International Journal of Pharmaceutical Research and Applications
Volume 8, Issue 2 Mar-Apr 2023, pp: 305-316 www.ijprajournal.com ISSN: 2249-7781

A Comprehensive Review on Floating Drug Delivery System

1. Snehal M. Kankate 2. Shubhangi S. Mulane 3. Dr. Sachin Somwanshi
Pravara Rural Education Society's College of Pharmacy for Womens, Chincholi, Nashik-422102

Submitted: 09-03-2023 Accepted: 18-03-2023

ABSTRACT
The recent literature with some special interest on the principal mechanism of floatation to obtain gastric retention is the main purpose of writing this review on floating drug delivery systems (FDDS). The recent developments infloating drug delivery systems containing the physiological and formulation variables impacting on gastric retention time, approaches to formulating of single-unit and multiple-unit floating systems, and their classification and formulation aspects are discussed in detail. This review also summarizes evaluation parameters and application of floating drug delivery systems. These systems areuseful to several problems introduced during the formulations of a pharmaceutical dosage form.

INTRODUCTION

The solid oral dosage forms such as capsules, tablets gives specific drug concentration in Systemic blood circulation without getting any control over drug delivery system and also cause major fluctuations in plasma drug concentrations.[1] There are so many attempts have been performed to develop prolonged(sustained) release preparations with extended clinical effects and reducedfrequency of dose. A problem continuously encounteredwith conventional sustained release dosage forms is the residence time in stomach is unable to increase and there is no control over drug delivery of drug which leads to fluctuations in plasma drug concentration level. The most convenient and preferredmeans of any drug delivery to the systematic circulation is the oral Administration. To achieveimproved therapeutic advantages the oral controlled release drug delivery system have recently beenof increasing interest in pharmaceutical field, such as ease ofadministration of doses, patient compliance towards the product and flexibility informulation of drug.[2]Those drugs are eliminated quickly from the systemic circulation who are easily absorbed fromgastrointestinal tract (GIT) and have short half-life. To achieve suitable therapeutic activity in body these drugs is required frequent dosing.The development of sustained-controlled release oral formulations is to avoid this limitation and it is an attempt to release the drug slowly into the gastrointestinal tractand maintain the therapeutic drug concentration in the blood circulation for a long period of time.For to get maximum gastric retention of solid dosage forms is followed by the mechanisms of muco-adhesion, sedimentation, flotation,modified shapesystems,expansion,or by the simultaneous administration of pharmacologicalagents followed by gastric emptying. The classification of floating drug deliverysystems (FDDS) has been described in detail on the basis of these approaches. [1]To get the efficiency and application of such systems the in vivo/in vitroevaluation of FDDS has also been discussed by the researchers. With bioavailability problems severalrecent examples have also been reported showing the efficiencyof such systems for drugs. The diminished efficacy of the administered dose due to incomplete drug release from the DDS caused by the relatively short gastric residence time in humans (2–3h) through the major absorption zone such as proximal part of GIT. Thus, considerations have led to the development of oral controlled-release(CR) dosage forms possessing gastric retention capabilities are the control of location of a Drug delivery system, especially for drugs exhibiting an absorption window in the GI tract or drugs with a stability problem, in a specific region of the GI tract offers several advantages.[3] In this review the technological developments which are currently invented in floating drug delivery system and patented or clinically available products are also discussed.

International Journal of Pharmaceutical Research and Applications
Volume 8, Issue 2 Mar-Apr 2023, pp: 305-316 www.ijprajournal.com ISSN: 2249-7781

Physiology Of Gastrointestinaltract

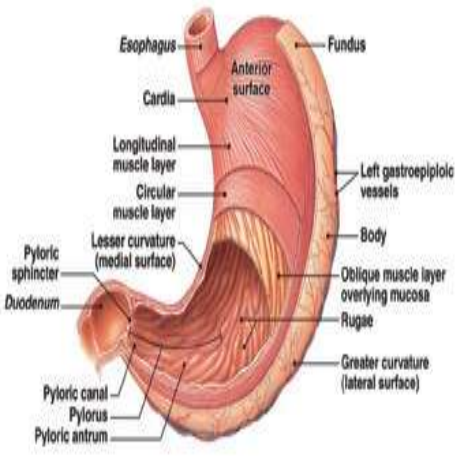

Figure 1: Anatomy of stomach

The stomach motility is distinct in 2 states. During fasting state, inter digestive series of electrical events takes place, which cycles both through stomach and intestine every 2 to 3 hours. This is called the interdigestive myoelectric cycle or migratingmyloelectric cycle (MMC), as described by Wilson and Washington (1989) it is further divided into following 4 phases.

1.Phase I (basal phase) with contractionsupto 40 to 60 minutes.
2. Phase II (pre burst phase) with intermittent action potential and contractions it lasts for 40 to 60 minutes and the intensity and frequency also increases gradually during the phase progresses.
3. Phase III (burst phase) It includes intense and regular contractions for short period and stays upto 4 to 6 minutes. It is also known as the house keeper wave because this wave doall the undigested material is swept out of the stomach down to the small intestine.
4. Phase IV It isoccurs between phases III and I of 2 consecutive cycles and last for 0 to 5 minutes. The pattern of contractions changes from fasted to that of fed stateafter taking mixed meal. This is also called as digestive motility pattern and bring outcontinuous contractions as in phase II of fasted state. These contractionsreduces the size of food particlesless than1mm, which are pushed toward the pylorus in a suspension form. During the fed state onset of migratingmyloelectric cycle is delayed resulting in reducedgastric emptying rate.[4]

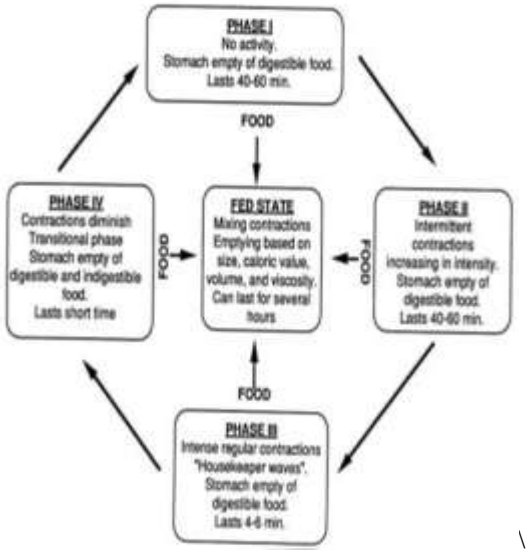

Figure 2: Schematic representation of myloelectric cycle

Needs for gastric retention
1) Drugs which are absorbed from the Upper part of the gastrointestinal tract (GIT).
2) Drugs which are less soluble in GIT or are degrades by the basic pH they administered at the Lower(distal) part ofGIT.
3) Drugs which are absorbed during the variable gastric emptying time. To treat certain conditions Local or sustained drugdelivery to the stomach and small intestine.
4) Mostly very useful for the treatment of peptic ulcers caused by Helicobacter Pylori Infections.[2]

FLOATING DRUG DELIVERY SYSTEMS (FDDS):
These formulations have very low density and so float over the gastric materials.
1. Bioadhesive systems: They arefix with stomach mucosa and hence, gives the localized retention of the system.
2. Swelling systems: These systems absorb water and get enlarged size by swelling.
3. High density systems: These arestays in the stomach for longer period of time, by settling down to the folds of stomach.[2][4]

Floating systems are low density systems that have maximum buoyancy to float on the gastricmaterial and remain in the stomach for longer period of time. During the system hang over the gastric contents, the drug is released sustainly with desired rate, which results in elevated gastric retention time and minimizes fluctuation also.A

International Journal of Pharmaceutical Research and Applications
Volume 8, Issue 2 Mar-Apr 2023, pp: 305-316 www.ijprajournal.com ISSN: 2249-7781

minimumstomachic content required to allow the proper achievement of the buoyancy retention principle, a minimum floating force (F) is also required to keep the dosage form to be buoyant on the Surface of the gastric content. A novel apparatus for determination of resultant weight has been reported to measure the kinetics of floating force. The apparatus works by measuring the force equivalentto F (as a function of time) that is required to maintain the submerged dosage form. The drug floats efficiently if force F is on the higher positive.

F = F (buoyancy) – F (gravity)

= (DF – Ds)g.v---------- (1)

Where, F= total vertical force,
DF = fluid density,
Ds= objectdensity,
v= volume
and g = acceleration due to gravity.

These are oral dosage forms (capsule or tablet) that are designed to prolong the retention time of the drug within the GI tract . The recent literature survey shows that interest increased in academics and industrial research regarding the development of novel dosage forms that can be sustained in the stomach for a longer and predictable period of time.The numerous marketed FDDS are given in table 1.[7]

Brand name	Delivery system	Drug	Company name
Almagate Flot coat®	Floating dosage form	Al-Mg Antacid	
Cifran OD®	Gas-generating floating form	Ciprofloxacin	Ranbaxy, India
Convoron®	Colloidal gel forming FDDS	Ferrous sulphate	Ranbaxy, India
Cytotech®	Bilayer floating capsule	Misoprostol	Pharmacia, USA
Liquid Gaviscon®	Effervescent Floating liquid alginate preparations	Al hydroxide, Mg carbonate	Glaxosmithkline, India
Madopar ®HBS (Prolopa®HBS)	Floating, CR capsule	Benserazide and L-Dopa	Roche Products, USA
Oflin OD®	Gas generating floating tablet	Ofloxacin	Ranbaxy, India
Topalkan®	Floating liquid alginate preparation	Al-Mg antacid	Pierre FabreDrug, france
Valrelease®	Floating capsule	Diazepam	Hoffmann-LaRoche, USA

Table 1: Marketed FDDS

CLASSIFICATION OF FDDS

(A) Effervescent FDDS
1. Gas generating system
2. Volatile liquidcontaining system

(B) Non- Effervescent FDDS
1. Colloidal gel barrier system
2. Microporous compartment system
3. Floating microsphere
4. Alginate floating beads.

(C) Raft forming system

FACTORS AFFECTING THE GASTRIC EMPTYING

1. Density
2. size
3. shape of the dosage form
4. Simultaneousintake of the food and its nature, caloric content and frequency of intake
5. Biological factor such as gender, posture, age, sleep, physical activity, body weight, and disease states (e.g. B.P, diabetes).[6]

a) Effervescent floating dosage forms

These systems are matrix typeswhich are prepared by using various effervescentcompounds like Sodium carbonate, Calcium carbonate,Tartaric acid and Citric acid and swellable like HPMC, methyl cellulose andchitosan based polymers. These dosage forms are formulated in such away that when it comes in contact with the acidic gastric contents, CO_2 liberation takes place and this gas entrapped in to theswollen hydrocolloids network which gives buoyancy to the dosage forms such as Amlodipine besylatewhich is shown in figure no 3 (a).

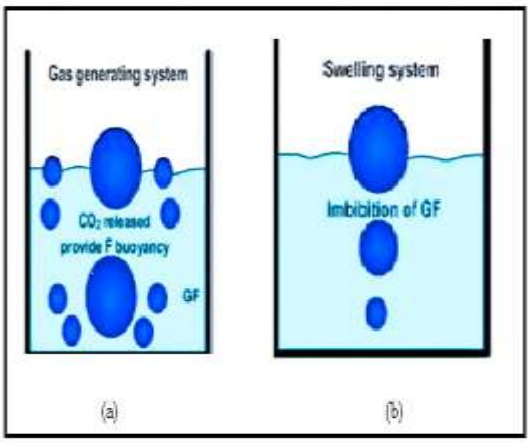

Figure 3: (a) Effervescent Systems (b) Swelling Floating System

International Journal of Pharmaceutical Research and Applications
Volume 8, Issue 2 Mar-Apr 2023, pp: 305-316 www.ijprajournal.com ISSN: 2249-7781

b) Non effervescent floating dosage form

These dosage forms made from gel forming or swellablehydrocolloids (cellulose type),polysaccharides andpolymers which forms matrix like polymethacrylate, polycarbonates and polystyrene. The formulation is made bymixing the drug and the gel-forming polymers, afteradministration by orally of this dosage form get swells during in contact with gastric content. The buoyancy of solid dosage form was achieved due to the air entrapment in to theswollen gel like structure acts as a reservoir and allows slowly release of drug throughthe polymer masswhich is shown in figure no. 3 (b).[5]

METHODS OF PREPARATION

1) Solvent evaporation method

For to create hollow inner core the floating multi-particulate dosage form was prepared by solvent diffusion and evaporation methods. The polymer was dissolved in an organic solvent and then drug is dissolved inprepared polymer organic solution. Then drug solution is emulsified after into an aqueous phase which containing PVA (Polyvinyl alcohol) to form O/W emulsion,After that the organic solvent is evaporated by increasing the temperature or by continuous stirring. The solvent elimination leads toprecipitation of polymer at the oil in water (O/W) interface of droplets, by the formation of cavity and thus made them hollow to introduce the floating properties. The polymers considered for the development of such floating systems include Cellulose acetate, Chitosan, Polyvinyl acetate, Acrycoat, Methocil, Eudragit, Polyacrylates, Carbopol, Polycarbonates, Polyethylene oxide and Agar. Floating microparticles consisting of Polypropylene foam powder, Theophylline (as the model drug) and Eudragit RS, ethyl cellulose or polymethylmethacrylate(PMMA) were prepared with an O/W solvent evaporation method (Figure no. 4a). Therate-controlling polymer and drug were dissolved in Methylene chloride. After that polypropylenepowder was then dispersed within prepared organic phase. The final suspension was further emulsified into an another aqueous PVA (polyvinyl alcohol) solution.The macroparticles were separated by sieving method and give washing with cold water and dried them in a desiccator with sufficient amount of silica gel; they are all irregular in shape and size with highly porous structure. Majorly, the drug combining efficiency was high and almost independent of the theoretical assumption of drug loading in the system.A broad spectrum of drug release patterns can be obtained with the evaluation of formulations. Major benefit of the such novel preparation technique include short preparation time, no exposure of the component to high temperatures, the tendency to avoid toxic organic solvents and high drug combiningefficacy (near to 100%). Floating microparticle system consisting of polymer foam powder, model drug (e.g.Chlorpheniramine maleate) and a secondary polymer [Polymethyl methacrylate)] were prepared by soaking microporous foam particles with an organic solution containing drug and polymer(Figure 4b). Additionally, the low- density microparticles can be compressed into fastly disintegrating tablets, providing an easily administrable oral dosage form.

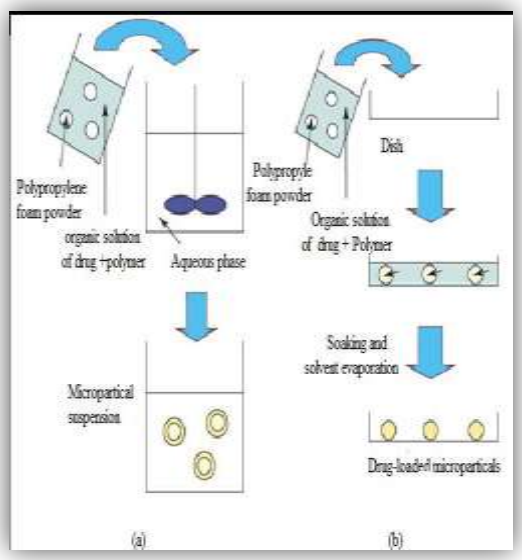

Figure 4: Schematic presentation of the preparation of floating microparticles based on low-density foampowder, using (a) The solvent evaporation method or (b)The soaking method.

2)Ionotropic gelation method

The mechanism of Ionotropic gelation is depend on the ability of polyelectrolytes to cross link with presence of counter ions leads to formation of beads. Since, the use of Alginates, Chitosan, CMC and Gellan gum for the encapsulation of drugs this gelation technique has been widely used for preparation of the beads. These anions forms mesh like structure by combining with the polyvalent cations and insert gelation by combining mainly to the anion blocks. The hydrogel beads are prepared by dropping a

International Journal of Pharmaceutical Research and Applications
Volume 8, Issue 2 Mar-Apr 2023, pp: 305-316 www.ijprajournal.com ISSN: 2249-7781

drug-loaded polymer solution into the polyvalent cationic aqueous solution. The introduction of biomolecules can also be possible into these beads under mild conditions to maintain their 3D structure. The schematic representation of ionotropic gelation method is shown in figure 5.[6]

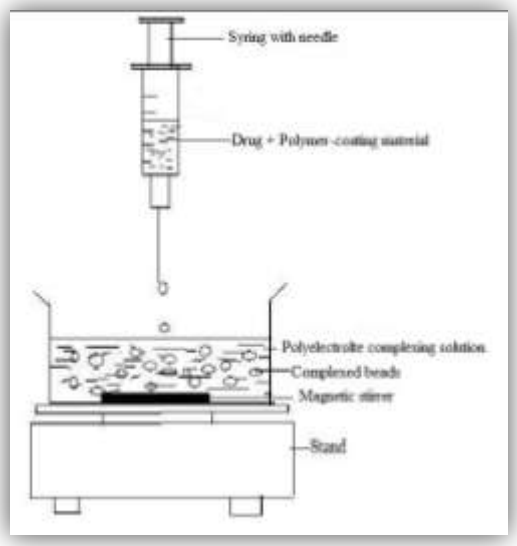

Figure 5: Ionotropic gelation method

3) Emulsion solvent diffusion method

Microballoons (hollow microspheres) with drug in their outer polymer shell prepared by novel emulsion solvent diffusion method. The preparation procedure and mechanism of microballoon formation is schematically illustrated in Figure no. 6. A solution of polymer and drug in ethanol methylene chloride is poured into an agitated aqueous solution of poly (vinyl alcohol). The subsequent evaporation of the entrapped methylene chloride leads to the formation of internal cavities within the microparticles.[6]

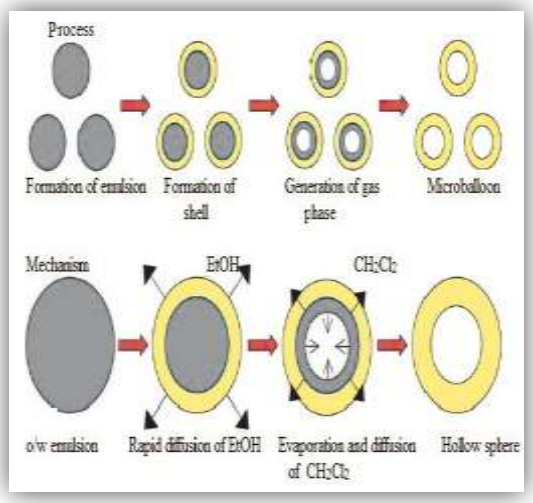

Figure 6: Preparation technique (emulsion-solvent diffusion method) and mechanism of 'microballoon'formation.

Evaluation of floating drug delivery systems[8]

1. Angle of Repose: Angle of repose used to calculate powder flowability by assessing interparticular friction.If angle of repose is higher then poor is the flowability of powder. Determination of angle of repose of each powder blend was performed by glass funnel method, using following equation,

$$\tan\theta = \frac{h}{r}$$

Where, θ- angle of repose,
h - height of pile above the flat surface,
r - radius of the circle formed by the powder blend.

2. Bulk Density: It is ratio of mass of microsphere to bulk volume of microsphere. Bulk density pf powder may vary dissolution and other properties and depends on the particle size, shape and affinity of particles to adhere together one. The bulk density of beadswas calculated by following equation,

$$\text{Bulk density} = \frac{Mass\ of\ microspheres}{Bulk\ volume}$$

3. Tapped density: Tapped density used to determine flowability and packing geometry of formulation. Tapped density is the ratio of weighed amount of sample and volume of powder determined by tapping using measuring cylinder. Tapped density of formulated beads was calculated by following equation,

International Journal of Pharmaceutical Research and Applications
Volume 8, Issue 2 Mar-Apr 2023, pp: 305-316 www.ijprajournal.com ISSN: 2249-7781

$$\text{Tapped density} = \frac{Mass\ of\ microspheres}{Volume\ of\ microspheres\ after\ tappin}$$

4. Carr's compressibility index: This is anvery important property in maintaining uniform weight of dosage form. It is calculated using following Equation,

$$\text{Carr, s Index} = \frac{Tapped\ density - Bulk\ density}{Tapped\ density} x100$$

Table 2: Carr's compressibility index:

Carr's (compressibility index)	Flowability
5-15	Excellent
12-16	Good
18-21	Fair to passable
23-35	Poor
33-38	Very poor
>40	Extremely poor

5. Hausner's ratio: It is the ratio of tapped density and bulk density. Hausner's ratio less than 1.25 shows good flow and greater than 1.5 shows poor flow property whereas between 1.25 and 1.5 indicates intermediate glidant flow. Hausner's ratio can be calculated by formula,

$$\text{Hausner, s Ratio} = \frac{Tapped\ density}{Bulk\ density}$$

6. Morphology study: For characterization of surface of prepared beads Scanning Electron Microscopy (SEM) was performed. Beads are mounted directly onto the sample pan and coated with gold ion to analyze it for surface morphology.

7. Particle size analysis: The particle size of formulated beadswere measured by an optical microscope fitted with calibrated eyepiece and stage micrometer along with particle size distribution was calculated.

8. Determination of Percentage yield : The formulated beads were collected and weighed. The measured weight was divided by the total amount of all ingredient, which were used for the formulation of the beads.

$$\text{Percentage Yield} = \frac{Actual\ weight\ of\ products}{Weight\ of\ drug\ and\ excipients} x100$$

9. Drug Entrapment Efficiency: Beads containing 100 mg equivalent of the drug were taken for evaluation purposes. The amount of drug entrapped was calculated by extracting crushed beads with aliquots of 0.1N HCl repeatedly. The resultant extract was transferred to a 100 ml volumetric flask and the final volume was made up to 100ml using 0.1N HCl. The solution was then filtered and the absorbance was measured at λ_{max}wavelength against appropriate blank. The amount of drug entrapped in the beads was calculated by the following formula,

$$\text{Drug entrapment efficiency} = \frac{Amount\ of\ drug\ actually\ present}{Theoretical\ drug\ loaded\ expected} x100$$

10. In vitro buoyancy study: Beads (300mg) were put over the surface of a USP dissolution apparatus type II filled with 900 ml of 0.1 N HCl containing 0.02% Tween 80 solution. The solution was stirred with a paddle rotating at 100 rpm for 12 hr. The floating and the settled part of beads were recovered separately and they were dried and weighed separately. Buoyancy percentage was calculated as the ratio of the mass of the floating beads and the total mass of the beads.

$$\%\ \text{Buoyancy} = \frac{Qf}{Qf + Qs} x100$$

Where,
Qf =Weight of floating beads
Qs =Weight of settled beads

11. In-vitro drug release study: The drug release study from formulated beads is performed with the help of USP dissolution apparatus Type I in 900 ml of 0.1 N HCl dissolution media (pH- 1.2) at 100 rpm and 37°C temperature. 2 ml sample was withdrawn at every1 hr. time interval for 12 hr and same volume of fresh solution was replaced to maintained sink condition. Withdrawn samples were assayed spectrophotometrically at suitable wavelength. The drug release by beads was analyzed by UV spectro- photometer.

12. Determination of Moisture Content : Moisture content study was performed by using an

International Journal of Pharmaceutical Research and Applications
Volume 8, Issue 2 Mar-Apr 2023, pp: 305-316 www.ijprajournal.com ISSN: 2249-7781

IR moisture balance by placing the beads at 60 °C for 10 min.

14. Drug-excipient interaction It is measured by using FTIR and HPLC. Appearance of a new peak and/or disappearance of original drug peaks or excipient peaks indicate the drug excipient interaction.

15. Floating lag time: It is the time taken to float tablet onto the surface of medium after it is kept in to the dissolution medium. It is measured in minutes or seconds.

16. In vivo evaluation of gastric retention: The position of the dosage form in the GIT is analyze by an imaging technique such as γ-scintigraphy and X-ray. In γ-scintigraphy, a small amount of stable isotope is mixed in the dosage forms during its preparation. The radiation of a γ- emitting radio-nuclide in a formulation allows indirect external observation using a γ-camera or scinti scanner. For x-ray analysis, barium sulphate is used as a contrast medium. It helps to locate dosage form in the Gastrointestinal tract by which prediction and correlation of the gastric emptying time and the passage of dosage form can be done. In addition, gastro-endoscopy and ultrasonography studies can be included in the in vivo evaluation of gastric retention systems. Gastroscopy comprises of per-oral endoscopy, used with ocular and video systems. Ultrasonography is not routinely used in the evaluation of such systems. In vivo plasma profiling of drug can also be obtained by performing the study in suitable animal model. [3]

17. Water uptake study: It is performed by introduction the dosage form in simulated gastric fluid at 37^{o}C and study the dimensional changes, such as diameter and thickness, at regular interval of time. The swollen beads are weighed and water uptake is calculated in the terms of percentage weight gain, as given:

$$Wu = \frac{(Wt.-Wo) \times 100}{Wo}$$

Where, Wt and Wo are the weight of the tablet after time t and initially, respectively

Advantages of Floating Drug Delivery:

1. Enhancement bioavailability of drug: The bio-availability of some drugs for e.g. LevodopaIn controlled release –gastric retention drug delivery is significantly increases in comparison to administration of non-gastric retentive polymeric formulations.
2. Enhancement First-Pass hepatic biotransformation: When the drug is presented to the metabolic enzymes (cytochrome P-450, in particular CYP-3A4) in a controlled manner, the pre- systemicmetabolism of the drug may be considerably increased rather than by a bolusinput.
3. Sustained delivery of drug dosing:
4. Targeted drug therapy for local ailments in the proximal GI tract: The prolonged and sustained administration of the drug from floating system to the stomach may be useful for local therapy in the stomach. [2]
5. Reduced variation inplasma drug concentration: The fluctuations in plasma drug concentration are reduces, and concentration-dependent adverse effects that are comes with peakconcentrations can also be minimizes
6. Reduced counter-activity of human body: Slow release of the drug into the body reducesthe counter activity caused due to higher drug efficiency.
7. Extended time over effective concentration: The sustained mode of administration enables prolongation of the time
8. Improvement in Receptor activation selectivity: FDDS decreases the drug concentration variation over a critical concentration and thus increases the pharmacological effects.[7]
9. Reduced adverse activity at the intestine: Retention of the drug in gastric retentive formulation at stomach, minimizes the amount of drugs that reaches the colon and hence prevents the degradation of drug that may degraded in the colon.
10. Site specific Delivery of drug
11. Gastro retentive drug delivery can produces prolong and sustain release of drugs from dosage forms which provide local therapy in the GIT.
12. The controlled, slow delivery of drug form gastroretentive dosage form provides sufficient local action at the diseased site, thus minimizing or eliminating systemic exposure of drugs. 13. This sitespecific drug delivery decreases side effects of drug.

14. Gastroretentive dosage forms minimize the fluctuation of drug concentrations and side effects. Therefore, concentration dependent side effects that are related with maximum concentrations can be prevented.

International Journal of Pharmaceutical Research and Applications
Volume 8, Issue 2 Mar-Apr 2023, pp: 305-316 www.ijprajournal.com ISSN: 2249-7781

15. Gastroretentive drug delivery can minimize the counter activity of the body leading to higher drug efficiency.
16. Reduction of fluctuation in drug concentration makes it possible to obtain improved selectivity in receptor activation.
17. The sustained mode of drug release from Gastroretentive doses form enables extension of the time over a critical concentration. [11]

APPLICATIONS

Floating multiparticulate drug delivery gives several applications for drugs having poor bioavailability because of the narrow absorption window in the upper part of the GI tract. It retains the dosage form at the site of absorption and thus increases the bioavailability of drug. These are summarized as follows.

1) Sustained drug delivery

Hollow microspheres of NSAID are very effective for controlled release as well as it reduces the major side effect of gastric irritation; e.g.floating microspheres of Indomethacin are more beneficial for rheumatic patients.

2) Site-specific drug delivery

These systems are particularly useful for drugs that are specifically absorbed fromstomach or the proximal part of the small intestine. Bilayer-floating capsule was developed for local delivery of Misoprostol, which is a synthesized from prostaglandin E1 and as a gastric ulcersprotective caused by administration of NSAIDs.

3) Absorption enhancement

Drugs which have poor bioavailability because of site- specific absorption from the proximal part of the GI tract are potentially strong candidates to be formulated as floating drug delivery systems, thereby maximizing their absorption.[11]

INNOVATIVE TECHNOLOGIES FOR FDDS

1. **Oleotec™ and Soctec™ :**Oleotec™ and Soctec™ gastro-retentive capsule technology are innovated by Skyepharma company. ForDrugs having high therapeutic doses, OleotacTM technique is designed but it is not suitable for the conventional dosage form. Drugs that show effect primarily in the proximal part of the gastro intestinal tract are developed by this technique. Oleotec system is basically a gel incorporated in the form of stick pack that forms a continuous layer at walls of the stomach. SoctecTM system is designed for the drugs that should be administered as controlled release and should be absorbed in the proximal part of intestine for increasing the bioavailability of drug. Soctec is an elongated capsule fill with drug. It can be used with a range of drugs that have a short absorption window and are preferably absorbed in the proximal intestine fragment. It can also improve the bioavailability of drugs that are degraded by the basic pH of the distal part of GIT.

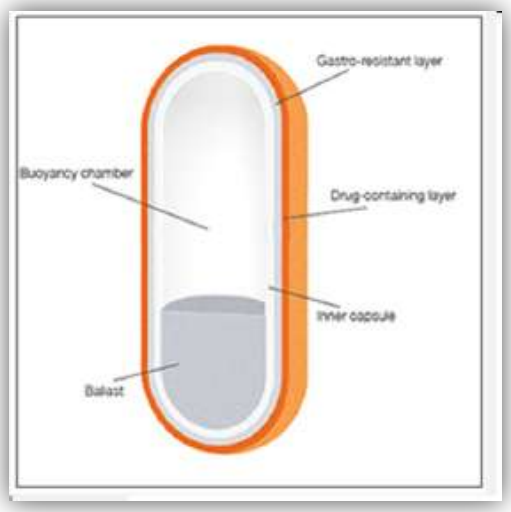

Figure 7: SoctecTMGastro retentive capsule

2. **Accordion Pill™ Technology:** This is a versatile gastro adhesive formulation composed of the biodegradable polymers. It is a multi-layer, planar structure, folded to an accordion shape into regular standard size capsule. When capsule reachesto the stomach, it dissolves, the folded pill unfolds and is sustained in the stomach last up to 12 hours. During it is in the stomach, the pill releases the drug in a controlled manner towards the proximal part of the GI tract which gives prolonged and continuous absorption phase of the drug in the upper part of the GI tract, resulting in increased efficacy and safety profiling, as well as reducing frequency dosing.The drug release mechanism is not dependent on the Accordion pill™ retention mechanism. After the Accordion Pill™ is expelled from the stomach, it is get degraded

International Journal of Pharmaceutical Research and Applications
Volume 8, Issue 2 Mar-Apr 2023, pp: 305-316 www.ijprajournal.com ISSN: 2249-7781

in the intestinal media. Drugs which are belonging to the BCS Class II and BCS Class IV are more preferable for this system.

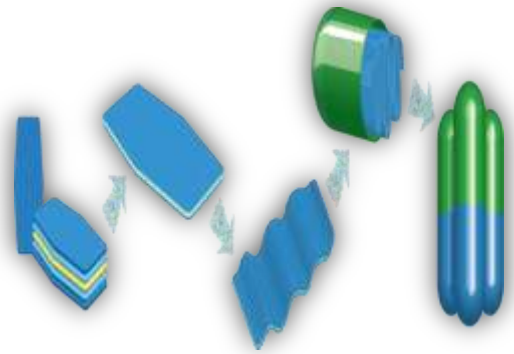

Figure 8: Accordion Pill™ Technology

3. **Gastro Retentive Innovative Device (GRID):** Gastro Retentive Innovative Device (GRID) is an ideal once-a-day system for drugs that are otherwise absorbed only in stomach or small intestine. GRID is designed so that drug is retained in the stomach for over an eight-hour span. Longer retention in stomach improves the drug absorption. The tablet offers a combination of instant and sustained drug release profiles, and being once a day improves patient compliance. This innovative system is a dosage form with specialized multiple coatings. On ingestion of the dosage form along with food, it floats instantaneously on the gastric contents. GRID's coatings are activated by gastrointestinal fluid, eventually leading to swelling, to about eight to eleven times its initial volume. Plasma concentrations for medicines are thus maintained in the therapeutic range for a prolonged period; hence this dosage form can be used as a "Once-a- day" system. Specific release profiles for drugs can be tailored to achieve combination of immediate and slow release using this innovative dosage form. Retention of the dosage form close to its site of absorption may help in reducing the dose and thus the side effects.

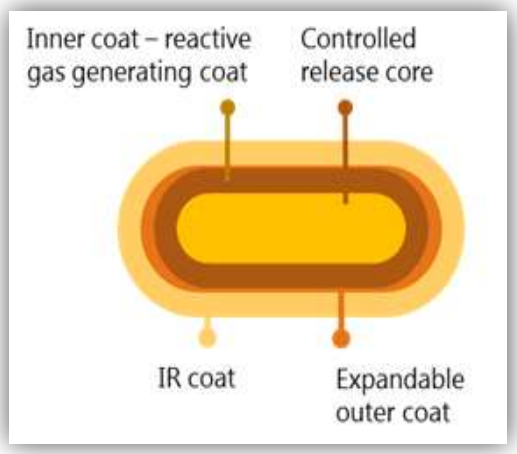

Figure 9: Gastro Retentive Innovative Device

4. **Multiple Polymers Hydrophilic Matrix Technology:** Multiple polymer hydrophilic matrix technology is a sustained gastro drug delivery system. Cetapin XR is a formulation of this system patented by Sanofi which contain Metformin XR as a drug , to achieve extended release of Metformin hydrochloride. The polymers are made by combining non-ionic and ionic hydrophilic polymers. The drug release from the matrix pore occurs through a process of dissolution of the drug and undergoing diffusion through the gel matrix in a sustained manner. This technology gives consistent and reproducible results with goodoptimal absorption, minimum irritation, increased plasma drug levels andgood bioavailability.

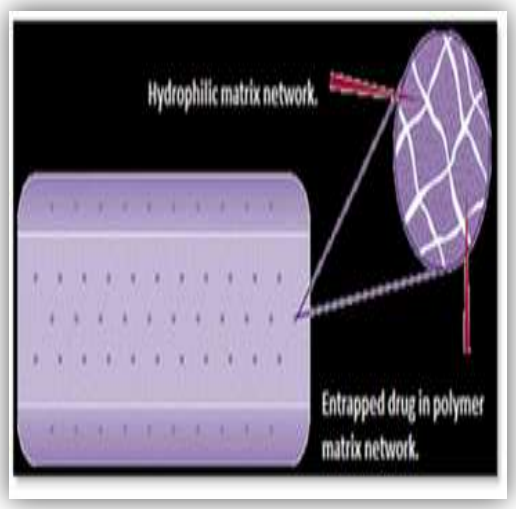

Figure 10: Hydrophilic Matrix Technology

International Journal of Pharmaceutical Research and Applications
Volume 8, Issue 2 Mar-Apr 2023, pp: 305-316 www.ijprajournal.com ISSN: 2249-7781

5. **Acuform® technology:** Acuform® is formulated patented by Depomed's. it is a polymer-based technology formulated to optimize drug delivery in GIT. This technology permittargeted and controlled delivery of drug to the proximal (upper)GIT which is the preferable absorption site for many oral drugs. In particular, for drugs that are absorbed in the upper GI region this technology is an effective delivery solution. It is also valuable for drugs insoluble in water,irritating for mucosa of the small intestines or not safe in the distal GIT region and it is more effective when plasma drug levels have less fluctuation.

6. **Gastrointestinal Permeation Enhancement Technology:** Gastrointestinal Permeation Enhancement Technology (GIPET) is developed by Merrion Pharmaceutical's and it is unique approach which allows drugs that now can onlybe injected by parenterally (injectable).For to converted into oral solid formse.g. tablet/capsule, as well as enhance theabsorption of oral drugs. Gastrointestinal Permeation Enhancement Technology uses selectivelyformulated oral formulations absorption enhancers which activates micelle formation undergoing transport of drug and increasing absorption with good reproducibility and a strong safety profile.

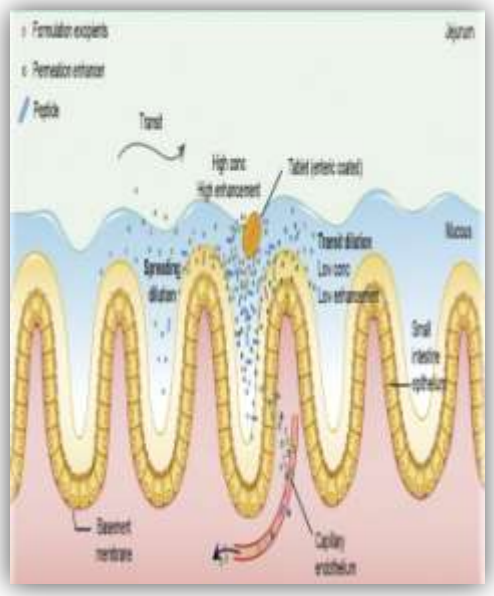

Figure 11: Gastrointestinal Permeation Enhancement Technology

7. **Micropump Technology:** Flamel's Micropump® platform felicitate either sustained, or both delayed andsustained, delivery of small molecule drugs through oral route. Micropump consists of a multiple-particulatesystem which having 5,000 to 10,000 microparticles per capsule or tablet. The microparticles having 200-500 microns diameter size release the drug at an adjustable rate and over an prolonged period of time.Micropump's key includes extended release in the Gastrointestinal tract allowing mean plasma retention timesto be prolonged for up to 24 hours.

REFERENCES

[1]. Juhi Dubey and Navneet Verma,Floating Drug Delivery System: A Review, 10.13040/Ijpsr.0975-8232.4(8).2893-99

[2]. Bhavjit Kaur, Shivani Sharma, Geetika Sharma, Rupinder Saini, Sukhdev Singh, Meenu Nagpal, Upendra K Jain, Mandeep Sharma. A Review of Floating Drug Delivery System. Asian Journal of Biomedical and Pharmaceutical Sciences 03 (24); 2013; 1-6

[3]. A.R.Dhole*, P.D.Gaikwad, V.H.Bankar, S.P.Pawar,A Review On Floating Multiparticulate Drug Delivery System – A Novel Approach To Gastric Retention,Volume 6, Issue 2, January – February 2011; Article-037.

[4]. Amit Kumar Nayak *, Ruma Maji, Biswarup Das,Gastroretentive drug delivery systems: a review,Vol.3 Issue 1, January-March 2010.

[5]. Shweta Arora,1 Javed Ali,1 Alka Ahuja,1 Roop K. Khar,1 and Sanjula Baboota1,Floating Drug Delivery Systems: A Review,AAPS PharmSciTech 2005; 6 (3) Article 47.

[6]. Purnima Tripathi*1,U.Ubaidulla2,Roop Kishan Khar3,Vishwavibhuti1,FLOATINGDRUG DELIVERY SYSTEM,Purnima et.al., March-April, 2012, 1(1), 1-10.

[7]. Chikhalikar SS and Wakade RB: Floating Drug Delivery System – An Approach To Oral Controlled Drug Delivery. International Journal of PharmTech Research 2012; 4(4) 1812-26.

International Journal of Pharmaceutical Research and Applications
Volume 8, Issue 2 Mar-Apr 2023, pp: 305-316 www.ijprajournal.com ISSN: 2249-7781

[8]. Setia M, Kumar K, Teotia D, Gastro-retentive floating beads a new trend of drug delivery system, Journal of Drug Delivery and Therapeutics. 2018; 8(3):169-180

[9]. A.Badoni, A. Ojha , G. GnanarajanI , P. KothiyaI, Review on Gastro Retentive Drug Delivery System, Vol. 1 No. 8 2012,32-42.P. D. Bairagi1*, S. B. Gondkar1, R.B. Saudagar2,floating beads as a magical drug carrier: a review,ajperjanuary – March 2018, Vol 7, Issue 1 (1-17)

[10]. M Sharath, Chandra Goud and V P Pandey,Review Article On Gastroretentive Drug Delivery System,Ijpbs,Volume 6,Issue 3,JUL-SEP 2016,158-165.

[11]. B M Singh and K H Kim, Floating drug delivery systems: an approach to oral controlled drug delivery via gastric retention. J Control Release 2000; 63:235-259.

[12]. Chudiwal V, Shahi S, Chudiwal S and Ahale D. Innovative Technologies for Gastro-Retentive Drug Delivery Systems. Asian Journal of Pharmaceutical Education and Research. 2017; 6(4): 22-28.

[13]. Rouge N, Allemann E, Gex-Fabry M, Balant L, Cole ET, Buri P, Doelker E. Comparative pharmacokinetic study of a floating multiple-unit capsule, a high density multiple- unit capsule and an immediate-release tablet containing 25 mg atenolol. Pharm Acta Helbetiae 1998; 73: 81-7.

[14]. Streubel A, Siepmann J, Bodmeier R. Gastroretentive drug delivery system. Expert Opin Drug Deliv 2006; 3(2): 217-33.

[15]. J M Patil, R S hirlekar, P S Gide and V J Kadam, Trends in floating drug delivery systems. J SCI IND RES; 2006; 65.

[16]. Ichikawa M, Watanabe S, Miyake Y, A new multiple unit oral floating dosage system I: Prepration and in-vitro evaluation of floating and sustained-release kinetics, J. Pharm. Sci. 1991, 80, 1062-1066.

[17]. Narang N: AN Updated Review On: Floating Drug Delivery System (FDDS). International Journal of Applied Pharmaceutics 2011; 3(1): 1-7.

[18]. Dwivedi S and Kumar V: Floating Drug Delivery Systems- A Concept of Gastroretention Dosages Form. International Journal of Research in Pharmaceutical and Biomedical Sciences 2011; 2(4): 1413-26.

[19]. Pare A, Yadav SK and Patil UK: Formulation and Evaluation of Effervescent Floating Tablet of Amlodipine besylate. Research Journal of Pharmaceutics and Technology 2008; 1(4):526-30.

[20]. Klusner EA, Lavy E, Friedman M, Hoffman A. Expandable gasrtroretentive dosage forms. J Control Release 2003; 90(2): 143-62.

[21]. S Sungthongjeen, P Ornlakasana, Limmatvapirat, Puttipipatkhachorn, Preparation and in vitro evaluation of multiple unit floating drug delivery system based on gas formation technique. Int J Pharm; 2006; 324; 136-143.

[22]. P R Nepal, M K Chun, H K Choi. Preparartion of floating microspheres for fish farming. Int J Pharm; 2007; 341; 85-90.

[23]. Whiteland L, Fell JT, Collett JH. Development of gastroretentive dosage form. Eur J Pharm Sci 1996; 4(suppl.): S182.

[24]. Moes A. Gastroretentive dosage forms. Crit Rev Ther Drug Carrier Syst 1993; 10: 143-95.

[25]. Chandel A, Chauan K, Parashar B, Kumar H, Arora S. Floating Drug delivery System: A Better Approach. International current Pharmaceutical Journal. 2012; 1, 104-115.

[26]. Jayanthi G, Jayaswal SB, Srivastava AK. Formulation and evaluation of terfenadine microbaloons for oral controlled release. Pharmazie, 1995; 5, 769-770.

[27]. Mitra SB, Sustained release oral medicinal delivery device, US Patent 4, 451, 260, May 29, 198

[28]. Baumgartne S, Kristl J, Vrecer F, Vodopivec P, Bojan Z. Optimisation of floating matrix tablets and evaluation of their gastric residence time. European Journal of Pharmaceutics and Biopharmaceutics. 2008; 2, 708–717.

[29]. Pradeep K. Nimase, Vidyasagar G. Preparation and evaluation of floating calsium alginate beads of Clarithromycin,

Pelagia Research Library. 2010, 1(1), 29-35.

[30]. Binoy B, Jayachandran Nair CV. Floating drug delivery system- A new approach in gastric retention- A review, J Drug Delivery Res. 2012, 1(3), 18-31.

[31]. Kakar S, Singh R, Shallusandhan. Gastroretentive drug delivery systems: A review, African J Pharma and Pharmacology. 2015, 9(12), 405-417.