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RECENT RESEARCH ON FLOATING DRUG DELIVERY SYSTEMS-A REVIEW

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ABSTRACT

Formulation of floating drug delivery system (FDDS) is a topic of current interest in pharmaceutical products development. Floating drug delivery systems are low-density systems that float over the gastric content and remain buoyant in the stomach for a prolonged period of time .They enhance drug bioavailability, reduce drug wastage and provide controlled drug delivery and better patient compliance .Several approaches and techniques were developed in recent year for FDDS. Literature on FDDS along with recent research in this area is reviewed in this article.

Keywords: Floating drug delivery systems, Gastric Residence Time, Formulation approaches, Recent Research.

INTRODUCTION

Oral drug delivery is the most desirable and preferred method of administering therapeutic agents for their systemic effects. The high level of patient compliance in taking oral dosage forms is due to the ease of administration, patient compliance, flexibility in formulation and handling of these forms[1]. However the oral route of administration suffers with certain drawbacks mainly short residence time of the dosage form in the GI tract, unpredictable gastric emptying and degradation of the drug due to highly reactive nature of GI contents. Gastric emptying is a complex process and makes *in vivo* performance of the drug delivery system uncertain. Formulation of floating drug delivery systems is an useful approach to avoid this variability with increased gastric retention time of the drug delivery system. Floating systems or hydrodynamically controlled systems are low-density systems that have sufficient buoyancy to float over the gastric contents and remain buoyant in the stomach without affecting the gastric emptying rate for a prolonged period of time .While the system is floating on the gastric contents, the drug is released slowly at the desired rate from the system. After release of drug, the residual system is emptied from the stomach .This results in an increased gastric residence time and a better control of the fluctuation in plasma drug concentration[2,3] .

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Advantages of FDDS[4]

Floating dosage systems form important technological drug delivery systems with gastric retentive behaviour and offer several advantages in drug delivery. These advantages include:

1. Improved drug absorption, because of increased gastric residence time and more time spent by the dosage form at its absorption site
2. Controlled delivery of drugs.
3. Delivery of drugs for local action in the stomach.
4. Minimizing the mucosal irritation due to drugs, by drug releasing slowly at controlled rate.
5. Treatment of gastrointestinal disorders such as gastro-esophageal reflux.
6. Simple and conventional equipment for manufacture.
7. Ease of administration and better patient compliance.
8. Site-specific drug delivery.

Disadvantages of FDDS [5,6,7]

1. Floating systems are not feasible for those drugs that have solubility or stability problems in gastric fluids.

2. Drugs such as Nifedipine, which is well absorbed along the entire GI tract and which undergo significant first-pass metabolism, may not be suitable candidates for FDDS since the slow gastric emptying may lead to reduced systemic bioavailability. Also there are limitations to the applicability of FDDS for drugs that are irritant to gastric mucosa.
3. Gastric retention is influenced by many factors such as gastric motility, pH and presence of food. These factors are never constant and hence the buoyancy cannot be predicted.
4. Drugs that cause irritation and lesion to gastric mucosa are not suitable to be formulated as floating drug delivery systems.

Suitable Drug Candidates for FDDS

Various drugs have their greatest therapeutic effect when released in the stomach, particularly when the release is prolonged in a continuous, controlled manner. In general, appropriate candidates for FDDS are molecules that have poor colonic absorption but are characterized by better absorption properties at the upper parts of the GIT[8-12].

1. Drugs with narrow absorption window in GIT, e.g., Riboflavin and Levodopa
2. Drugs that primarily absorbed from stomach and upper part of GIT, e.g., Calcium supplements, chlordiazepoxide and cinnarazine.
3. Drugs that act locally in the stomach, e.g., Antacids and Misoprostol.
4. Drugs that degrade in the colon, e.g., Ranitidine HCl and Metronidazole.
5. Drugs that disturb normal colonic bacteria, e.g., Amoxicillin Trihydrate

Classification of Floating Drug Delivery Systems

A. Single Unit Floating Dosage Systems

Non-effervescent Systems (balanced systems)
Effervescent Systems (Gas-generating Systems)

B. Multiple Unit Floating Dosage Systems

Non-effervescent Systems (balanced systems)
Effervescent Systems (Gas-generating Systems)
Hollow Microspheres

C. Raft Forming Systems

A. Single Unit Floating Dosage

I. Non-effervescent Systems (balanced systems)

These are single-unit dosage forms, containing one or more gel-forming hydrophilic polymers. Hydroxypropylmethylcellulose (HPMC) is the most commonly used excipient, although ethylcellulose (HEC), hydroxypropylcellulose (HPC), sodium carboxymethyl agar, carrageen or alginic acid are also used. The polymer is mixed with drug and usually administered in a gelatine capsule. The capsule rapidly dissolves in the gastric fluid, and hydration and swelling of the surface polymers produces floating mass [13,14]. Drug release is controlled by the formation of a hydrated boundary at the surface. Continuous erosion of the surface allows water penetration to the inner layers, maintaining surface hydration and buoyancy[15]. Incorporation of fatty excipients gives low-density formulations and reduced penetration of water, reducing the erosion. Effective drug delivery depends on the balance of drug loading and the effect of polymer on its release profile [16].

II. Gas-generating systems

Floatability can also be achieved by generation of gas bubbles. Carbon dioxide (co2) can be generated in situ by incorporation of carbonates or bicarbonates, which react with acid, either the natural gastric acid or co-formulated as citric or tartaric acid [17,18]. The optimal stoichiometric ratio of citric acid and sodium bicarbonate for gas generation is reported to be 0.76:1.Gastric floating drug delivery system (GFDDS) offers numerous advantages over other gastric retention systems[19,20]. These systems have a bulk density lower than gastric fluids and thus remain buoyant in the stomach without affecting the gastric emptying rate for a prolonged period of time[21]. While the system is floating on the gastric contents, the drug is released slowly at desired rate from the stomach [22,23].

B. Multi –Unit Dosage Forms:

The purpose for designing multiple-unit dosage form is to develop a formulation which has all the advantages of a single-unit form and also devoid the above mentioned disadvantages of single-unit formulations. In pursuit of this endeavor many multiple-unit floatable dosage forms have been designed[24]. Microspheres with high loading capacity can be formulated using various polymers such as albumin, gelatine,

starch, polymethacrylate, polyacrylamine, and polyalkylcyanoacrylate. Spherical polymeric microsponges, are referred as "microballoons," have been prepared[25].Microspheres have a characteristic internal hollow structure and show an excellent in vitro float ability. In Carbon dioxide–generating multiple-unit oral formulations several devices with features that extend, unfold, or are inflated by carbon dioxide generated in the devices after administration have been described in the recent patent literature. These dosage forms are excluded from the passage of the pyloric sphincter if a diameter of ~12 to 18 mm in their expanded state is exceeded[26].

C. Raft Forming Systems:

Raft forming systems have received much attention for the delivery of antacids and drug delivery for gastrointestinal infections and disorders. The mechanism involved in the raft formation includes the formation of viscous cohesive gel in contact with gastric fluids, wherein each portion of the liquid swells forming a continuous layer called a raft. This raft floats on gastric fluids because of low bulk density created by the formation of CO_2.Usually, the system contains a gel forming agent and alkaline bicarbonates or carbonates responsible for the formation of CO2 to make the system less dense and float on the gastric fluids [27]an antacid raft forming floating system. The system contains a gel forming agent (e.g. alginic bicarbonate, calcium arbonate, mannitol and a sweetener. These ingredients were granulated, and citric acid was added to the granules. The formulation produces effervescence and aerates the raft formed, making it float acid), sodium bicarbonate and acid neutralizer, which forms a foaming sodium alginate gel (raft) when in contact with gastric fluids. The raft thus formed floats on the gastric fluids and prevents the reflux of the gastric contents (i.e. gastric acid) into the esophagus by acting as a barrier between the stomach and esophagus. A patent assigned to Reckitt and Colman Products Ltd., describes a raft forming formulation for the treatment of helicobacter pylori (H. Pylori) infections in the GIT[28].

Formulation excipients used in FDDS[29]

1.Polymers: The following polymers used in preparations of FDDS -HPMC K4 M, Calcium alginate, Eudragit S100, Eudragit RL, Propylene foam, Eudragit RS, ethyl cellulose, poly methyl methacrylate, Methocel K4M, Polyethylene oxide, β Cyclodextrin,HPMC 4000, HPMC 100, CMC, Polyethylene glycol,polycarbonate, PVA, Polycarbo-nate, Sodium alginate, HPC-L, CP 934P, HPC, Eudragit S, HPMC, Metolose S.M. 100, PVP, HPC-H, HPC-M, HPMC K15, Polyox, HPMC K4, Acrylic polymer, E4 M and Carbopol.

2.Inert fatty materials (5%-75%): Edible, inert fatty material 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.

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

4. Release rate accelerants (5%-60%): eg. lactose, mannitol.

5. Release rate retardants (5%-60%): eg. Dicalciumphosphate,talc, magnesium stearate.

6. Buoyancy increasing agents (upto80%): eg. Ethyl cellulose.

7. Low density material: Polypropylene foam powder (AccurelMP 1000).

Factors Affecting the Floating and Floating Time

1. **Density: -** Floating is a function of dosage form buoyancy that is dependent on the density.

2. **Shape of dosage form: -** Tetrahedron and ring shaped devices with flexural modules of 48 and 22.5 kilo pounds per square inch (KSI) are reported to have better floating, 90% to 100% retention at 24 hours compared with other shapes[30].

3 .**Concomitant drug administration: -** Anticholinergics like atropine and propantheline,opiates like codeine and prokinetic agents like metoclopramide and cisapride; can affect floating time.

4. **Fed or unfed state: -** Under fasting conditions, the GI motility is characterized by periods of strong motor activity or the migrating myoelectric complex (MMC) that occurs every 1.5 to 2 hours[31].

5. **Nature of meal: -** Feeding of indigestible polymers or fatty acid salts can change the motility pattern of the stomach to a fed state, thus decreasing the gastric emptying rate and prolonging drug release[32].

6. **Caloric content and feeding frequency: -** Floating can be increased by four to 10 hours with a meal that is high in proteins and fats. The floating can increase by over 400 minutes when successive meals are given compared with a single meal due to the low frequency of MMC.

7. **Age:** - Elderly people, especially those over 70, have a significantly longer; floating[33]. Disease condition such as diabetes and crohn's disease etc also affect drug delivery.

8. **Posture: -** Floating can vary between supine and upright ambulatory states of the patient[34].

Evaluation of Floating Drug Delivery Systems

Various parameters that need to be evaluated in gastro retentive formulations include floating duration, dissolution profiles, specific gravity, content uniformity, hardness, and friability in case of solid dosage forms[35]. In the case of multiparticulate drug delivery systems, differential scanning calorimetry (DSC), particle size analysis,flow properties, surface morphology, and mechanical properties are also performed. In vivo evaluation is performed by X-ray[35], Gamma-scintigraphy[36], gastroscopy[37,38], and ultra sonography[39,40] .

Applications of Floating Drug Delievery Systems

1. Enhanced Bioavailability:

The bioavailability of riboflavin CR-GRDF is significantly enhanced in comparison to the administration of non-GRDF CR polymeric formulations. There are several different processes, related to absorption and transit of the drug in the gastrointestinal tract, that act concomitantly to influence the magnitude of drug absorption[41].

2. Sustained drug delivery:

Oral CR formulations are encountered with problems such as gastric residence time in the GIT. These problems can be overcome with the HBS systems which can remain in the stomach for long periods and have a bulk density <1 as a result of which they can float on the gastric contents. These systems are relatively larger in size and passing from the pyloric opening is prohibited[42].

3. Site specific drug delivery systems:

These systems are particularly advantageous for drugs that are specifically absorbed from the stomach or the proximal part of the small intestine .The controlled, slow delivery of drug to the stomach provides sufficient local therapeutic levels and limits the systemic exposure to the drug. This reduces side effects that are caused by the drug in the blood circulation. In addition, the prolonged gastric availability from a site directed delivery system may also reduce the dosing frequency. Eg: Furosemide and Riboflavin[43].

4. Absorption enhancement:

Drugs which are having poor bioavailability because of site specific absorption from the upper part of the GIT are potential candidates to be formulated as floating drug delivery systems, there by maximizing their absorption[44].

5. Minimized adverse activity at the colon:

Retention of the drug in the HBS systems at the stomach minimizes the amount of drug that reaches the colon. Thus, undesirable activities of the drug in colon may be prevented. This Pharmacodynamic aspect provides the rationale for GRDF formulation for betalactam antibiotics that are absorbed only from the small intestine, and whose presence in the colon leads to the development of microorganism's resistance.

6. Reduced fluctuations of drug concentration:

Continuous input of the drug following crgrdf administration produces blood drug concentrations journal of current pharmaceutical research 2011; 7 (1): 6-20 within a narrower range compared to the immediate release dosage forms. Thus, fluctuations in drug effects are minimized and concentration dependent adverse effects that are associated with peak concentrations can be prevented. This feature is of special importance for drugs with a narrow therapeutic index[45].

Drugs Investigated in Floating Drug Delivery Systems

Several drugs belongs to various pharmacological categories were investigated in different types of Floating Drug Delivery Systems as shown in Table 1.

Table 1[46]: Drugs Investigated In Floating Drug Delivery Systems

S. No	Types Of Dosage Forms	Drugs Explored In Floating Dosage Forms
1	Microspheres	Aspirin, Griseofulvine, P-Nitro Aniline, Ibuprofen, Ketoprofen, Terfenadine, Tranilast, Verapamil.
2	Granules	Diclofenac Sodium, Indomethacin, Prednisolone.
3	Films	Cinnarizine, Drug Delivery Device.
4	Capsules	Chlordiazepoxide Hcl, Diazepam, Furocemide, L-Dopa And Benserazide, Misoprostol, Nicardipine, Propranolol Hcl, Ursodeoxychoric Acid
5	Tablets/Pills	Acetaminophen, Aspirin, Amoxycillin Trihydrate, Ampicillin, Atenolol, Captopril, Ciprofolxacin, Chlorpheniramine Maleate, Cinnarizine, Furosemide, 5-Fluorouracil,Isosorbide Mononitrate, Diltiazem, Isosorbide Dinitrate, Nimodipine, Para Amino Benzoicacid, Piretanide, Prednisolone, Quinidine, Varapamil Hcl, Riboflavin, Sotalol ,Theophylline.

Recent Research on Floating Drug Delivery Systems:

A summary of recent research on floating drug delivery systems is given in Table 2

CONCLUSION

Formulation of floating drug delivery systems is an efficient and potential approach for gastric retention of dosage forms to improve bioavailability and also to achieve controlled release. Though several approaches and techniques are developed for FDDS, research in this area is needed until an ideal system with applicability and industrial feasibility is developed.

Table 2: Summary of Recent Research on Floating Drug Delivery Systems[47-96]

S. No	Drugs (Category)	Type of Dosage Form	Excipients / Polymers Used	Method	Reason / Results	Ref no
1	Captopril (Anti Hypertensive-ACE inhibitor)	Core mini tablets	HPMCK100, Ethylcellulose7cps,MCC.	Direct compression	Prolonged gastric gastric residence time and Increased bioavailability.	47
2	Acyclovir (antiviral drug)	Tablet	Psyllium husk , HPMC K4M, sodium bicarbonate.	Wet granulation	Increased gastric residence time and bioavailability	48
3	Ciprofloxacin (First generation fluroquinolone)	Tablet	HPMC 4M, K15M, K100M, Citricacid, anhydrous, sodium bicarbonate.	Direct compression	Improved GI absorption and controlled release of drug.	49
4	Clarithromycin (Macrolide antibiotic)	Tablet	HPMC K4M, sodium bicarbonate.	Wet granulation	Improved bioavailability.	50
5	Famotidine (Histmine H2receptor antogonist)	Gel beads	Sodium alginate, HPMC K15m.	Gelation method	Prolonged the gastric residence time upto 8hr and improved bioavailability.	51
6	Metformin (Antidiabetic)	Micro Capsule	Cellulose acetate butyrate , Eudragit	Solvent evaporation method	Enhanced absorption and improved bioavailability.	52
7	Propranolol HCL (Anti hypertensive)	Tablet	HPMC,HPC, Xanthan gum sodium alginate	Direct compression	Increase bioavailability and Gastric residence time.	53
8	Rantidine (Histmine H2receptor antagonist)	Tablet	HPMC K4M Guar gum , Xanthan gum	Direct compression	Increased Gastric residence time and better sustained effect.	54

9	Rifabutin (Anti-mycobacterial agent)	Beads	Deacetylated gellan gum	Ionotropic gelation in acidic medium	Sustained pharmacological action and improved bioavailability.	55
10	Silymarin (Anti-Oxident)	tablet	Psyllium husk, HPMC K4M, k15M, sodium bicarbonate, crosprovidone , MCC.	Direct compression	Prolonged drug release and improved the bioavailability and patient compliance.	56
11	Tizanidine HCL (central acting muscle relaxant)	Matrix tablet	HPMC, MCC PH 102, Dicalcium phosphate, Lactose	Wet granulation	Sustained release over 24hr.	57
12	Zidovudine (antiviral drug)	Tablet	HPMC K4M, Xanthan gum, ccarbapol 934P.	Direct compression technique	Improved the bioavailability and control release.	58
13	Itopride (peptic ulcer)	Matrix tablet	HPMC K100M, K4M, K15M. NaHCo3	Direct compression	Improved bioavailability	59
14	Hydro Chlor Thiazide (thiazide diuretic)	Micro sphere	EC, cellulo seacetate, cross linked PVP, polyacrylamide,PEG HPMC	Ionotropic gelation in acidic medium	Sustained and pH independent and reproducible drug release.	60
15	Verapamil HCL (Anti hypertensive-calcium channel blocker)	Tablet	MCC 102, HPMC K4M ,HPMC 15M.	Direct compression	PH dependent and controlled release was obtained	61
16	Atenolol (Beta adrenergic blocker)	Tablet	HPMC K4m, K100m, Directly compressible lactose, xanthan gum.	Direct compression	Prolonged gastric residence time.	62
17	Foscarnet sodium (antiviral drug)	Alginate beads	HPMCK15m,Guar gum, Tamarind gum. .	Ionic gelation method	Prolong gastric residence time and increased bioavailability.	63
18	Gabapentin (Anti-convulsant)	Tablet	HPMC K100M, K15M, PVPK30, MCC.	Direct compression	Increased bioavilability and Prolonged drug release.	64
19	Metoprolol tartrate (cardio selective β blocker)	Core mini tablets	HPMC K15M, PVPK30, HCL , MCC.	Wet granulation	Increased gastric residence time.	65
20	Refabutin (Anti-microbial)	Microspheres	Gellan gum	Ionic gelation	Remained buoyant up to 18h and provided controlled release.	66
21	Verapamil HCL (Anti hypertensive)	Gel beads	Sodium alginate, calcium chloride.	Emulsion gelation technique	Prolonged drug release.	67
22	Rosiglitazone maleate (Antidiabetic)	Micro sphere	Eudragit RS100, tributylcitrate,heavy liquid paraffin, petroleum ether.	Emulsification-solvent evaporation method	Control release and improved bioavailability.	68
23	Cefpodoxime Proxetil (cephalosporin prodrug)	Matrix tablet	HPMC K4M, sodium CMC, carbopol 934P.	Direct compression	Prolonged gastric residence time and increased drug absorption and bioavailability.	69
24	Cefuroxime HCl (Cephalosporin)	Matrix tablet	HPMC K4M, sodium bicarbonate.	Direct compression	Buoyancy over 8-24hr.	70
25	Cinnarizine (Histmine H2receptor antogonist)	Gelling suspension	Sod alginate , calcium carbonate.	Ionic gelation	98.90% release in 12 hours over instant floating.	71
26	Atorvastatin calcium (HMG-CoA reductase inhibitor)	Tablets	HPMC K4M, Ethyl cellulose Bees wax	Melt granulation	Drug release in a controlled manner for extended period of time .	72

27	carbamazepine (Anti-convulsant)	Matrix tablet	HPMC, sodium bicarbonate, and EC	Melt granulation	Improved drug absorption and bioavailability.	73
28	Labetalol Hydrochloride (non-selective α,β-adreno receptor antagonist)	Matrix tablets	HPMCK4M Carbopol 934P , Sod CMC ,citric acid sodium bicarbonate.	Simplex Centroid Design	Improved bioavailability and controlled over 12hr.	74
29	Levofloxacin (antibiotic)	Tablet	Citric Acid and Sodium Bicarbonate. HPMC, EC.	Direct compression	Drug release with prolonged Period.	75
30	Lornoxicam (NSAID)	Matrix tablets	HPMC K15M, calcium carbonate (13%).	Direct compression	Prolonged gastric residence time and improved bioavailability.	76
31	Metoclopramide HCL (Anti-emetic)	Capsule	HPMC K4M ,Carbopol 934P , Sod CMC, mannitol,Sod alginate.	Capsule	Controlled drug release upto 6-8hr.	77
32	Montelukast (selective leukotriene receptor antagonist.)	Matrix tablets	HPM(K4M, K15M), xanthan gum sodium bicarbonate	Direct compression	Prolonged drug release over 24hr.	78
33	Nifedipine (calcium channel blocking agent)	Floating tablet	HPMC K100M	Fabrication	Prolonged gastric residence time, and controlled release over 24hr and improved bioavailability.	79
34	Nizatidine (an antiulcer)	Tablet	HPMC (K100, K4M, K15M & K100M) ,sodium bicarbonate	Direct compression	Controlled rehlease and enhanced bioavailability.	80
35	Norfloxacin (antibiotic)	Tablet	HPMC K4M, HPMC K100M, and xanthan gum. citric acid	Direct compression	Increased bioavailability.	81
36	Ofloxacin (antibacterial)	Tablet	guar gum, locust bean gum,HPMC K100M , sodium bicarbonate	Wet granulation	Prolonged gastric residence time and controlled and uniform release.	82
37	Ondansetron HCL (OND) (selective serotonin 5HT3 receptor antagonist)	Coated pellets	HPMC-E6; Eudragit RL-100 (ERL) RS-100 (ERS) cetyl alcohol. NaHCO3 PEG6000	Direct compression	Prolonged gastric residence time and increased bioavailability.	83
38	Cephalexin (β-lactum antibiotic)	Tablet	Citric Acid , Sodium Bicarbonate. HPMC K100M.	Wet granulation	Drug release over 12hr	84
39	Piroxicam (NSAID)	Micro spheres	Eudragit S 100). Polyvinyl alcohol (0.1-0.5 g)	Emulsification solvent-evaporation	Sustained drug delivery.	85
40	Pregabalin (Anti convulsent)	Matrix tablet	HPMC K4M ethyl cellulose,crospovidone	Wet granulation	Improved bioavailability.	86
41	Rabeprazole sodium (Anti-ulcer)	Micro spheres	HPMC,Ethyl cellulose and Chitosan	Solvent evaporation	Polongation of gastric retention time and enhanced drug absorption and bioavailability	87
42	Tinidazole (Antibacterial and anti protozaol)	Tablet	HPMC, Sodium bicarbonate, citric acid.	Direct compression	Good Controlled release improved bioavailability.	88
43	Tramadol (Opoid analgesic)	Matrix tablet	15M, HPMC 100 LV ,Sodium biocarbonate, gum tragacanth,	Direct compression	Prolonged gastric residence time and enhanced bioavailability .	89

44	Amoxycillin trihydrate (Anti-bacterial)	Matrix tablet	HPMC K4M, xanthan gum,ethocel,	Direct Compression	Sustained release over 12hr.	90
45	Glipizide. (Antidiabetic)	Matrix tablets	HPMC K100M, sodium alginate, Carbopol 940, and PVP K30	Direct Compression	Prolonged gastric retention and improved bioavailability	91
46	Perindopril erbumine (Anti-hypertensive)	Microspheres	Ethyl cellulose, HMPC K4M, Eudragit S100, PVP K30 & PVP K90	Double emulsion solvent diffusion method	Polymer ratio affected the size, entrapment efficiency, % buoyancy & drug release.	92
47	Trimetazidin Dihydro chloride(Anti-anginal agent)	Micro spheres	Chitosan	Capillary extrusion technique	Prolonged drug release (12 h) and remained buoyant for > 11 hours.	93
48	Acetazolamide (Anti-epileptic & Anti-hrpertensive agent)	Microspheres	HPMC K15M,Ethyl cellulose 25 cps	Non aqueous solvent evaporation method	Remained buoyant for 12hr.	94
49	Ketorolac trometamol (NSAID)	Microspheres	Ethyl cellulose, HPMC K4M,Eudragit S100, Eudragit 100	Emulsion solvent diffusion technique	Improved absorption and bioavailability.	95
50	Boswellic acid (Analgesic, anti-arthritis,anti-inflammatory)	Microspheres	Ethyl cellulose, HPMC	Solvent evaporation technique	Remained buoyant for more than 12h.	96

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