A REVIEW ON FLOATING DRUG DELIVERY SYSTEM

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ABSTRACT
Management of infirmity through medication is entering a new era in which growing number of novel drug delivery systems are being employed and are available for therapeutic use. Oral sustained release gastro-retentive dosage forms (GRDFs) offer many advantages for drugs with absorption from upper parts of gastrointestinal tract and for those acting locally in the stomach, improving the bioavailability of the medication. Floating Drug Delivery Systems (FDDS) is one amongst the GRDFs used to achieve prolonged gastric residence time. The purpose of writing this review on floating drug delivery systems (FDDS) was to compile the recent literature with special focus on the principal mechanism of floatation to achieve gastric retention. The recent developments of FDDS including the physiological and formulation variables affecting gastric retention, approaches to design single-unit and multiple-unit floating systems, and their classification and formulation aspects are covered in detail. This review also summarizes the in vitro techniques, in vivo studies to evaluate the performance and application of floating systems, and applications of these systems.

Keywords: Floating drug delivery systems, classification, patents.

INTRODUCTION
Gastric emptying of dosage forms is an extremely variable process and ability to prolong and control emptying time is a valuable asset for dosage forms, which reside in the stomach for a longer period of time than conventional dosage forms. Several difficulties are faced in designing controlled release systems for better absorption and enhanced bioavailability. One of such difficulties is the inability to confine the dosage form in the desired area of the gastrointestinal tract. Drug absorption from the gastrointestinal tract is
a complex procedure and is subject to many variables. It is widely acknowledged that the extent of gastrointestinal tract drug absorption is related to contact time with the small intestinal mucosa. Thus small intestinal transit time is an important parameter for drugs that are incompletely absorbed\[1\].

Delivery of drugs at a specific region in gastrointestinal tract, the so called absorption window needs the development of gastro retentive dosage forms \[1-2\]. The attempts to develop gastro retentive drug delivery systems may be largely divided into two classes: Those that rely on the natural physiology of the gastrointestinal tract and those that are designed to overcome it. The main approaches that have been examined for gastro retentive dosage forms (GRDFs) are: low density of GRDF that cause buoyancy above gastric fluid (Floating system), high density GRDF which retain the dosage form in the body of stomach. Gastric emptying of dosage forms is an extremely variable process and ability to prolong and control emptying time is a valuable asset for dosage forms, which reside in the stomach for a longer period of time than conventional dosage forms. Several difficulties are faced in designing controlled release systems for better absorption and enhanced bioavailability. One of such difficulties is the inability to confine the dosage form in the desired area of the gastrointestinal tract. Drug absorption from the gastrointestinal tract is a complex procedure and is subject to many variables. It is widely acknowledged that the extent of gastrointestinal tract drug absorption is related to contact time with the small intestinal mucosa \[3\]. Thus small intestinal transit time is an important parameter for drugs that are incompletely absorbed. Gastroretensive systems can remain in the gastric region for several hours and hence significantly prolong the gastric residence time of drugs. Prolonged gastric retention improves bioavailability, reduces drug waste and improves solubility for drugs that are less soluble in a high pH environment. It has applications also for local drug delivery to the stomach and proximal small intestines. Gastro retention helps to provide better availability of new products with new therapeutic possibilities and substantial benefits for patients \[4\]. Gastro retention helps to provide better availability of new products with suitable therapeutic activity and
substantial benefits for patients. This mode of administration would best achieve the known pharmacokinetic and pharmacodynamic advantages of CR-DFs of these drugs. The need for gastroretentive dosage forms (GRDFs) has led to extensive efforts in both academia and industry towards the development of such drug delivery systems. The idea of gastroretention stems from the need to localize drugs at a specific region of G.I. tract such as stomach in the body. Gastroretention is essential for drugs that are absorbed from the stomach, drugs that are poorly soluble or degraded by the higher pH of intestine, and drugs with an absorption which can be modified by changes in gastric emptying time. Gastroretentive dosage forms are also useful for local as well as sustained drug delivery for certain conditions, like H. pylori infection which is the cause of peptic ulcers. To formulate a successful stomach specific or gastroretentive drug delivery system, several techniques are currently used such as hydrodynamically balanced systems (HBS) / floating drug delivery system [3], lowdensity systems [5-7], mucoadhesive systems [8], high density systems [9-11], superporous hydrogels & magnetic systems.

Criteria for selection of drug candidate for GRDF

1. Drugs required to exert local therapeutic action in the stomach: e.g. misoprostol, 5 Flurouracil, and antacids Preparations, anti Helicobacter pylori agents and certain enzymes.
2. Drugs exhibiting site-specific absorption in the stomach or upper part of the small intestine: e.g. Atenolol, Frusemide, levodopa, p-Aminobenzoic acid, piretanide, salbutamol, thiamide.
3. Drugs unstable in lower part of GI tract: e.g. captopril.
4. Drugs insoluble in intestinal fluids (acid soluble basic drugs): e.g. chlorpheniramine, cinnarizine, dizapam, diltiazem, Propranolol, Verapamil
5. Drugs with variable bioavailability: e.g. sotalol hydrochloride and levodopa

CLASSIFICATION OF FLOATING DRUG DELIVERY SYSTEM

Floating drug delivery systems are classified depending up on the two formulations variables Effervescent and Noneffervescent systems.
Effervescent Floating Drug Delivery System

These are matrix type systems prepared with the help of swellable polymers such as hydroxypropyl methyl-cellulose or polysaccharides and chitosan and various effervescent components like sodium bicarbonate, calcium carbonate, citric acid or tartaric acid. These dosage forms are developed in such a way that, when they come in contact with gastric juice in the stomach, carbon dioxide is liberated and is trapped in the swollen hydrocolloids. This provides buoyancy to the dosage form. The liberated carbon dioxide may intimately get mixed within the tablet matrix in case of single layered tablet. The multiparticulate floating reservoir types of delivery systems may contain double or triple layers. The triple layered tablets may be prepared, which contains swellable gas generating layer, sustainable approach was utilized in the development of floating or pulsatile drug delivery system based on the coated effervescent core. The dosage form had two layers, first layer consisted of drug, cellulose acetate or HPMC as a sustained release core and second layer consisted of effervescent agents, PEG 4000 (4% based on the weight of the second layer) and lactose or microcrystalline cellulose as filler. Sodium bicarbonate and citric acid were used as an effervescent agent in a ratio of 1:0 in the concentration of 30-50% of the w/w of the core. The carbon dioxide is generated upon contact with the medium and gets entrapped in the polymeric matrix, which provides buoyancy to the dosage form. It was observed that addition of 10-20% w/w of HPMC significantly retarded drug release compared to the dosage form without HPMC.

Programmable drug delivery systems for oral administration were developed. It was a new prototype model device (3 cm long and 0.9 cm internal diameter) made to comprise of a cylindrical shell in the form of oral capsule. Drug was placed in a cylindrical disc made up of slowly eroding polymer and compressed to zero porosity, a flexible rubber disc, compressible acid resistant spring and a special acid impervious non-permeable rubber ballooning system containing bicarbonate granules. The device in the form of non-digestible oral capsule containing drug in a slowly eroding matrix was designed to utilize on automatically operated geometric obstruction that keeps the device floating in the
stomach and prevents the system from passing through remainder of GIT. The different grades of HPMC were used to develop the eroding matrix. They concluded that duration of action was dependent on erosion rate of the incorporated polymer and the in vitro release of drug from developed device could be maintained up to 20 days\cite{5}.

![Diagrammatic sketch of the device representing its operation mechanism (A, B, C, D.)(A) Intact device; (B) device at the beginning of drug release; (C) device with half drug-polymer compact eroded; and (D) device after complete drug-polymer erosion and evacuation of entrapped carbon dioxide. Sodium alginate beads consisting of gas forming agent were made up of HPMC and sodium alginate (9:1 w/w) with gas generating agent in the concentration 0:1 to 1:1 (gas forming agent/alginate w/w). The resultant solution was dropped in to 1% (w/v) calcium chloride solution containing 10% (v/v) acetic acid. The suspended beads were stirred with a magnetic stirrer for 10 minutes. The prepared beads were evaluated for the effect of carbon dioxide producing agent on size, floating properties, porosity, morphology and mechanical strength of beads. It was observed that amount of gas forming agent had a significant effect on size, floating ability, porosity,
morphology, release rate and mechanical strength. Calcium carbonate formed smaller but stronger beads as compared to sodium bicarbonate. Calcium carbonate was found to be less effective gas generating agent than sodium bicarbonate. But it forms superior quality floating beads with significantly extended drug release. Multiple unit type of floating pills composed of inner effervescent layer containing sodium bicarbonate and tartaric acid and outer swellable polymeric membrane made up of polyvinyl acetate and purified shellac. The inner layer was further divided into two sub layers to avoid physical contact between sodium bicarbonate and tartaric acid. When the pill was immersed in buffer solution at 37 °C, it settled down at the bottom, buffer solution entered in to the effervescent layer through the outer swellable membrane. Carbon dioxide was generated due to reaction between sodium bicarbonate and tartaric acid and formed swollen pills (like balloons) with a density much lesser than 1.0 g/ml. The system was found to float completely within 10 minutes and had a good floating ability independent of pH, viscosity of the medium and drug release in a sustained manner[3].

These effervescent systems further classified into two types.
I. Gas Generating systems
II. Volatile Liquid/Vacuum

I. Gas - Generating Systems:
1. Intra Gastric Single Layer Floating Tablets or Hydrodynamically Balanced System: These are formulated by intimately mixing the CO2 generating agents and the
drug with in the matrix tablet. These have a bulk density lower than gastric fluids and therefore remain floating in the stomach unflattering the gastric emptying rate for a prolonged period. The drug is slowly released at a desired rate from the floating system and after the complete release the residual system is expelled from the stomach. This leads to an increase in the GRT and a better control over fluctuations in plasma drug concentration\cite{11}.

2. Intra Gastric Bilayer Floating Tablets:
These are also compressed tablet as shown below and containing two layer i.e.,
i. Immediate release layer and ii. Sustained release layer.

3. Multiple Unit type floating pills:
These systems consist of sustained release pills as ‘seeds’ surrounded by double layers. The inner layer consists of effervescent agents while the outer layer is of swellable membrane layer. When the system is immersed in dissolution medium at body temp, it sinks at once and then forms swollen pills like balloons, which float as they have lower density. This lower density is due to generation and entrapment of CO2 within the system\cite{11}.

![Diagram of floating pills](image)

**Figure 3**
(a) A multi-unit oral floating dosage system (b) stage of floating mechanism

II. Volatile Liquid / Vacuum Containing Systems:
1. Intragastric Floating Gastrointestinal Drug Delivery System:
These system can be made to float in the stomach because of floatation chamber, which may be a vacuum or filled with air or a harmless gas, while drug reservoir is encapsulated inside a microporous compartment\textsuperscript{[11]}.

Figure 4
Intra Gastric Floating Gastrointestinal Drug Delivery Device

2. Inflatable Gastrointestinal Delivery Systems:
In these systems an inflatable chamber is incorporated, which contains liquid ether that gasifies at body temperature to cause the chamber to inflate in the stomach. These systems are fabricated by loading the inflatable chamber with a drug reservoir, which can be a drug impregnated polymeric matrix, then encapsulated in a gelatin capsule. After oral administration, the capsule dissolves to release the drug reservoir together with the inflatable chamber. The inflatable chamber automatically inflates and retains the drug reservoir compartment in the stomach. The drug continuously released from the reservoir into the gastric fluid\textsuperscript{[10]}.

Figure 5
Inflatable Gastrointestinal Delivery System
3. Intragastric Osmotically Controlled Drug Delivery System:

It is comprised of an osmotic pressure controlled drug delivery device and an inflatable floating support in a biodegradable capsule. In the stomach, the capsule quickly disintegrates to release the intragastric osmotically controlled drug delivery device. The inflatable support inside forms a deformable hollow polymeric bag that contains a liquid that gasifies at body temperature to inflate the bag. The osmotic pressure controlled drug delivery device consists of two components; drug reservoir compartment and an osmotically active compartment. The floating support is also made to contain a bioerodible plug that erodes after a predetermined time to deflate the support. The deflated drug delivery system is then emptied from the stomach.[11]
mixing of drug and gel forming hydrocolloids. After oral administration, the dosage form comes in contact with gastric fluids and gets swollen, form a gelatinous barrier at the surface. The swollen dosage form maintains a relative integrity of shapes and bulk density less than 1.0. The air entrapped within the swollen polymer matrix imparts buoyancy to the dosage forms.

Hydrodynamically balanced capsules containing mixture of drug and hydrocolloids. Upon contact with gastric fluid, the capsule shell dissolved in gastric fluid followed by swelling of mixtures, formation of a gelatinous barrier and maintains bulk density less than 1.0, which remained buoyant on the gastric fluid for an extended period of time[4]. The various types of this system are as[11]:

1. Single Layer Floating Tablets:
They are formulated by intimate mixing of drug with a gel-forming hydrocolloid, which swells in contact with gastric fluid and maintain bulk density of less than unity. The air trapped by the swollen polymer confers buoyancy to these dosage forms.

2. Bilayer Floating Tablets:
A bilayer tablet contain two layer one immediate release layer which release initial dose from system while the another sustained release layer absorbs gastric fluid, forming an impermeable colloidal gel barrier on its surface, and maintain a bulk density of less than unity and thereby it remains buoyant in the stomach[11].

3. Alginate Beads:
Multi unit floating dosage forms were developed from freeze-dried calcium alginate. Spherical beads of approximately 2.5 mm diameter can be prepared by dropping a sodium alginate solution into aqueous solution of calcium chloride, causing precipitation of calcium alginate leading to formation of porous system, which can maintain a floating force for over 12 hours. When compared with solid beads, which gave a short residence time of 1 hour, these floating beads gave a prolonged residence time of more than[7].

4. Hollow Microspheres:
Hollow microspheres (microballoons), loaded with drug in their outer polymer shells were prepared by a novel emulsion-solvent diffusion method. The ethanol : dichloromethane solution of the drug and an enteric acrylic polymer was poured into an agitated aqueous solution of PVA that was thermally controlled at 400°C. The gas phase generated in dispersed polymer droplet by evaporation of dichloromethane formed an internal cavity in microsphere of polymer with drug\[6\].

**Intragastric Floating Drug Delivery Device**

The system composed of a drug reservoir encapsulated in a microporous compartment having pores on top and bottom surfaces. The peripheral walls of the reservoir compartment were completely sealed to prevent any physical contact of the undissolved drug with walls of the stomach.

![Diagram](image.png)

**Figure 7**

Intragastric floating drug delivery device

Novel levodopa gastro retentive dosage form based on unfolding polymeric membranes, that combines extended dimensions with high rigidity. It was folded into a large size gelatin capsules. In vitro studies showed that unfolded form reached within 15 minutes after administration and it was confirmed in vivo in beagle dogs. The unfolded form was maintained for at least 12 hours. It was concluded that this dosage form could improve therapy of different narrow absorption window drugs. However, there are possibilities of the polymeric films to get stuck in the esophagus causing extreme discomfort to the patient or drug related injuries and repeated administration of rigid dosage form may result in gastric obstruction\[2\].
LIST OF DRUGS EXPLORED FOR VARIOUS FLOATING DOSAGE FORMS

Microspheres Tablets /Pills
Chlorpheniramine maleate, Aspirin, griseofulvin, Acetaminophen, p-nitroaniline, Acetylsalicylic acid, Ibuprofen, Amoxycillin trihydrate, Terfenadine, Ampicillin, Tranilast, Atenolol, Theophylline, Captopril, Isosorbide di nitrate, Sotalol, Isosorbide mononitrate

Films
P-Aminobenzoic acid, Cinnarizine, Piretanide, Prednisolone, Quinidine gluconate

Granules Cinnarizine, Diclofenac sodium, Diltiazem, Indomethacin, Fluorouracil, Prednisolone, Isosorbide mononitrate, Isosorbide dinitrate. Riboflavin, phosphate, Sotalol, Theophylline

Capsules
Verapamil HCl, Chlordiazepoxide HCl, Diazepam, Furosemide, L-dopa and benserazide Misoprostol, Propranolol HCl, Ursodeoxycholic acid, Nicardipine

MARKETED PRODUCTS OF FDDS

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Products</th>
<th>Active Ingredients</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Madopar</td>
<td>Levodopa and benserzide</td>
</tr>
<tr>
<td>2</td>
<td>Valrelease</td>
<td>Diazepam</td>
</tr>
<tr>
<td>3</td>
<td>Topalkan</td>
<td>Aluminum magnesium Antacid</td>
</tr>
<tr>
<td>4</td>
<td>Almagate</td>
<td>flatcoat Antacid</td>
</tr>
<tr>
<td>5</td>
<td>Liquid gavison</td>
<td>Alginic acid and sodium bicarbonate</td>
</tr>
</tbody>
</table>

POLYMERS AND OTHER INGREDIENTS USED IN PREPARATIONS OF FLOATING DRUGS

Polymers
The following polymers used in preparations of floating drugs –
HPMC K4 M, Calcium alginate, Eudragit S100, Eudragit RL, Propylene foam, Eudragit RS, ethyl cellulose, poly methyl methacrylate, Methocel K4M, Polyethylene oxide, β

Inert fatty materials (5%-75%)

Edible, inert fatty materials having a specific gravity of less than one can be used to decrease the hydrophilic property of formulation and hence increase buoyancy. E.g. Beeswax, fatty acids, long chain fatty alcohols, Gelucires 39/01 and 43/01.

Effervescent agents

Sodium bicarbonate, citric acid, tartaric acid, Di-SGC (Di-Sodium Glycine Carbonate, CG (Citroglycine).

Release rate accelerants (5%-60%)

eg. lactose, mannitol

Release rate retardants (5%-60%)

eg. Dicalcium phosphate, talc, magnesium stearate.

Buoyancy increasing agents (upto80%)

eg. Ethyl cellulose.

Low density material

Polypropylene foam powder (Accurel MP 1000).

EVALUATION OF FLOATING DOSAGE FORMS

For Single Unit Dosage Forms (ex: tablets)\[7\].

I. Floating lag time: It is the time taken by the tablet to emerge onto the surface of dissolution medium and is expressed in seconds or minutes.

II. Invitro drug release and duration of floating: This is determined by using USP II apparatus (paddle) stirring at a speed of 50 or 100 rpm at 37 ± 0.2 °C in simulated gastric fluid (pH 1.2 without pepsin). Aliquots of the samples are collected and analysed for the drug content.
III. The time (hrs) for which the tablets remain buoyant on the surface of the dissolution medium is the duration of floating and is visually observed.

IV. In vivo evaluation for gastro-retention: This is carried out by means of X-ray or Gammascintigraphic monitoring of the dosage form transition in the GIT. The tablets are also evaluated for hardness, weight variation, etc.

For Multiple Unit Dosage Forms (ex: microspheres)

Apart from the In vitro release, duration of floating and in vivo gastro-retention tests, the multiple unit dosage forms are also evaluated for

(i) Morphological and dimensional analysis with the aid of scanning electron microscopy (SEM). The size can also be measured using an optical microscope.

(ii) % yield of microspheres: This is calculated from

\[
\text{Weight of microspheres obtained} \times \frac{100}{\text{total weight of drug and polymer}}
\]

(iii) Entrapment efficiency: The drug is extracted by a suitable method, analysed and is calculated from

\[
\frac{\text{Practical amount of drug present}}{\text{Theoretical drug content}} \times 100
\]

(iv) In vitro floating ability (Buoyancy %): A known quantity of microspheres are spread over the surface of a USP (Type II) dissolution apparatus filled with 900 ml of 0.1 N HCl containing 0.002% v/v Tween 80 and agitated at 100 rpm for 12 hours. After 12 hours, the floating and settled layers are separated, dried in a dessicator and weighed. The buoyancy is calculated from the following formula.

\[
\text{Buoyancy (\%)} = \frac{W_f}{W_f - W_s} \times 100
\]

Where, \(W_f\) and \(W_s\) are the weights of floating and settled microspheres respectively.

(v) Drug-excipient (DE) interactions: This is done using FTIR. Appearance of a new peak, and/or disappearance of original drug or excipient peak indicates the DE interaction. Apart from the above mentioned evaluation parameters, granules (ex:
Gelucire 43/01) are also evaluated for the effect of ageing with the help of Differential Scanning Calorimeter or Hot stage polarizing microscopy\textsuperscript{[9]}. 

**CHARACTERIZATION PARAMETERS:**

Size and shape evaluation:
The particle size and shape plays a major role in determining solubility rate of the drugs and thus potentially its bioavailability. The particle size of the formulation was determined using Sieve analysis, Air elutriation analysis, Photo analysis, Optical microscope, Electro resistance counting methods (Coulter counter), Sedimentation techniques, Laser diffraction methods, ultrasound attenuation spectroscopy, Air Pollution Emissions Measurements etc.

Floating Properties:
Effect of formulation variables on the floating properties of gastric floating drug delivery system was determined by using continuous floating monitoring system and statistical experimental design.

Surface Topography:
The surface topography and structures were determined using scanning electron microscope (SEM, JEOL JSM – 6701 F, Japan) operated with an acceleration voltage of 10k.v, Contact angle meter, Atomic force microscopy (AFM), Contact profilometer.

Determination of Moisture Content:
The water content per se is seldom of interest. Rather, it shows whether a product intended for trade and production has standard properties such as\textsuperscript{[8]}.

1. Storability
2. Agglomeration in the case of powders
3. Microbiological stability
4. Flow properties, viscosity
5. Dry substance content
6. Concentration or purity
7. Commercial grade (compliance with quality agreements) Thus moisture content of the prepared formulations was determined by Karl fisher titration, vacuum drying, Thermo gravimetric methods, Air oven method, Moisture Meters, Freeze drying as well as by physical methods[3].

Swelling Studies:
Swelling studies were performed to calculate molecular parameters of swollen polymers. Swelling studies was determined by using Dissolution apparatus, optical microscopy and other sophisticated techniques which include H1NMR imaging, Confocal laser scanning microscopy (CLSM), Cryogenic scanning electron microscopy (Cryo-SEM), Light scattering imaging (LSI) etc. The swelling studies by using Dissolution apparatus (USP dissolution apparatus (usp-24) labindia disso 2000) was calculated as per the following formula[6].

\[
\text{Swelling ratio} = \frac{\text{Weight of wet formulation}}{\text{Weight of formulations}}
\]

Determination of the Drug Content:
Percentage drug content provides how much amount of the drug that was present in the formulation. It should not exceed the limits acquired by the standard monographs. Drug content was determined by using HPLC, HPTLC methods, Near infrared spectroscopy (NIRS), Microtitrimetric methods, Inductively Coupled Plasma Atomic Emission Spectrometer (ICPAES) and also by using spectroscopy techniques[11].

Percentage Entrapment Efficiency:
Percentage entrapment efficiency was reliable for quantifying the phase distribution of drug in the prepared formulations. Entrapment efficiency was determined by using three methods such as Micro dialysis method, Ultra centrifugation, and pressure Ultra filtration[10].

In-vitro Release Studies:
In vitro release studies (USP dissolution apparatus (usp-24) lab India disso 2000) were performed to provide the amount of the drug that is released at a definite time period.
Release studies were performed by using Franz diffusion cell system and synthetic membrane as well as different types of dissolution apparatus\textsuperscript{[11]}.  

**Powder X-ray Diffraction:**  
X-ray powder diffraction (Philips analytical, model pw1710) is the predominant tool for the study of poly-crystalline materials and is eminently suited for the routine characterization of pharmaceutical solids. Samples were irradiated with \( \alpha \) radiation and analyzed between 2 oC and 60 oC. The voltage and current used were 30KV and 30mA respectively\textsuperscript{[2]}.  

**Fourier Transform Infrared Analysis:**  
Fourier transform infrared spectroscopy (FT-IR, Shimadzu, Model-RT-IR-8300) is a technique mostly used to identify organic, polymeric, and some inorganic materials as well as for functional group determination. Fourier Transform Infrared Analysis (FT-IR) measurements of pure drug, polymer and drug loaded polymer formulations were obtained on FTIR. The pellets were prepared on KBr-press under hydraulic pressure of 150kg/cm\(^2\); the spectra were scanned over the wave number range of 3600 to 400 cm\(^{-1}\) at the ambient temperature\textsuperscript{[5]}.  

**Differential Scanning Calorimetry (DSC):**  
DSC (Shimadzu, Model-DSC-60/DSC-50/ Metler Toldeo) are used to characterize water of hydration of pharmaceuticals. Thermo grams of formulated preparations were obtained using DSC instrument equipped with an intercooler. Indium/Zinc standards were used to calibrate the DSC temperature and enthalpy scale. The sample preparations were hermetically sealed in an aluminum pan and heated at a constant rate of 10°C/min; over a temperature range of 25°C – 65°C. Inert atmosphere was maintained by purging nitrogen gas at the flow rate of 50ml/min\textsuperscript{[4]}.  

**CONCLUSION**  
Drug absorption in the gastrointestinal tract is a highly variable procedure and prolonging gastric retention of the dosage form extends the time for drug absorption. Gastro-retentive floating drug delivery systems have emerged as an efficient means of enhancing
the bioavailability and controlled delivery of many drugs. The increasing sophistication of delivery technology will ensure the development of increase number of gastroretentive drug delivery to optimize the delivery of molecules that exhibit absorption window, low bioavailability and extensive first pass metabolism. FDDS promises to be a potential approach for gastric retention. Although there are number of difficulties to be worked out to achieve prolonged gastric retention, a large number of companies are focusing toward commercializing this technique.

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