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## A Review on Gastro Retentive Drug Delivery Systems with the Special Focus on Floating Drug Delivery

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### ABSTRACT

Gastro Retentive Drug Delivery System is one of the novel approach and all researchers in pharma industries are focused in the same. The main aim of writing this review on Gastro Retentive floating drug delivery systems is to assemble the recent literature with special emphasis on its principal mechanism of floatation to achieve gastric retention and its recent development. Floating systems are low density systems that has density lower than gastric fluid and floats over the gastric fluid and remains buoyant in the stomach without affecting the gastric emptying rate for a prolonged period of time. Floating dosage forms can be formulated as tablets, capsule. This review article includes detailed information about its classification, advantages and *in-vitro* evaluation parameters.

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## INTRODUCTION

Oral administration is one of the most appropriate and widely used route for drug to show the systemic effect. The drugs that are well absorbed in the GIT, gets degraded in the intestine, and have a short half-life requires the frequent dosing to achieve the specific therapeutic activity. The development of oral sustained or controlled release formulation, such as gastro retentive drug delivery system can be an attempt to release the drug slowly into GIT for prolonged period and maintain an effective drug concentration in the systemic circulation. The complete absorption of the drug in the absorption site can be prevented by the rapid gastrointestinal transit and can reduce the therapeutic efficacy of the dose that is administered. Most of the drugs are absorbed in the stomach or upper part of small intestine. Gastro-retentive Drug Delivery System (GRDDS) are the type of dosage forms that retains in the stomach. The gastric retention of solid dosage forms can be achieved by different mechanisms such as floating system, sedimentation, modified shape systems, expandable systems etc. FDDS is one of the most feasible approach for achieving the gastric retention for prolonged period. The bulk density of the floating drug delivery system is lower than the gastric fluid thus they remain buoyant in the stomach for longer period of time without affecting the gastric emptying rate. The Gastro-retentive dosage forms on contact with the gastric fluid forms the colloidal gel barrier around the surface, the gel barrier is impermeable to water and thus maintains the bulk density less than one and remains buoyant in the stomach until the entire dose is released. These type of dosage forms remains in the gastric region for several hours and hence considerably increases the gastric residence time of the drugs<sup>1</sup>.

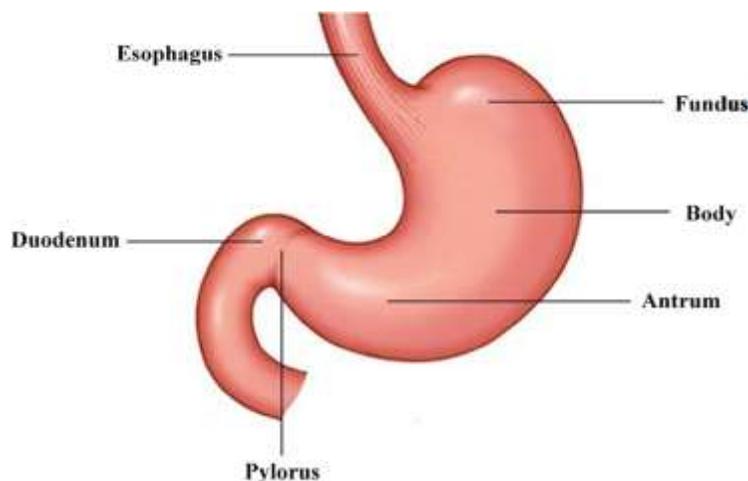
The FDDS are mainly useful for drugs that are absorbed in the upper part of the gastrointestinal tract, and drugs that are less soluble in GIT or are degraded by the alkaline pH may benefit from prolonged gastric retention<sup>2</sup>. The FDDS are also useful for local and sustained drug delivery to the stomach and proximal small intestine to treat certain condition, prolonged gastric retention of the drug may offer several advantages together with improved bioavailability and therapeutic efficacy, reduction in dose frequency and possible reduction of the dose size<sup>3</sup>.

## PHYSIOLOGY OF GIT:

GIT system has a complex anatomy and physiology. Variation in pH, bile contents, enzyme activity etc. can influence the dissolution, release and absorption of drug in GIT from the dosage form<sup>4</sup>. The Gastro-intestinal tract is essentially a tube about nine meters long that runs through the middle of the body from the mouth to the anus and includes the throat (pharynx), esophagus, stomach, small intestine (consisting of the duodenum, jejunum and ileum) and large intestine (consisting of the

cecum, appendix, colon and rectum). Mainly the stomach is divided into three regions the Fundus, Body and Antrum (pylorus).

- ❖ Body: It acts as a reservoir for undigested materials.
- ❖ Fundus: Proximal part of stomach.
- ❖ Antrum: It is the main site for mixing motion and act as a pump for gastric emptying propelling action<sup>5</sup>.

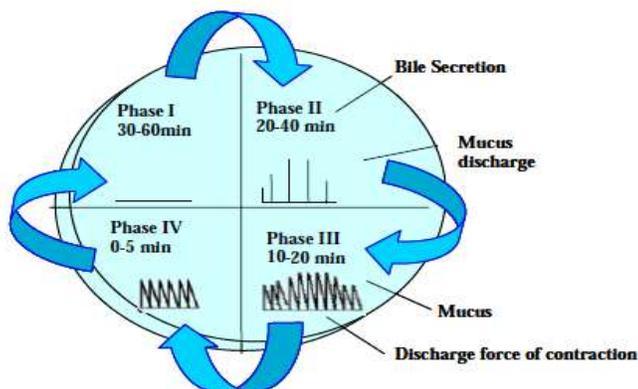


#### **Migrating Myoelectric Cycle (MMC)<sup>6</sup>:**

Gastric emptying takes place both in fed and fasting states, the pattern of motility differs in both the states. Due to this bioavailability of drug administered orally is different, because it depends upon the state of feeding. During fasting state inter-digestive series of electrical event takes place between stomach and intestine which is called as inter-digestive myoelectric cycle or migrating myoelectric cycle (MMC). It is divided into four phases-:

1. Phase-I-: It is a basic phase, remains for 30-60 minutes, it does not have any secretory activity and contractile motion.
2. Phase-II-: It is also known as pre-burst phase, intermittent contractions occur and it last for 20-40 minute. As the phase progresses the intensity and frequency also increases gradually.
3. Phase-III-: It is known as burst phase; remains for 4-6 minutes. It includes intense and regular contractions for short time. It is due to wave that all the undigested material is moved out of the stomach down to the small intestine. It is also known as the housekeeper wave.
4. Phase-IV-: It remains for 0-5 minute, occur between Phase III and Phase I.

After ingestion of the meals, the pattern of contraction changes from fasted to feed state. These contractions result in reducing the size of food particles to less than 1 mm which is then pushed in the form of suspension towards the pylorus.



### Different features of stomach<sup>6</sup>:

Gastric pH: Fasted healthy subject  $1.1 \pm 0.15$

Fed healthy subject  $3.6 \pm 0.4$

Volume: Resting volume is about 25-50 ml

Gastric secretion: Acid, pepsin, gastrin, mucus and some enzymes about 60 ml with approximately 4 mmol of hydrogen ions per hour.

Effect of food on Gastric secretion: About 3 litres of secretions are added to the food. Gastro Intestinal transit time increase.

### FACTORS AFFECTING GASTRIC RETENTION<sup>7</sup>:

The factors that affects the gastric emptying of an oral dosage form are as follows,

- Density: Gastric resident time (GRT) of dosage form buoyancy that is dependent on the density. If the dosage form is having density less than the gastric fluid which can increase the GRT.
- Size: Dosage form having a diameter of 7.5 mm has reported to have an increased GRT when compared with the dosage form having diameter of 9.9 mm.
- Shape: Tetrahedron and ring shaped devices remains in the stomach for longer period of time with better GRT up to 90-100% retention at 24hrs when compared with the other shapes like planar disc, planar multi lobe, continuous stick and string.
- Single or multiple unit formulation: Multiple unit formulations show a more obvious release profile and minor impairing of performance due to failure of units, allow co-administration of dosage form units with different release profiles or containing incompatible substances and permit a more safety against dosage form failure compared with single unit dosage forms. Multiple unit formulations are more reliable as compared to single unit formulations, which suffer “all or none concept”. The units of multiple unit systems are freely distributed throughout the GI tract.
- Fed or unfed state: Under fasting conditions, the GI motility is affected by the period of the migrating myoelectric complex (MMC) that occurs every 1.5 to 2 hours. The MMC pushes the

undigested material from the stomach, and if the time of administration of the formulation coincides with the MMC, the GRT of the dosage for unit can be expected to be very short. However, in the fed state, MMC is delayed and GRT is considerably longer.

- Nature of meal: Feeding of indigestible polymers or fatty acid salts such as cellulose, starch, reffinose and poly-dextrose can delay MMC by changing motility pattern of the stomach, thus can decrease the gastric emptying rate, increases the GRT of the dosage form.
- Caloric content: GRT can be increased by 4 to 10 hours with the meal containing high proteins and fats can increase the GRT to up to 4-10 hours.
- Frequency of feed: The GRT can increase by 400 minutes when successive meals are given compared with a single meal due to the low frequency of MMC.
- The resting volume of the stomach is 25 to 50 ml. Volume of liquids administered affects the gastric emptying time. When volume is large, the emptying is faster.

**Biological factors such as:**

- Gender: GRT in males around (3.4±0.6 hours) compared with their age and GRT of female around (4.6±1.2 hours), regardless of the weight, height and body surface.
- Age: Geriatrics, especially those over 70, have a significantly longer GRT, normal adult's men have faster gastric emptying rate when compared to women and old people.
- Stress can increase the gastric emptying rate while it is decreased in case of depression.
- Posture: GRT can vary between supine and upright ambulatory states of the patient.

**SUITABLE DRUG CANDIDATES FOR GASTRO-RETENTIVE DRUG DELIVERY SYSTEM<sup>8</sup>:**

1. Generally, the ideal candidates for GRDDS are molecules that have poor intestinal absorption but having the better absorption in the upper part of the GIT.
2. Acts locally in the stomach.
3. Primarily absorbed in the stomach.
4. Poorly soluble at an alkaline pH.
5. Absorbed rapidly from the stomach.
6. Degrade in the colon.
7. It should be absorbed primarily in the duodenum and upper jejunum segments. e.g. Calcium is mainly absorbed in the duodenum.
8. Drugs which have a short half-life and require frequent dosing.
9. Drugs which undergoes first pass metabolism.

10. e.g. Nitro-glycerin.
11. Which have poor solubility in intestinal media and poor bioavailability.
12. Drugs that are required for local action in stomach.  
e.g. Antacids and enzymes preparation.

#### ADVANTAGES OF GASTRO-RETENTIVE DRUG DELIVERY SYSTEM<sup>9</sup>:

- The bioavailability can be enhanced for those drugs which has absorption in upper GIT and those gets degraded in intestinal pH.
- Sustained drug release and reduced frequency of dosing. This improves patient compliance.
- Targeted delivery of the drug at the upper part of the GIT making it suitable for the local treatment of the disease of the region e.g.; antacids, anti-ulcer drugs, antibacterial for H. pylori infection.
- The drugs which are having pH dependent absorption from stomach can be formulated as GRDDS e.g. Furosemide, Captopril, Diazepam, Verapamil, Cefpodoxime proxetil.
- Suitable for the drugs which gets degraded in the intestine or colon e.g., Ranitidine hydrochloride.
- There is no fluctuation in the Drug level and maintains the optimal therapeutic plasma and tissue concentrations over prolonged time period. This avoids sub-therapeutics as well as toxic concentration and minimizes the risk of failure of the medical treatment and undesirable side effects.
- The drugs which are having less half-life can be formulated as GRDDS thus reduces the frequent dosing.
- Gastro-retentive drug delivery can minimize the activity of the body leading to higher Drug efficiency.

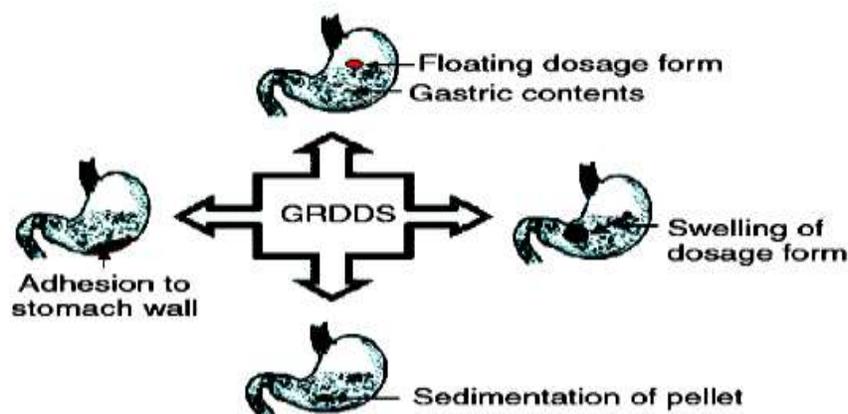
#### LIMITATIONS OF GRDDS<sup>9</sup>:

1. It is not suitable for the drugs which are not stable in acidic environment.
2. It is not suitable for the drugs which are absorbed better in the lower part of GIT.
3. Difficulty to attain the desired outcome and problem of the dose dumping.
4. Gastric retention is influenced by many factors like gastric motility, pH and presence of food. Hence, the dosage form must be able to withstand the grinding and churning force of peristaltic wave of stomach.
5. Poor *in-vitro* and *in-vivo* correlation.
6. Higher cost of formulation.

7. Retrieval of drug is difficult in case of toxicity, poisoning or hypersensitivity reaction.

### CLASSIFICATION OF GRDF<sup>10</sup>:

1. High density systems
2. Expandable system
3. Super porous hydrogels
4. Mucoadhesive or bioadhesive systems
5. Magnetic system
6. Dual working systems
7. Floating systems



#### 1. High density systems<sup>11</sup>:

This approach involves formulation of dosage forms with the density more than the normal density of the stomach content i.e., 1.004g/ml. These formulations are prepared by coating the drug with the heavy inert material such as iron powder, zinc oxide, titanium dioxide, barium sulphate etc. The main drawback of these system is that it is difficult to manufacture with a large amount of drug because the dry material in it interacts with the gastric fluid to release the drug.

#### 2. Swellable and Expandable systems<sup>12</sup>:

A dosage form can remain in the stomach without affecting by the gastric transit, if it is bigger than pyloric sphincter. In all type of dosage forms the patient compliance is the main criteria so the dosage form must be small enough to be swallowed, and must not cause gastric obstruction on accumulation. Thus, it is necessary to develop an expandable system to prolong gastric retention time (GRT):

- 1) a small form for oral intake,
- 2) an expanded gastro-retentive form, and
- 3) a final small form for easy evacuation of the device after the release of entire drug from the device.

Thus, gastric retention can be improved by combination of significant dimension with high rigidity

of dosage form to withstand peristalsis and mechanical contractility of the stomach. Unfoldable and swellable systems have been investigated and recently tried to develop an effective gastro-retentive drug delivery. Unfoldable systems are usually made of biodegradable polymers. They are available in different geometric forms like tetrahedron, ring or planar membrane (4 - label disc or 4 - limbed cross form) of bio-erodible polymer compressed within a capsule which extends in the stomach. Swellable systems are also retained in the gastro intestinal tract (GIT) due to their mechanical properties. The swelling is due to osmotic absorption of water and the dosage form is small enough to be swallowed by the gastric fluid, Expandable systems have some drawbacks like problematical storage of much easily hydrolysable, biodegradable polymers relatively short-lived mechanical shape memory for the unfolding system most difficult to industrialize and not cost effective. Permanent retention of rigid, large single-unit expandable drug delivery dosage forms may cause short-term obstruction.

### **3. Super porous hydrogels<sup>12</sup>:**

These type of swellable systems are different from the conventional types. Absorption of water by conventional hydrogels is a very slow process and may take more time to reach the equilibrium state. Because more time consumption for the premature evacuation of the dosage form may occur. In Super porous hydrogel it has a pore size  $>100\mu\text{m}$  which can swell to equilibrium size within a minute, due to rapid intake of water by capillary wetting through inter connected open pores. They swell to a larger size and have sufficient mechanical strength to withstand the pressure by gastric contraction. This is achieved by co-formulation of a hydrophilic particulate material.

### **4. Mucoadhesive or Bio-adhesive systems<sup>13</sup>:**

In these system the drug is incorporated with the bio/ muco-adhesive agents. The agents which enables the device to adhere to the mucus membrane of the stomach, thus resisting the gastric emptying. A bio-adhesive agent can be a natural or synthetic polymer which are capable of adhering to the mucus membrane. The bio-adhesion is not so effective because the stomach contents are highly hydrated which decreases the bio-adhesiveness of the polymers.

### **5. Magnetic systems<sup>13</sup>:**

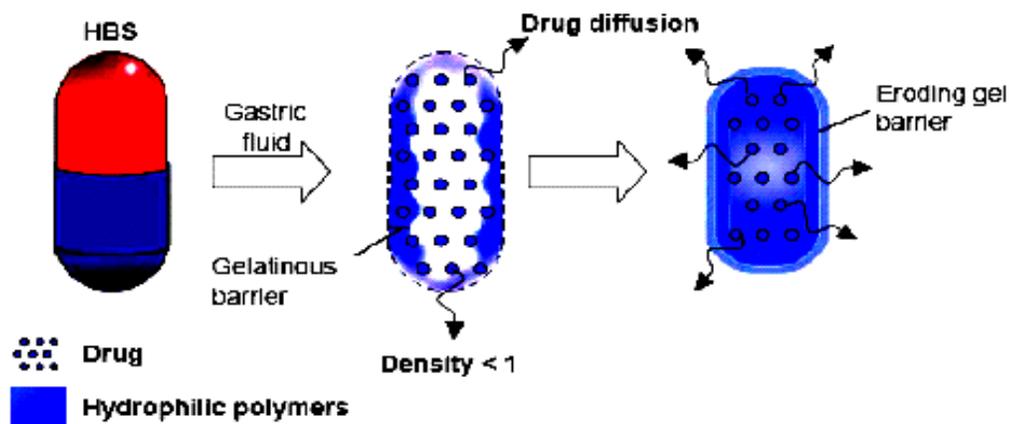
The magnetic dosage form contains a small internal magnet and an extra-corporal magnet which controls the gastro intestinal transit of the dosage form. These type of system works only if the external magnet is positioned with degree of precision that might compromise the patient compliance.

### **6. Dual working systems<sup>13</sup>:**

These systems are based on the two working principles such as either floating and bio-adhesion or swelling and bio-adhesion. FDDS are formulated to continue floating on the gastric fluid when the stomach is full after a meal. When the stomach empties during the Gastric transit the tablet reaches the pylorus, this may reduce the buoyancy of the dosage form. Then the dosage form may pass through the pylorus into the small intestine. Thus, the buoyancy of an FDDS in the stomach may be restricted only for 3–4 h. Furthermore, floating systems may not always release the drug at the specific site. In a bio-adhesive drug delivery system, it is quite likely that the system may detach from the mucosal wall of stomach when the system is full and the semiliquid contents are mixing around due to the effect of peristalsis. A dual working system can overcome drawbacks associated with bio-adhesive, swelling, and floating systems, and can have a significant effect on improving the therapeutic effect of the drug involved.

### 7. Floating systems<sup>14</sup>:

It is also known as Hydro-dynamically Balanced System (HBS). These systems have a bulk density less than gastric fluids, thus remain buoyant in the stomach without affecting the gastric emptying rate for prolonged period of time. The drug will release slowly at the desired rate, which results in increased gastric-retention time and reduces fluctuation.



However, besides a minimal gastric content needed to allow the proper achievement of the buoyancy retention principle, a minimal level of floating force ( $F$ ) is also required to keep the dosage form consistently buoyant on the surface of the meal. Many buoyant systems have been developed based on granules, powders, capsules, tablets, laminated films and hollow microspheres.

### Principle of HBS<sup>15</sup>:

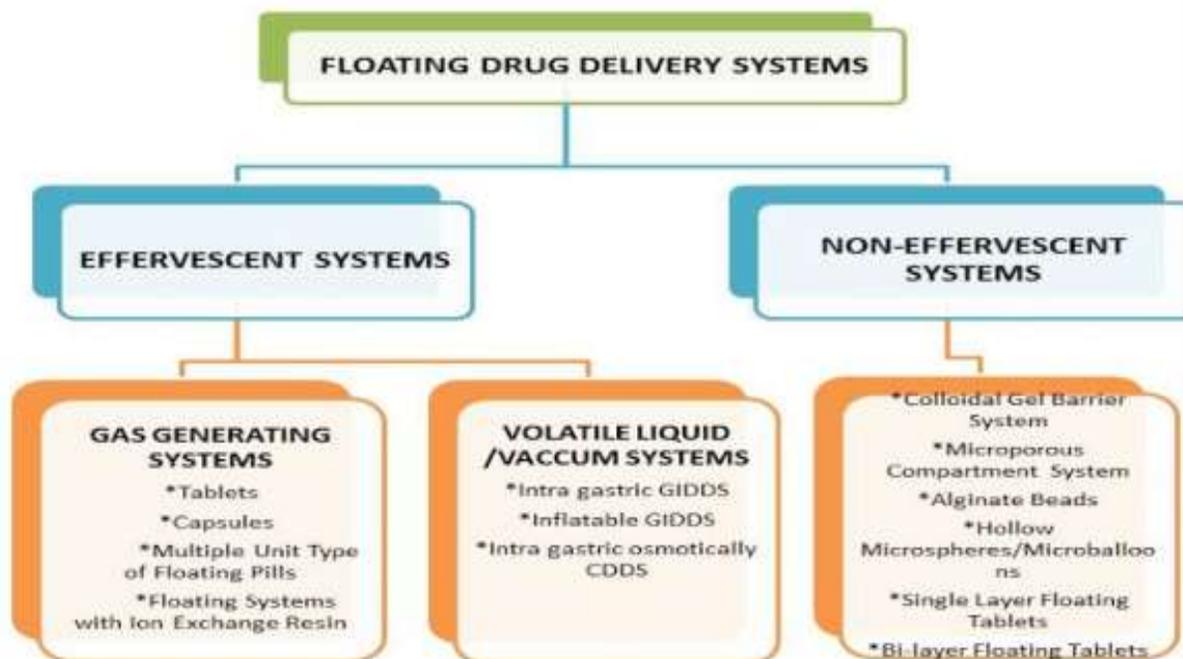
The gel barrier controls the rate of the fluid penetration into the device and hence, the release of drug from the device. With time the external surface of the dosage form goes in to the solution and the

hydrocolloid layer becomes hydrated and thus maintains the gel layer. The HBS must fulfill the three basic criteria's:

1. It must have sufficient structure to form cohesive gel barrier.
2. It should maintain the density lower than that of gastric contents.
3. It should dissolve slowly so that it can act as a reservoir for the drug delivery system.

Based on this principle, bilayer tablet containing one immediate release and other sustained release layer can be prepared. Immediate release layer releases the initial dose whereas the other layer absorbs gastric fluid and forms a colloidal gel barrier on its surface. A multi-layer, flexible, sheath-like device buoyant in gastric fluid showing sustained release characteristics have also been developed. This device consists of one dry self-supporting carrier film, made up of water insoluble polymer matrix containing drug which is either dispersed or dissolved and a barrier film covering the carrier film. Both carrier and barrier films are sealed together along their edge in such a way that it can entrap a group of small air pockets, which bring about the buoyancy to the laminated films.

#### CLASSIFICATION OF FLOATING DRUG DELIVERY SYSTEM<sup>16</sup>:



#### Non-Effervescent systems<sup>16</sup>:

These are also called as hydro-dynamically balanced systems (HBS). It is incorporated with gel-forming or highly swellable cellulose type hydrocolloids, polysaccharides, and matrix forming polymers such as polycarbonate, polyacrylate, polymethacrylate and polystyrene. The buoyancy to these dosage forms is provided by air trapped in the swollen polymer. When such dosage forms come in contact with an aqueous medium, the hydrocolloid starts to hydrate to form a gel at the

surface of the dosage form. This gel structure then regulates the rate of diffusion of solvent-in and drug-out of the dosage form. As the outer surface goes into solution, the gel barrier is maintained by the hydration of hydrocolloid layer which is present together. As a result, the drug dissolves in and diffuses out with the diffusing solvent.

#### **Colloidal gel barrier systems<sup>17</sup>:**

These types of FDDS contains drug with gel forming or swellable polymers like cellulose type hydrocolloids, polysaccharides etc. They contain high levels (20 to 75 % w/w) of one or more gel forming highly polymers incorporated either in tablets or capsules. After intake of such systems, the hydrocolloid gets hydrated in gastric fluid and forms a colloidal gel barrier around its surface. The air trapped inside the swollen polymer maintains the density less than density of gastric fluid and deliberates buoyancy to these dosage forms. The rate of fluid penetration into the device controlled by the gel barrier and also the release of drug. With time the outer surface of the dosage form goes in to the solution, the adjacent hydrocolloid layer becomes hydrated and thus maintains the gel layer.

#### **Micro porous compartment system<sup>17</sup>:**

In this type of systems, drug reservoir is encapsulated inside a micro porous compartment with pores along its top and bottom surfaces. To prevent any direct contact of gastric mucosal surface, the peripheral walls of the drug reservoir compartment are completely sealed. In stomach, the entrapped air of floatation chamber causes the delivery system to float over the gastric contents. Gastric fluid enters the system only through the pores, dissolves the drug and carries. The dissolved drug for continuous transport across the intestine for absorption.

#### **Alginate beads<sup>17</sup>:**

Multiple unit floating dosage forms have been developed from freeze-dried calcium alginate. Spherical beads of approximately 2.5mm in diameter were prepared by dropping a sodium alginate solution into aqueous solution of calcium chloride, causing a precipitation of calcium alginate. These beads were then separated; snap frozen in liquid nitrogen and freeze-dried at 40°C for 24 hrs, leading to formation of porous system that maintained structure for over 12 hrs. The floating beads gave a prolonged residence time of more than 5.5-10 hours.

#### **Hollow Microspheres<sup>17</sup>:**

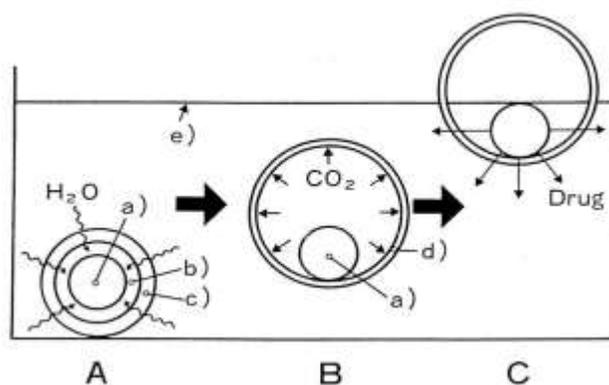
Hollow microspheres (micro balloons) for ibuprofen were prepared by novel emulsion solvent diffusion method. These micro balloons floated continuously for more than 12 hrs over the surface of acidic solution media that contained surfactant.

#### **Effervescent System FDDS<sup>18</sup>:**

These are matrix type of system, prepared with the help of swellable polymer such as methylcellulose and Chitosan and various effervescent compounds. Ex: sodium bicarbonate, tartaric acid, citric acid. These are formulated in such a way that when they come in contact with gastric content, CO<sub>2</sub> is liberated and gets entrapped in swollen hydrocolloid which provides buoyancy to dosage form. The design of this delivery system was based on swellable asymmetric triple layer tablet approach.

### (I) Gas Generating Systems:

These are low density FDDS which are based on the formation of CO<sub>2</sub> within the device following contact with body fluids. The materials are fabricated so that upon arrival in stomach, CO<sub>2</sub> liberated by acidity of the gastric content and is entrapped in the jellified hydrocolloid this produce upward motion of the dosage form and maintain its buoyancy. Decrease in specific gravity cause dosage form to float on the chyme. The CO<sub>2</sub> generating components may be intimately mixed within the tablet matrix in which case a single layer or bilayer is produced which contain the gas generating mechanism in one hydrocolloid containing layer and the drug in the other layer formulated for a sustained release effect.



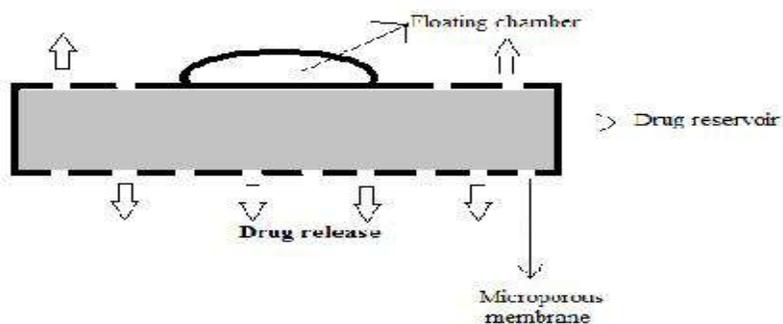
**Figure; Mechanism of floatation via CO<sub>2</sub> liberation**

**(II) Volatile Liquid Containing Systems:(Osmotically Controlled DDS)** As an Osmotically controlled floating system, the device comprised of a hollow unit that was alterable from a collapsed position after an extended period of time. A housing was attached to the deformable unit and it was internally divided into a first and second chamber with the chambers separated by an impermeable, pressure responsive movable bladder. The first chamber contains an active drug, while the second chamber contain a volatile liquid, such as cyclo pentane or ether that vaporises at physiological temperature to produce a gas. To enable the unit to exit from the stomach, the device contained a bio erodible plug that allowed the vapour to escape.

These are classified as:

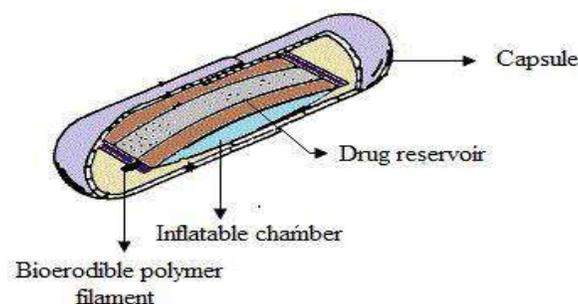
### Intra gastric floating gastrointestinal drug delivery system<sup>19</sup>:

This system contains a floatation chamber which contains vacuum or an inert, harmless gas and a micro-porous compartment enclosing drug reservoir. These are the type of floating gastro retentive drug delivery system in which gel forming hydrocolloids, polysaccharides and matrix forming polymers like polycarbonate, polystyrene, polymethacrylate etc. are used.



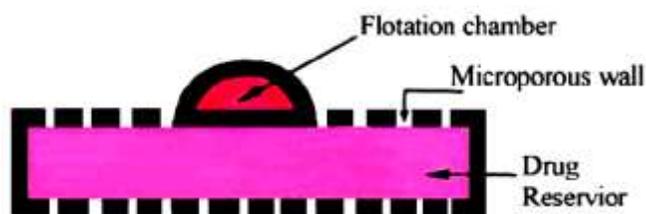
### b. Inflatable gastrointestinal drug delivery system<sup>19</sup>:

These systems contains inflatable chamber in which liquid ether is present, which are gasifiers at body temperature to inflate the stomach. Inflatable chamber contains bio erodible polymer filament (e.g. Copolymer of poly vinyl alcohol and polyethylene) that gradually dissolves in gastric fluid and finally cause inflatable chamber to release gas and collapse.



### c. Intra-gastric osmotically controlled drug delivery system<sup>19</sup>:

It is composed of osmotic pressure controlled drug delivery device and an inflatable floating capsule. In the stomach, inflatable capsule disintegrates and release the osmotically controlled drug delivery system which contains two components: drug reservoir compartment and osmotically active compartment.



## ADVANTAGES OF FLOATING DRUG DELIVERY SYSTEM<sup>19</sup>:

1. Enhance bioavailability.
2. Reduce dosing frequency.
3. Site specific delivery.
4. Reduced fluctuations of drugs concentration.
5. Minimize adverse activity at the colon.
6. Ease of administration and patient compliance.

## DISADVANTAGES OF FLOATING DRUG DELIVERY SYSTEM<sup>19</sup>:

1. Require high amount of fluid in stomach to float.
2. Not feasible for those drugs having solubility or stability problems in gastric fluids.
3. Drugs such as Nifedipine, which under goes first pass metabolism may not be desirable for the preparation of these types of systems.
4. Drugs which are irritants to gastric mucosa are also not suitable.
5. These systems do not offer significant advantages over the conventional dosage forms for drugs, which are absorbed throughout the gastrointestinal tract

## EVALUATION PARAMETERS<sup>20</sup>:

### *In-vitro* evaluation of tablets

#### **1. Buoyancy Lag Time:**

It is determined in order to know the time taken by the dosage form to float on the top of the dissolution medium, after it is placed in the medium.

#### **2. Floating Time:**

It is the time taken by the dosage form to float continuously on the dissolution media. This test is usually performed in SGF-Simulated Gastric Fluid in which the temperature is maintained at 37<sup>0</sup>C.

#### **3. Specific Gravity / Density:**

Density is usually determined by the displacement method, in which Benzene used as displacement medium.

#### **4. Swelling Index:**

After immersion of swelling dosage form into SGF at 37<sup>0</sup>C, dosage form is removed out at regular interval and dimensional changes are measured in terms of increase in tablet thickness /diameter with time.

#### **5. Water Uptake:**

It is an indirect measurement of swelling property of swellable matrix. Here dosage form is removed out at regular interval and weight changes are determined with respect to time. So it is also termed as Weight Gain.

$$\text{Water uptake} = \text{WU} = (\text{Wt} - \text{Wo}) * 100 / \text{Wo}$$

Where, Wt = weight of dosage form at time t

Wo = initial weight of dosage form

### 6. Weight variation:

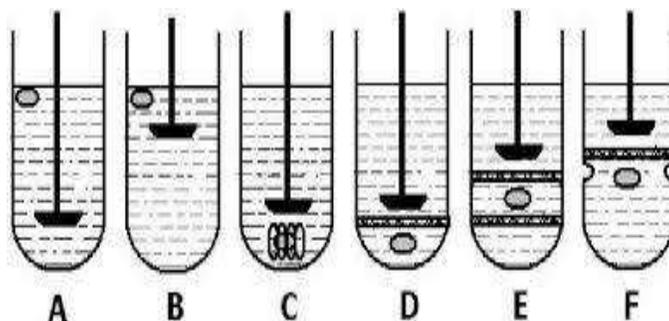
According to USP the weight variation test done by weighing 20 tablets individually. And then calculating the average weight and comparing the individual tablet weights to the average. Not more than 2 tablets can exceed the limit.

### 7. Hardness & friability:

Hardness is defined as the “force required to break a tablet in diametric compression test.” Hardness is also known as the tablet crushing strength. The devices which are used to test hardness are Monsanto tester, strong Cobb tester, Pfizer tester, etc. Friability of tablets can be determined by using Roche Friabilator. In this, a pre-weighed tablet sample is placed, which is then operated for 100 revolutions.

### 8. In-vitro Dissolution Tests:

*In-vitro* dissolution test is generally performed by using USP apparatus with paddle and GRDDS is placed normally as per other conventional tablets. But sometimes as the vessel is large and paddles are at bottom, there is much lesser paddle force acts on floating dosage form which generally floats on surface. If the floating dosage form does not rotate may not give proper result and also may not give reproducible result. Different types of transformation in dissolution assembly have made to produce reproducible results. They are as shown in following figure.



**Table: Technologies adopted for GRDDS<sup>21</sup>:**

Technology	Product	API
Bioadhesive tablets	Xifaxan	Rifaximin
Floating liquid alginate preparation	Topalkan	Aluminium magnesium antacid

Polymer-based swelling technology: Acu Form	Gabapentin GR	Gabapentin
Coated multi-layer floating and swelling system	Baclofen GRS	Baclofen
Bilayer Floating Capsule	Cytotec	Misoprostol
Colloidal Gel Forming FDDS	Convicon	Ferrus Sulphate
Gas Generating Floating Form	Cifran OD	Ciprofloxacin
Floating Capsule	Valrelease	Diazepam
Floating CR Capsule	Madopar	Levodopa and Sodium Bicarbonate
Floating Dosage Form	Almagate	Antacid
	Floatcoat	
Polymer-based swelling	Glumetza	Metformin HCL

## CONCLUSION:

Based on the recent literature, it is concluded that gastro-retentive drug delivery system offers various advantages for drug that has poor bioavailability, act locally in the stomach, poorly soluble in alkaline pH, well absorbed in the stomach, have a narrow window of absorption, gets degraded in the intestinal environment. They can be delivered competently thereby maximizing their absorption and enhancing their bioavailability. Increased GRT of a controlled release formulation has various practical applications. Gastro-retentive floating drug delivery systems have emerged as an effective means of enhancing the bioavailability and controlled delivery of many drugs. This floating drug delivery system based on effervescent and non-effervescent systems for variation of oral controlled drug delivery is found to have great importance. These systems have special additional advantages for the drugs that are mainly absorbed from the upper part of the GIT. With an improved knowledge of formulation aspects one can improve the bioavailability of the such drugs.

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