotic pump.
   ii) Monolithic osmotic systems.
   iii) Osmotic bursting osmotic pump.
   iv) OROS – CT
   v) Multi particulate delayed release systems (MPDRS)
   vi) Liquid Oral Osmotic System (L-OROS)

4. Novel Technologies in Osmotic Drug Delivery Systems
   i) Osmodex® Technology
   ii) Duros Technology

**Implantable:**

**The Rose Nelson pump**

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

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

The drug and water chamber are separated by a rigid semi permeable membrane. The difference in osmotic pressure across the membrane moves water from the water chamber into salt chamber. The volume of the salt chamber increases because of this water flow, which distends the latex diaphragm separating salt and drug chamber thereby pumping drug out of this device.

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

Higuchi- Theeuwes pump
In the early 1970 Higuchi – Theeuwes developed a similar form of Rose Nelson pump. The semipermeable wall itself act 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.
**Mini Osmotic Pumps**

Mini osmotic implantable pumps were initially designed by Alza Corp. for experimental studies in animal models. These pumps operate on osmotic pressure difference between a compartment within the pump, called the salt sleeve and the tissue environment in which the pump is implanted. The high osmolality of the salt sleeve causes water to flux into the pump through a semipermeable membrane which forms the outer surface of the pump. As the water enters the salt sleeve, it compresses the flexible reservoir, displacing the test solution from the pump at a controlled, predetermined rate. Because the compressed reservoir cannot be refilled, the pumps are designed for single use only.

<table>
<thead>
<tr>
<th>Type of Osmotic Pump</th>
<th>Composition</th>
<th>Mechanism of Action</th>
<th>Advantages</th>
<th>Figures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Chamber Osmotic Pumps</td>
<td>osmotic core (containing drug with or without an osmagent) coated with a semipermeable membrane (SPM) and a</td>
<td>Imbibes water through the SPM because of the osmotic pressure gradient and forms a saturated solution inside the device. This</td>
<td>Suitable for delivery of drugs having moderate water solubility</td>
<td></td>
</tr>
<tr>
<td>Elementary osmotic pump</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Osmotic Pump with Non-Expanding Second Chamber</strong></td>
<td>Multi-chamber devices comprise of systems containing a non-expanding second Chamber</td>
<td>Purpose of second chamber is either dilution of drug solution leaving the device (particularly useful in handling drugs with high incidence of GI irritation) or simultaneous delivery of two drugs</td>
<td>Relatively insoluble drugs can also be delivered</td>
<td></td>
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</tbody>
</table>

A small orifice is created in the membrane increases the hydrostatic pressure inside the tablet and forces the saturated drug solution through the orifice present in the membrane.
**Push-pull osmotic pump (PPOP)**

| Two compartments: Upper compartment (drug compartment) contains the drug along with osmotically active agents. Lower compartment (push compartment) contains the polymeric osmotic agents. | When the dosage form comes in contact with 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. | Deliver both highly water-soluble (oxybutynin hydrochloride) and practically water-insoluble (nifedipine, glipizide) drugs. |

**Modified Osmotic Pumps**

| CPOPs are similar to EOP, the only difference being that the delivery orifice from which the drug release takes place is formed. | After coming in contact with water, water soluble additives present in the coating dissolves and it results in an in situ formation of a | Eliminates the need for a separate manufacturing step (creating an orifice using a laser drilling machine). Suitable for |

**Controlled porosity osmotic pumps (CPOP)**

<p>| CPOPs are similar to EOP, the only difference being that the delivery orifice from which the drug release takes place is formed. | After coming in contact with water, water soluble additives present in the coating dissolves and it results in an in situ formation of a | Eliminates the need for a separate manufacturing step (creating an orifice using a laser drilling machine). Suitable for |</p>
<table>
<thead>
<tr>
<th>Multiparticulate Delayed-Release System</th>
<th>Pellets containing drug with or without osmotic agent are coated with an SPM.</th>
<th>The osmotic pressure gradient induces a water influx, resulting in a rapid expansion of the membrane, leading to the formation of pores. The osmotic ingredient and the drug are released through these pores.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiparticulate Delayed-Release System</td>
<td>Microporous membrane as shown in figure. The release of drug takes place through this microporous channels</td>
<td>Delivery of drugs having intermediate water solubility and extremes of water solubility by so</td>
</tr>
</tbody>
</table>

**Monolithic Osmotic tablet Systems (MOTS)**

- A simple dispersion of a water-soluble agent is made in a polymer matrix.
- Water imbibitions by the active agent takes place that ruptures the polymer matrix capsule surrounding the MOTS for a water-insoluble drug was developed using gum arabic as the osmotic, suspending, and expanding agent.
### Novel Technologies in Osmotic Drug Delivery Systems:

1) **Osmodex® Technology Family**

The Osmodex family of proprietary technologies combines laser-drilled tablet technology with a variety of single-active and multiple-active drug delivery devices. Osmodex systems simplify dosing and may aid in patient compliance.

**Osmodex ID Delivery for Insoluble Drugs**

This platform provides flexible delivery options for insoluble drugs. It can accommodate first-order, zero-order or delayed-release options while assuring full release over the targeted

| OROS-CT | System can be a single osmotic unit or it may contain as many as 5–6 push–pull units enclosed within a hard gelatin capsule. | Immediately after ingestion, hard gelatin capsule shell dissolves. Enteric coating on the system prevents entry of fluid from stomach to the system and it dissolves after entering into intestine. The drug is delivered out of the orifice at a rate controlled by the rate of water transport across the membrane | Once- or twice-a-day formulation for targeted delivery of drugs to the colon |
timeframe. This technology has been used to solve several challenging insoluble drug delivery problems (Example: Nifedipine Extended-release Tablets).

**Osmodex SD Delivery**

This platform technology can be used to resolve delivery challenges of soluble low-bioavailability drugs or drugs requiring targeted delivery.

**Osmodex IR/CR Combination**

This platform technology provides a combination of immediate release and controlled release of either one or two drugs. This innovative approach allows an immediate release profile to be safely and uniformly combined with a programmed release according to the pharmacokinetic or pharmacodynamic needs of the product (Example: Allegra-D® 24 Hour Tablet*).

* Allegra-D® is a registered trademark of Sanofi-Aventis U.S. LLC

**DuodexTM Double CR Combination**

This dual-controlled release platform allows delivery of two drugs from a single osmotic tablet where each drug release pattern can be independently tailored to the desired release profile.

**Osmodex Triple Combination**

This delivery system incorporates compressed drug layers around an osmotic core. This combination provides the benefits of immediate-release and controlled-release delivery, along with the unique benefits of an osmotic-controlled release to achieve three different release rates in the same tablet.

2) **Duros Technology:**

DUROS pharmaceutical systems are miniature osmotic implants that deliver drugs for 3 months to 1 year with precise zero-order delivery kinetics. The technology is suited for potent drugs and can deliver up to 500 mg of drug from a single implant with a 1-cc drug reservoir. Formulation technology has been developed that maximizes drug payload, stabilizes drugs chemically and physically for extended periods at body temperature, and involves the use of aqueous and non-aqueous vehicles. Advanced applications of the DUROS technology are in clinical and preclinical testing and include the CHRONOGESIC system, delivering sufentanil systemically for chronic pain. The DUROS technology is a miniature drug dispensing system that operates like a miniature syringe and releases minute quantities of concentrated drug formulations in a continuous, consistent flow over months or years. The system is implanted under the skin and can be as small as 4 mm OD X 44 mm L or smaller. The drug formulation is contained in the drug reservoir compartment. The drug formulation may be either a solution or suspension. DUROS drug solutions can be both aqueous and non-aqueous in nature. DUROS drug
formulations must exhibit stability at body temperature (37°C) for extended periods of time, usually ranging from 3 months to 1 year.

Duros system was chosen for their biocompatibility and suitability for implant use. The drug-contacting materials are also screened for compatibility with the drug and the specific drug formulation excipients.

Radiation sterilization (gamma) may be utilized to sterilize the final drug product. If the drug formulation cannot withstand sterilizing doses of radiation, then a DUROS subassembly is radiation sterilized, and the drug formulation is added in a final aseptic operation.

**MARKETED PRODUCTS** [8, 9]:

<table>
<thead>
<tr>
<th>List of marketed products</th>
<th>Trade Name</th>
<th>Active ingredient</th>
<th>Design system</th>
<th>Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Alpress LP</td>
<td>Prazosin</td>
<td>Push -Pull</td>
<td>2.5 - 5 mg</td>
</tr>
<tr>
<td></td>
<td>Acutrim</td>
<td>Phenylpropanolamine</td>
<td>Elementary pump</td>
<td>75 mg</td>
</tr>
<tr>
<td></td>
<td>Cardura XL</td>
<td>Doxazosin</td>
<td>Push -Pull</td>
<td>4, 8 mg</td>
</tr>
<tr>
<td></td>
<td>Covera HS</td>
<td>Verapamil</td>
<td>Push -Pull with time delay</td>
<td>180, 240 mg</td>
</tr>
<tr>
<td></td>
<td>Ditropan XL</td>
<td>Oxybutinin chloride</td>
<td>Push -Pull</td>
<td>5, 10 mg</td>
</tr>
<tr>
<td></td>
<td>Dynacirc CR</td>
<td>Isradipine</td>
<td>Push -Pull</td>
<td>5, 10 mg</td>
</tr>
<tr>
<td></td>
<td>Invega</td>
<td>Paliperidone</td>
<td>Push -Pull</td>
<td>3, 6, 9 mg</td>
</tr>
<tr>
<td></td>
<td>Efidac 24</td>
<td>Chlorpheniramine maleate</td>
<td>Elementary Pump</td>
<td>4 mg IR, 12 mg CR</td>
</tr>
<tr>
<td></td>
<td>Glucotrol XL</td>
<td>Glipizide</td>
<td>Push - Pull</td>
<td>5, 10 mg</td>
</tr>
<tr>
<td></td>
<td>Minipress XL</td>
<td>Prazocine</td>
<td>Elementary pump</td>
<td>2.5, 5 mg</td>
</tr>
<tr>
<td></td>
<td>Procardia XL</td>
<td>Nifedipine</td>
<td>Push - Pull</td>
<td>30, 60, 90 mg</td>
</tr>
<tr>
<td></td>
<td>Sudafed 24</td>
<td>Pseudoephedrine</td>
<td>Elementary pump</td>
<td>240 mg</td>
</tr>
<tr>
<td></td>
<td>Volmax</td>
<td>Sabutamol</td>
<td>Elementary pump</td>
<td>4, 8 mg</td>
</tr>
<tr>
<td></td>
<td>Tegretol XR</td>
<td>Carbamazepine</td>
<td></td>
<td>100, 200, 400 mg</td>
</tr>
<tr>
<td></td>
<td>Viadur</td>
<td>Leuprolide acetate</td>
<td>Implantable osmotic systems</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chronogesic</td>
<td>Sulentamil</td>
<td>Implantable osmotic systems</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Concerta</td>
<td>Methylphenidate</td>
<td>Implantable osmotic systems</td>
<td>18, 27, 36, and 54 mg</td>
</tr>
</tbody>
</table>

**FORMULATION CONSIDERATIONS OF OCDDS** [8-14]:

Generally OCDDS consists of two parts: One of this is core and another is semipermeable membrane (coating). Core of OCDDS consists of drugs, osmotic agents, hydrophilic and hydrophobic polymers, flux regulating agents, wicking agents, while coating includes polymer, coating solvent, plasticizers and pore forming agents.

**Drugs**
Drugs which have short biological half-life (2-6hr) and which are used for prolonged treatment are ideal candidate for osmotic systems. Various drug candidates such as Diltiazemhydrochloride, Carbamazepine, Metoprolol, Oxprenolol, Nifedipine, Glipizide, etc are formulated as osmotic delivery.

**Osmotic Agents**

Osmotic agents maintain a concentration gradient across the membrane. They also generate a driving force for the uptake of water and assist in maintaining drug uniformity in the hydrated formulation. Osmotic components usually are ionic compounds consisting of either inorganic salts or hydrophilic polymers

**Hydrophilic and Hydrophobic Polymers**

These polymers are used in the formulation development of osmotic systems for making drug containing matrix core. The selection is based on the solubility of the drug as well as the amount and rate of drug to be released from the pump.

The polymers are of either swellable or non-swellable nature. Mostly, swellable polymers are used for the pumps containing moderately water-soluble drugs, since they increase the hydrostatic pressure inside the pump due to their swelling nature. The non-swellable polymers are used in case of highly water-soluble drugs. Ionic hydrogels such as sodium carboxymethyl cellulose are preferably used because of their osmogenic nature.

**Flux regulating agents**

Delivery systems can be formulated to regulate the permeability of the fluid by incorporating flux-regulating agents in the layer. Hydrophilic substances improve the flux, whereas hydrophobic materials tend to decrease the flux. Insoluble salts or insoluble oxides, which are substantially water-impermeable materials, also can be used for this purpose.

**Wicking agent**

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 swellable or non-swellable nature. The function of wicking agent is to carry water to surfaces inside the core of the tablet, thereby creating channels or a network of increased surface area.

**Semipermeable 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 sufficient thick to withstand the pressure within the device.

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

**Coating solvent**

Solvents suitable for making polymeric solution that is used for manufacturing the wall of the Osmotic device include inert inorganic and organic solvents that do not adversely harm the core, wall and other materials. The 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.

**Plasticizers**

Plasticizers lower the temperature of the second order phase transition of the wall or the elastic modules of the wall and also 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 in to 100 parts of wall forming materials.

Suitable polymers should have a high degree of solvent power for the materials, 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 should be non-toxic.

**Pore forming agents**

These agents are particularly used in the pumps developed for poorly water-soluble drug and in the development of controlled porosity or multiparticulate osmotic pumps. These pore forming agents cause the formation of microporous membrane. The microporous may be formed in situ by a pore former by its leaching during the operation of the system. The pore formers can be inorganic or organic and 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 which evolves gases prior to application or during application of 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.
### Table No: 3 Examples of Components

<table>
<thead>
<tr>
<th>Components</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Osmotic Agents</strong></td>
<td><strong>Water-soluble salts of inorganic acids</strong></td>
</tr>
<tr>
<td></td>
<td>Magnesium chloride or sulfate; lithium, sodium, or potassium chloride; sodium or potassium hydrogen phosphate</td>
</tr>
<tr>
<td></td>
<td><strong>Water-soluble salts of organic acids</strong></td>
</tr>
<tr>
<td></td>
<td>Sodium and potassium acetate, magnesium succinate, sodium benzoate, sodium citrate, sodium ascorbate</td>
</tr>
<tr>
<td></td>
<td><strong>Carbohydrates</strong></td>
</tr>
<tr>
<td></td>
<td>Mannose, sucrose, maltose, lactose</td>
</tr>
<tr>
<td></td>
<td><strong>Water-soluble amino acids and organic polymeric osmogents</strong></td>
</tr>
<tr>
<td></td>
<td>Sodium carboxymethyl cellulose, Hydroxypropylmethyl cellulose, Hydroxyethylmethylcellulose, Methylcellulose, Polyethylene oxide, Polyvinyl pyrrolidone etc.</td>
</tr>
<tr>
<td><strong>Hydrophilic and Hydrophobic Polymers</strong></td>
<td><strong>Hydrophilic polymers</strong></td>
</tr>
<tr>
<td></td>
<td>Hydroxyethylcellulose, carboxymethyl cellulose, hydroxypropylmethyl cellulose, hydroxyethylmethylcellulose, Methylcellulose, Polyethylene oxide, Polyvinyl pyrrolidone etc.</td>
</tr>
<tr>
<td></td>
<td><strong>Hydrophobic polymers</strong></td>
</tr>
<tr>
<td></td>
<td>Ethyl cellulose and wax materials</td>
</tr>
<tr>
<td><strong>Flux Regulating agents</strong></td>
<td><strong>Hydrophilic substances</strong></td>
</tr>
<tr>
<td></td>
<td>Polyethyleneglycols (300 to 6000 Da), polyhydric alcohols, polyalkylene glycols</td>
</tr>
<tr>
<td></td>
<td><strong>Hydrophobic materials</strong></td>
</tr>
<tr>
<td></td>
<td>Phthalates substituted with an alkyl or alkoxy (e.g., diethyl phthalate or dimethoxyethylphthalate)</td>
</tr>
<tr>
<td>Wicking agent</td>
<td>Colloidal silicon dioxide, kaolin, titanium dioxide, alumina, niacinamide. sodium lauryl sulphate (SLS), poly (vinyl pyrrolidone), m-pyrol, bentonite, magnesium aluminium silicate, polyester and polyethylene</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Semipermeable Polymers</td>
<td>Cellulose acetate, cellulose diacetate, cellulose triacetate, cellulose propionate, cellulose acetate butyrate, ethyl cellulose and eudragits</td>
</tr>
<tr>
<td>Coating solvent</td>
<td>Methylene chloride, acetone, methanol, ethanol, isopropyl alcohol, butyl alcohol, ethyl acetate, cyclohexane, carbon tetrachloride, water</td>
</tr>
<tr>
<td>Plasticizers</td>
<td>Dialkyl phthalates and other phthalates, trioctyl phosphates and other phosphates, alkyl adipates, triethyl citrate and other citrates, acetates, propionates, glycolates, glycerolates, myristates, benzoates, sulphonamides and halogenated phenyls</td>
</tr>
<tr>
<td>Pore forming agents</td>
<td><strong>Alkaline metal salts</strong> such as sodium chloride, sodium bromide, potassium chloride, potassium sulphate, potassium sulphate, potassium phosphate etc., <strong>Alkaline earth metals</strong> such as calcium chloride, and calcium nitrate, <strong>Carbohydrates</strong> such as sucrose, glucose, fructose, mannose, lactose, sorbitol, mannitol and diols, Polyols such as poly hydric alcohols and polyvinyl pyrrolidone</td>
</tr>
</tbody>
</table>

**EVALUATION OF OSMOTIC TABLET** [14, 15]:

**Precompression parameters of osmotic pump tablets**

1. Angle of repose
2. Bulk density
3. Tapped density
4. Compressibility index (Carr’s index)
5. Hausner’s ratio

**Post compression parameters of osmotic pump tablets**

1. Thickness
2. Hardness
3. Friability
4. Weight variation
5. Uniformity of drug content test
6. In vitro dissolution studies
7. Scanning electron microscopy (SEM)

**CONCLUSION**\(^{14-16}\):

The drug delivery systems have become advanced in recent years. In this era of modern science and technology Novel drug delivery systems has been an attractive and recognized drug delivery system for the pharmaceutical and health industry. The major advantage include precise control of zero order release over an extended time period, consistent release rates can be achieved irrespective of the environment factors at the delivery site. Drug delivery from this system is not influenced by the different physiological factors within the gut lumen and the release characteristics can be predicted easily from the known properties of the drug and the dosage form. Modifications implemented over time and many more possibilities for these system indicate, more promising drug delivery for nearly years.

**REFERENCES:**


