REVIEW ARTICLE

Self emulsifying systems: A review

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As a consequence of modern drug discovery techniques, there has been a steady increase in the number of new pharmacologically active lipophilic compounds that are poorly water soluble. It is a great challenge for pharmaceutical scientists to convert those molecules into orally administered formulations with sufficient bioavailability. Among the approaches to improve the oral bioavailability of these molecules, the use of self-emulsified drug delivery systems (SEDDS) has been shown to be reasonably successful in improving the oral bioavailability of poorly water-soluble and lipophilic drugs. SEDDS, which are isotropic mixtures of oils, surfactants, solvents and co-solvents/surfactants, can be used for the design of formulations in order to improve the oral absorption of highly lipophilic drug compounds. It can be orally administered in soft or hard gelatin capsules. These systems form fine emulsions (or micro-emulsions) in the gastrointestinal tract (GIT) with mild agitation provided by gastric mobility. Many parameters like surfactant concentration, oil/surfactant ratio, polarity of the emulsion, droplet size and charge play a critical role in oral absorption of drug from SEEDS. This formulation enhances bioavailability due to increase in the solubility of the drug and minimizes gastric irritation.

Key words: *Bioavailability, emulsions, isotropic, self-emulsifying drug delivery systems*

INTRODUCTION

Self-emulsified drug delivery system (SEDDS) formulations can be simple binary systems: Lipophilic phase and drug or lipophilic phase, surfactant and drug.[1] The formation of a SEDDS requires the use of a co-surfactant to generate a microemulsion. SEDDS formulations are characterized by *in vitro* lipid droplet sizes of 200 nm to 5 mm, and the dispersion has a turbid appearance. SEDDS are mixtures of oils and surfactants, ideally isotropic, and sometimes containing co-solvents, which emulsify spontaneously to produce fine oil-in-water emulsions when introduced into aqueous phase under gentle agitation.[4-8] Recently, SEDDS have been formulated using medium chain tri-glyceride oils and non-ionic surfactants, the latter being less toxic. Upon per oral administration, these systems form fine emulsions (or microemulsions) in the gastrointestinal tract (GIT), with mild agitation provided by gastric mobility [Table 1].[2-4,9,10]

Advantages of SEDDS

- Quick onset of action [11,12]
- Reduction in the drug dose
- Ease of manufacture and scale-up
- Improvement in oral bioavailability
- Intersubject and intrasubject variability and food effects
- Ability to deliver peptides that are prone to enzymatic hydrolysis in the GIT
- No influence of lipid digestion process
- Increased drug-loading capacity.

Disadvantages of SEDDS

- Traditional dissolution methods do not work because these formulations are potentially dependent on digestion prior to release of the drug [12]
- This *in vitro* model needs further development and validation before its strength can be evaluated
- Further development will be based on *in vitro – in vivo* correlations and therefore different prototype lipid-based formulations needs to be developed and tested *in vivo* in a suitable animal model
- The drawbacks of this system include chemical instabilities of drugs and high surfactant concentrations in formulations (approximately 30-60%).

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Excipients classes

Lipid-based excipients

The lipid-based excipients encompass vegetable oils and their derivatives.

a. Vegetable oils:
   Vegetable oils contain a mixture of triglycerides (90 - 95% w/w) and also free fatty acids, phospholipids and non-saponifiable products such as pigments and sterols or fat-soluble vitamins like tocopherol and carotenoids that act as natural antioxidants.[13]
b. Vegetable oil derivative:
   The main vegetable oil derivatives are hydrogenated vegetable oil, partial glyceride, polyoxyglyceride, ethoxylated glyceride and esters of edible fatty acid and various alcohols.[13]

Partial glycerides are products of glycerolysis. The physical aspect, melt characteristics and the hydrophilic – lipophilic balance (HLB) of partial glycerides vary depending on the nature of the fatty acid present and the degree of esterification with glycerol to yield mono- and diglycerides.[14]

Surfactants

Several compounds exhibiting surfactant properties may be employed for the design of self-emulsifying systems, but the choice is limited as very few surfactants are orally acceptable. [15,16] The most widely recommended ones are the non-ionic surfactants with a relatively high HLB 34. Safety is a major determining factor in choosing a surfactant. The four main groups of surfactants are defined as follows:-

- Anionic surfactants
- Cationic surfactant
- Ampholytic surfactants
- Non-ionic surfactants.

(a) Anionic surfactants:- Where the hydrophilic group carries a negative charge such as carboxyl (RCOO-), sulfonate (RSO3 -) or sulfate (ROSO3 -). Examples are potassium laurate and sodium lauryl sulfate
(b) Cationic surfactants:- Where the hydrophilic group carries a positive charge. Example is quaternary ammonium halide
(c) Ampholytic surfactants:- (Also called zwitterionic surfactants) Contain both a negative and a positive charge. Example is sulfobetaines
(d) Non-ionic surfactants:- Where the hydrophilic group carries no charge but derives its water solubility from highly polar groups such as hydroxyl or polyoxyethylene. Examples are sorbitan esters (Spans) and poly -sorbates (Tweens).

Co-solvents

The production of an optimum SEDDS requires relatively high concentrations (generally more than 30% w/w) of surfactants; thus, the concentration of the surfactant can be reduced by the incorporation of a co-surfactant.[17] The role of the co-surfactant together with the surfactant is to lower the interfacial tension to a very small, even transient, negative value.[18]

At this value, the interface would expand to form fine dispersed droplets and subsequently adsorb more surfactant and surfactant/co-surfactant until their bulk condition is depleted enough to make the interfacial tension positive again. However, the use of a co-surfactant in self-emulsifying systems is not mandatory for many non-ionic surfactants. The selection of the surfactant and co-surfactant is crucial not only to the formation of SEDDS but also to solubilization of the drug in the SEDDS.

METHOD OF PREPARATION

Solidification techniques for transforming liquid/semisolid

Various solidification techniques are as listed below:[19]

Capsule filling with liquid and semisolid self-emulsifying formulations

Capsule filling is the simplest and the most common technology for the encapsulation of liquid or semisolid SE formulations for the oral route. For semisolid formulations, it is a four-step process:

- Heating of the semisolid excipient to at least 20°C above its melting point
- Incorporation of the active substances (with stirring).
- Capsule filling with the molt cooling to room temperature. For liquid formulations, it involves a two-step process
- Filling of the formulation into the capsules followed by sealing of the body and cap of the capsule, either by banding or by microspray sealing.

Spray drying

Essentially, this technique involves the preparation of a formulation by mixing lipids, surfactants, drug, solid carriers and solubilization of the mixture before spray drying. The solubilized liquid formulation is then atomized into a spray of droplets.

The droplets are introduced into a drying chamber, where the volatile phase (e.g. the water contained in an emulsion), evaporated and prepared into tablet pattern and the drying chamber design are selected according to the drying characteristics of the product and powder specifications.

Adsorption to solid carriers

Free-flowing powders may be obtained from liquid SE formulations by adsorption to solid carriers. The adsorption process is simple and just involves addition of the liquid on to carriers by mixing in a blender.

Melt granulation

Melt granulation is a process in which powder agglomeration is obtained through the addition of a binder that melts or softens at relatively low temperatures.

Melt extrusion/extrusion spheronization

Melt extrusion is a solvent-free process that allows high drug loading (60%) as well as content uniformity.[20] Extrusion is a procedure of product of uniform shape and density by forcing it through a die under controlled temperature, product flow and pressure conditions.[21]

CHARACTERIZATION OF SEDDS

Ternary phase diagram

Pseudoternary diagrams are often constructed for the development of SEDDS that help in determining the optimum concentration of different excipients necessary to obtain homogeneous preconcentrates, self-emulsification ability and drug loading. In this method, water is incorporated into the SMEDDS (Self Microemulsifying Drug Delivery System) preconcentrate in a drop wise manner, with gentle stirring to allow equilibration. Addition of water leads to the formation of a complex system ranging from gels to a system containing lamellar, hexagonal phases to microemulsions. The mixture is visually examined for transparency. The points from clear to turbid and turbid to clear are designated as emulsion and microemulsion.[22]

Droplet size

Droplet size is an important factor in the self-emulsification performance because it determines the rate and extent of drug release as well as absorption. It is measured by dynamic light-scattering techniques. This employs the fluctuation in scattered light intensity to measure the velocity of Brownian diffusion and consequently the dispersed droplets. Photon correlation spectroscopy and coulter nanosizer are mainly employed for the determination of the emulsion droplet size.[23,24]

Zeta potential

This is used to identify the charge on the droplets. The charge on the oil droplets is due to inconventional SMEDDS, and is negative due to the presence of free fatty acids; however, incorporation of a cationic lipid such as oleylamine at a concentration range of 1-3% will yield cationic SMEDDS. Zeta potential helps to predict the stability and flocculation effect in emulsion systems. If the zeta potential falls below a certain level, colloid will aggregate due to attractive forces. Conversely, a high zeta potential maintains a stable system.[25]

Emulsification rate

The rate of self-emulsification is usually determined by adding a dose of the SMEDDS preconcentrate, preferably in a capsule, to a relevant amount of water or biorelevant media. The rate of dispersion is determined by visual observation.

FORMULATION OF SEDDS

The following points should be considered in the formulation of a SEDDS

Selection of oils, surfactant and co-solvent based on the solubility of the drug.

The preparation of the SEDDS formulation by dissolving the drug in a mixture of oil, surfactant and co-solvents.

The addition of drug to SEDDS is critical because the drug interferes with the self-emulsifying process to a certain extent, which leads to a change in optimal oil – surfactant ratio; therefore, the design of optimal SEDDS requires preformulation solubility and phase diagram studies. Recently synthesized drugs that are being discovered are lipophilic in nature and have poor aqueous solubility, thereby posing problems in their formulation into delivery systems. Because of their low aqueous solubility and low permeability, dissolution and/or release rate from the delivery system forms the rate-limiting step in their absorption and systemic availability.

More than 60% of potential drug products suffer from poor water solubility. For the therapeutic delivery of lipophilic active moieties (BCS class II drugs), lipid-based formulations are inviting increasing attention.[26,27] Currently, a number of technologies are available to deal with the poor solubility, dissolution rate and bioavailability of insoluble drugs. The self-dispersing lipid formulations (SDLFs) are one of the promising approaches to overcome the formulation difficulties of various hydrophobic/lipophilic drugs and to improve the oral bioavailability of poorly absorbed drugs.[11,33] The SDLFs contain an oil and surfactant mixture into which the drug is incorporated. They emulsify when mixed with an aqueous environment. The self-emulsification process is specific to the particular pair of oil and surfactant, surfactant concentration, oil/surfactant ratio and the temperature at which self-emulsification occurs. After self-dispersion, the drug is rapidly distributed throughout the GIT as fine droplets. The SDLFs are of two kinds, namely SEDDS formed using surfactants of HLB < 12 and SMEDDS formed using surfactants of HLB > 12. Both SEDDS and SMEDDS are stable preparations and improve the dissolution of the drug due to increased surface area on dispersion. Many researchers have reported the applications of SEDDS for delivering and targeting lipophilic drugs, e.g.: Coenzyme Q10,[28] Vitamin E,[29] Halofantrine[30] and Cyclosporine A.[31]

THE EMULSIFICATION PROCESS

Self-emulsification is a phenomenon that has been widely exploited commercially in formulations of emulsifiable concentrates of herbicides and pesticides.[32] Concentrates of crop sprays are to be diluted by the user, such as farmers or house-hold gardeners, allowing very hydrophobic compounds to be transported efficiently. In contrast, SMEDDS, using excipients acceptable for oral administration to humans, have not been widely exploited and knowledge about their physicochemical principles is therefore limited.

Mechanism of self-emulsification

In the emulsification process, the free energy (ΔG) associated is given by the equation:[33]

$$\Delta G = \Sigma Ni\pi ri \quad (1)$$

Where "N" is number of droplets with radius "r" and "σ" is the interfacial energy. It is apparent from the above equation that the spontaneous formation of the interface between the oil and water phases is energetically not favored. The system commonly classified as SEDDS has not yet been shown to emulsify spontaneously in the thermodynamic sense. The emulsification process may be associated with the ease with which water penetrates the oil – water interface with the formation of liquid crystalline phases resulting in swelling at the interface, thereby resulting in greater ease of emulsification.[34-36] However, for systems containing co-surfactants, significant partitioning of components between the oil and aqueous phases may take place leading to a mechanism described as "diffusion and stranding," whereby the oil is solubilized, leading to migration into the aqueous phase.

Dilution phases

Upon dilution of a SMEDDS formulation, the spontaneous curvature of the surfactant layer changes via a number of possible liquid crystalline phases. The droplet structure can pass from a reversed spherical droplet to a reversed rod-shaped droplet, hexagonal phase, lamellar phase, cubic phase and various other structures until, after appropriate dilution, a spherical droplet will be formed again dilution.

EVALUATION

Thermodynamic stability studies

The physical stability of a lipid-based formulation is also crucial to its performance, which can be adversely affected by precipitation of the drug in the excipient matrix.[37-39] In addition, poor formulation physical stability can lead to phase separation of the excipient, affecting not only formulation performance but visual appearance as well. In addition, incompatibilities between the formulation and the gelatin capsules shell can lead to brittleness or deformation, delayed disintegration or incomplete release of drug.

Heating cooling cycle

Six cycles between refrigerator temperature (40ºC) and 45ºC, with storage at each temperature of not less than 48 h, is studied. Those formulations that are stable at these temperatures are subjected to a centrifugation test.

Our freeze thaw cycle

Three freezes for the formulations were performed. Those formulations that passed this test showed good stability with no phase separation, creaming or cracking.

Dispersibility test

The efficiency of self-emulsification of oral nano- or microemulsions is assessed using a standard USP XXII dissolution apparatus 2. One milliliter of each formulation was added to 500 mL of water at 37 ± 0.5°C. A standard stainless steel dissolution paddle rotating at 50 rpm provided gentle agitation. The *in vitro* performance of the formulations is visually assessed by using the following method:

Grading system

Grade A: Rapidly forming (within 1 min) nanoemulsion, having a clear or bluish appearance

Grade B: Rapidly forming, slightly less-clear emulsion, having a bluish white appearance

Grade C: Fine milky emulsion that formed within 2 min

Grade D: Dull, grayish white emulsion having slightly oily appearance that is slow to emulsify (longer than 2 min)

Grade E: Formulation exhibiting either poor or minimal emulsification with large oil globules present on the surface.

Grade A and Grade B formulations will remain as a nanoemulsion when dispersed in the GIT, while formulations falling in Grade C could be recommend for SEDDS formulation.

Turbidimetric evaluation

Nepheloturbidimetric evaluation is performed to monitor the growth of the emulsification. A fixed quantity of a self-emulsifying system is added to a fixed quantity of suitable medium (0.1 N hydrochloric acid) under continuous stirring (50 rpm) on a magnetic plate at ambient temperature and the increase in turbidity is measured using a turbidimeter. However, because the time required for complete emulsification is too short, it is not possible to monitor the rate of change of turbidity (rate of emulsification).

Viscosity determination

The SEDDS system is generally administered in soft gelatin or hard gelatin capsules. Therefore, it can be easily poured into capsules and such a system should not be too thick to create a problem. The rheological properties of the microemulsion are evaluated using a Brookfield viscometer. These viscosity determinations confirm whether the system is w/o or o/w. If the system has low viscosity, then it is the o/w type of system and if the system has high viscosity, then it is a w/o type of system.

Droplet size analysis particle size measurements

The droplet size of the emulsions is determined by photon correlation spectroscopy (which analyses the fluctuations in light scattering due to Brownian motion of the particles) using a Zetasizer able to measure sizes between 10 and 5000 nm.

FUTURE TREND

In relation to the formulation development of poorly soluble drugs in the future [Table2], there are now techniques being used to convert liquid/semisolid SEDDS and SMEDDS

Table 1: Application of SEDDS in relation to BCS classification[10]

BCS class	Aqueous solubility	Membrane permeability	Hurdles overcome by SEDDS
1	High	High	Enzymatic degradation, gut wall efflux
2	Low	High	Solubilization, bioavailability
3	High	Low	Enzymatic degradation, gut wall efflux
4	Low	Low	Solubilization, enzymatic degradation

SEDDS: Self-emulsified drug delivery systems, BCS: Biopharmaceutical Classification System

Table 2: Marketed SEDDS formulation[39-41]

Brand name	Drug used	Dosage form	Company
Neoral	Cyclosporine	SGC	Novartis
Norvir	Ritonavir	SGC	Abbot Laboratories
Fortovase	Saquinavir	SGC	Hoffmann Roche
Agenerase	Amprenavir	SGC	GSK
Convulex	Valporic acid	SGC	Pharmacia

SEDDS: Self-emulsified drug delivery systems, SGC: Structural genomics consortium, GSK: Galaxo smith klein

formulations into powders and granules, which can then be further processed into conventional "powder-fill" capsules or even compressed into tablets. Hot melt granulation is a technique for producing granules or pellets and, by using a waxy solubilizing agent as a binding agent, up to 25% solubilizing agent can be incorporated in a formulation. There is also increasing interest in using inert adsorbents, such as the Neusilin products, for converting liquids into powders – which can then be processed into powder fill capsules or tablets. Oral delivery of poorly water-soluble compounds is to predissolve the compound in a suitable solvent and fill the formulation into capsules.

The main benefit of this approach is that predissolving the compound overcomes the initial rate-limiting step of particulate dissolution in the aqueous environment within the GIT. However, a potential problem is that the drug may precipitate out of the solution when the formulation disperses in the GIT.

REFERENCES

1. Groves MJ, Mustafa RMA, Carless JE. Phase studies of mixed phosphated surfactants, n-hexane and water. J Pharm Pharmacol 1947;26:616-23.
2. Pouton CW. Self-emulsifying drug delivery systems: Assessment of the efficiency of emulsification. Int J Pharm 1985;27:335-48.
3. Wakerly MG, Pouton CW, Meakin BJ. Evaluation of the self-emulsifying performance of a non-ionic surfactant-vegetable oil mixture. J Pharm Pharmacol 1985;6-39.
4. Pouton CW, Wakerly MG, Meakin BJ. Self-emulsifying systems for oral delivery of drugs. Proc Int Symp Control Releases Bioact Mater 1987;14:113-4.
5. Serajuddin AT, Shee PC, Mufson D, Bernstein DF, Augustine MA. Effect of vehicle amphiphilicity on the dissolution and bioavailability of poorly water-soluble drug from solid dispersions. J Pharm Sci 1988;77:414-7.
6. Tarr BD, Yalkowsky SH. Enhanced intestinal absorption of cyclosporine in rats through the reduction of emulsion droplet size. Pharm Res 1989;6:40-3.
7. Charman SA, Charman WN, Rogge MC, Wilson TD, Dutko FJ, Pouton CW. Self-emulsifying drug delivery systems: Formulation and biopharmaceutic evaluation of an investigational lipophilic compound. Pharm Res 1992;9:87-93.
8. Craig DQ. The use of self-emulsifying systems as a means of improving drug delivery. BT Gattefosse 1993;86:21-31.
9. Garrigue JS, Lambert G, Benita S. Self-emulsifying oral lipid-based formulations for improved delivery of lipophilic drugs. In: Drugs and the Pharmaceutical Sciences. Microencapsulation Methods and Industrial Applications. 2nd ed. Chap. 13. Benita S, editor. Switzerland: Informa Healthcare; 2005. p. 429-80.
10. Craig DQ, Lievens HS, Pitt KG, Storey DE. An investigation into the physico-chemical properties of self-emulsifying systems using low frequency dielectric spectroscopy, surface tension measurements and particle size analysis. Int J Pharm 1993;96:147-55.
11. Shah NH, Carvajal MT, Patel CI, Infeld MH, Malick AW. Self-emulsifying drug delivery system (SEDDS) with polyglycolyzed glycerides for improving *in vitro* dissolution and oral absorption of lipophilic drugs. Int J Pharm 1994;106:15-23.
12. Constantinides PP. Lipid microemulsion for improving drug dissolution and oral absorption: Physical and biopharmaceutical aspects. Pharm Res 1994;12:1561-72.
13. Kimura M, Shizuki M, Miyoshi K, Sakai T, Hidaka H, Takamura H, *et al*. Relationship between the molecular structures and emulsification properties of edible oils. Biosci Biotech Biochem 1994;58:1258-61.
14. Shah NH, Carvagal MT, Patel CI. Self-emulsifying drug delivery system (SEDDS) with polyglycolyzed glycerides for improving *in vitro* dissolution and oral absorption of lipophilic drugs. Int J Pharmacol 1994;106:15.
15. Meinzer A, Mueller E, Vonderscher J. Microemulsion—a suitable galenical approach for the absorption enhancement of low soluble compounds. B T Gattefosse 1995;88:21-6.
16. Craig DQ, Barkar SA, Banning D, Booth SW. An investigation into the mechanisms of self-emulsification using particle size analysis and low frequency dielectric spectroscopy. Int J Pharm 1995;144:103-10.
17. Reiss H. Entropy-induced dispersion of bulk liquids. J Colloid Interface Sci 1975;53:61-70.
18. Gershanik T, Benita S. Positively charged self emulsifying oil formulation for improving oral bioavailability of progesterone. Pharm Dev Technol 1996;1:147-57.
19. Khoo S, Humberstone AJ, Porter CJ, Edwards GA, Charman WN. Formulation design and bioavailability assessment of lipidic self-emulsifying formulations of halofantrine. Int J Pharm 1998;167:155-64.
20. Hauss DJ, Fogal SE, Ficorilli JV, Price CA, Roy T, Jayaraj AA, *et al*. Lipid-based delivery systems for improving the bioavailability and lymphatic transport of poorly water-soluble LTB4 inhibitor. J Pharm Sci 1998;87:164-9.
21. Pillay V, Fassihi R. Unconventional dissolution methodologies. J Pharm Sci 1999;88:843-51.
22. Rang MJ, Miller CA. Spontaneous emulsification of oils containing hydrocarbon, nonionic surfactant and oleyl alcohol. J Colloid Interface Sci 1999;209:179-92.
23. Julianto T, Yuen KH, Noor AM. Improved bioavailability of vitamin E with a self emulsifying formulation. Int J Pharm 2000;200:53-7.
24. Kommuru TR, Gurley B, Khan MA, Reddy IK. Self-emulsifying drug delivery systems (SEDDS) of coenzyme Q10: Formulation development and bioavailability assessment. Int J Pharm 2001;212:233-46.
25. Wasan KM. Drug Dev Ind Pharm 2001;27:267-76.
26. Lipinski CA. Drug-like properties and the causes of poor solubility and poor permeability. J Pharmacol Toxicol Methods 2003;44:235-49.
27. Strickley RG. Solubilizing excipients in oral and injectable formulations. Pharm Res 2004;21:201-30.
28. Yang S, Gursoy RN, Lambert G, Benita S. Enhanced oral absorption of paclitaxel in a novel self-microemulsifying drug delivery system with or without concomitant use of P-glycoprotein inhibitors. Pharm Res 2004;21:261-70.

29. Verreck G, Brewster ME. Melt extrusion-based dosage forms: Excipients and processing conditions for pharmaceutical formulations. Bull Tech Gattefosse 2004;97:85-95.
30. Ramsay-Olocco K, Alexandrova L, Nellore R, Killon R, Li L, Coen P, *et al*. Pre-clinical and clinical evaluation of solution and soft gelatin capsule formulations for a BCS class 3 compound with atypical physicochemical properties. J Pharm Sci 2004;93:2214-21.
31. Goddeeris C, Cuppo F, Reynaers H, Bouwman WG, Van den Mooter G. Light scattering measurements on microemulsions: Estimation of droplet sizes. Int J Pharm 2006;312:187-95.
32. Gursoy RN, Benita S. Self-emulsifying drug delivery system (SEDDS) for improved oral delivery of lipophilic drugs. Biomed Pharmacother 2004;58:173-82.
33. Pouton CW. Formulation of poorly water-soluble drugs for oral administration: Physicochemical and physiological issues and the lipid formulation classification system. Eur J Pharm Sci 2005;29:278-87.
34. Zhao Y, Wang C, Chow AH, Ren K, Gong T, Zhang Z, *et al*. Self-nanoemulsifying drug delivery system (SNEDDS) for oral delivery of Zedoary essential oil: Formulation and bioavailability studies. Int J Pharm 2006;383:170-7.
35. Hauss DJ. Oral lipid-based formulations. Adv Drug Deliv Rev 2007; 59:667-76.
36. Strickley RG. Currently marketed oral lipid-based dosage forms drug products and excipients. In: Hauss DJ, editor. Oral lipid-based formulations enhancing the bioavailability of poorly water soluble drugs. New York: Healthcare, Inc.; 2007. p. 1-339.
37. Patel PA, Chaulang GM, Akolkotkar A, Mutha SS, Hardikar SR, Bhosale AV. Self emulsifying drug delivery system: A review. Research J Pharm and Tech 2008;1:313-23.
38. Jannin V, Musakhanian J, Marchaud D. Approaches for the development of solid and semi-solid lipid-based formulations. Adv Drug Deliv Rev 2008;60:734-46.
39. Tang B, Cheng G, Gu JC, Xu CH. Development of solid self-emulsifying drug delivery systems: Preparation techniques and dosage forms. Drug Discov Today 2008;13:606-12.
40. Jannin V, Musakhanian J, Marchaud D. Approaches for the development of solid and semi-solid lipid based formulations. Adv Drug Deliv Rev 2008;60:734-46.
41. Yin YM, Cui FD, Mu CF, Choi MK, Kim JS, Chung SJ, *et al*. Docetaxel microemulsion for enhanced oral bioavailability: Preparation and *in vitro* and *in vivo* evaluation. J Control Release 2009;140:86-94.

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