

REVIEW ARTICLE**A COMPREHENSIVE REVIEW OF THE SELF-EMULSIFYING DRUG
DELIVERY SYSTEM (SEDDS) AND ITS RECENTLY DEVELOPED
FORMULATIONS**

Sehrish Iqbal¹, Muhammad Ahsan Waqar^{2}, Tehseen Riaz¹, Aimon Qureshi¹, Naila Tabassam¹,
Tooba Mehboob¹*

¹ Faculty of Pharmaceutical Sciences, University of Central Punjab, Lahore, Pakistan

² Department of Pharmaceutics, Faculty of Pharmaceutical Sciences, Lahore University of Biological & Applied Sciences, Lahore, Pakistan.

*Corresponding author's email: ahsanwaqar491@gmail.com

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ABSTRACT

Background: Poor water solubility of the therapeutic compounds has become a very challenging issue for the delivery of drugs through conventional approaches. Over 40% of newly discovered active compounds also have a lack of water solubility and are lipophilic in nature. One approach for increasing the oral bioavailability of therapeutic agents is to deliver the drug via a self-emulsifying drug delivery system (SEDDS). Although many studies have been carried out, there are few drug products on the pharmaceutical market formulated as SEDDS, confirming the difficulty of formulating hydrophobic drug compounds into such formulations. **Objectives:** This review aims to describe the SEDDS formulation, its composition, as well as the manufacturing techniques and recently developed formulations, and also highlights an important characterization test for the evaluation of SEDDS. **Methodology:** Relevant literature was searched in English using different databases, i.e. Google Scholar, PubMed, and Scopus. **Results:** Within recent years, SEDDS was also discovered for oral administration of hydrophilic macromolecular drugs such as peptides, proteins, polysaccharides and pDNA. SEDDS are stable blends of surfactants, oils, solvents, and co-solvents. This system of drug delivery is useful for improving the aqueous solubility of drugs. They could be manufactured by the spray cooling method, the melt granulation process, the lyophilization technique, and by extrusion or spheronization. Various characterization tests, such as zeta potential, viscosity, dispersibility, cloud test, percentage transmittance, etc., could also be performed to confirm the stability of the SEEDS. **Conclusion:** Recently, many formulations have been developed for the delivery of drugs through the use of SEEDS and have shown increased bioavailability of the drug, as well as many promising outcomes.

Keywords: SEDDS, lipophilic, solubility, bioavailability, drug development, characterization

INTRODUCTION

The biggest and the most serious problem with majority of existing drug substances and many newly discovered chemical entities is their poor water solubility that causes a challenge in successful development and new drug marketing of the formulations (1-3). Drug's solubility is its capacity to dissolve any other liquid vehicle. The maximum quantity of the material (solute) which is entirely dissolving into a suitable solvent on a specific pressure level and temperature and forms a solution of solute in the solvent that is homogenous is known as drug's solubility. If the compound does not dissolve completely in a particular solvent, then such compound is poorly or extremely poorly soluble and is referred to as insoluble. Almost 40% of the newly developed drug candidates are associated with a lack of solubility in water and administration through oral route is generally related to lower bioavailability, reduced dose proportionality and higher intra and inter subject variation. A drug's solubility is also important in its absorption. Thus, for efficient absorption of a drug, it must be properly soluble (4). Many formulation strategies are implemented to overcome these problems that include the usage of lipids, salt formation, cyclodextrins, surfactants, permeation enhancers, micronization, solid dispersions and nanoparticles (5).

Although, such methods have been successful in some selected cases. However, formulations based on lipids have gained much focus recently for the improvement of poorly water-soluble drug molecule's oral bioavailability. The most popular strategy is the one in which drug substance is incorporated in the lipid vesicles (inert) that include formulations that are self-emulsifying, oils, surfactant dispersions, liposomes and emulsions (6, 7). This review

aims to discuss how self-emulsifying drug delivery system (SEDDS) improves the water solubility of drugs, its composition, method of preparation of SEDDS along with their characterization test as well as also highlights recent drug developments via SEDDS.

Data were collected from four international databases, including Google scholar, Scopus, Web of science and PubMed from last thirty years. Keywords used for searching were self-emulsifying drug delivery system (SEDDS), BCS class II drugs, increased solubility, surfactants, mechanism, methods for preparation, etc. The outcomes of data collection from the aforementioned sources have been gathered, analysed, interpreted, and cited in this review accordingly.

LITERATURE REVIEW

SELF EMULSIFYING DRUG DELIVERY SYSTEM

SEDDS or "self-emulsifying system" are those formulations that consist of in-vitro lipid droplets having a dispersion with a turbid appearance and a diameter of 200 nm-5 μ m (8). Previously, self-emulsifying drug delivery systems were referred to as homogenous natural or synthetic oil mixtures, surfactants that are liquid or solid or those having one or more co-solvents and solvents with hydrophilic properties. These systems are characterized by their principal ability to develop emulsions of oil in water, nano-emulsions on slight stirring. Property linked to oral intake of hydrophobic drugs that are soluble in oil and surfactant mixtures make SEDDS a good candidate for drug delivery (9). This method can increase the rate and amount of absorption while also resulting in more consistent plasma concentration for lipophilic drugs with oral absorption that is limited by dissolution (10).

Role of SEDDS in improving solubility of BCS drugs

A variety of formulation strategies can be used for class II drugs (low solubility, high permeability) to improve bioavailability, such as increasing the rate of dissolution and keeping drug in intestine as solution. Bioavailability of Class IV drugs (low solubility and permeability) can be improved by formulating them as SEDDS, but this results in the low permeability of drug into membrane. Table 1 shows SEDDS application in overcoming the problems of various formulations (11).

Comparison between SEDDS, self-micro emulsifying drug delivery system (SMEDDS) and self-nano emulsifying drug delivery system (SNEDDS)

Self-emulsifying drug delivery systems (SEDDS), self-micro emulsifying drug delivery system (SMEDDS) and self-nano emulsifying drug delivery system (SNEDDS) are all composed of co-surfactants, solubilized compounds, surfactants and oils that are stable physically and after being added to water phase under mild stirring, can instantly and rapidly develop clear emulsions of oil in water type (o/w). Self-micro emulsifying drug delivery system (SMEDDS) and self-nano emulsifying drug delivery system (SNEDDS) consist of different diameter in size as shown in figure 1. Table 2 demonstrates the key differences between self-emulsifying drug delivery system (SEDDS), self-micro emulsifying drug delivery system (SMEDDS) and self-nano emulsifying drug delivery system (SNEDDS) (15).

Table 1. Problems overcome by SEDDS in relation to classification of BCS

Class of BCS	Solubility in aqueous phase	Permeability of membrane	Problems resolved by SEDDS	References
I	More	More	Gut wall efflux, Degradation due to enzymes	(12)
II	Less	More	Bioavailability, Dissolution	(13)
III	More	Less	Bioavailability, Degradation due to enzymes, Gut wall efflux	(14)
IV	Less	Less	Dissolution, Bioavailability, Degradation due to enzymes, Gut wall efflux	(12)

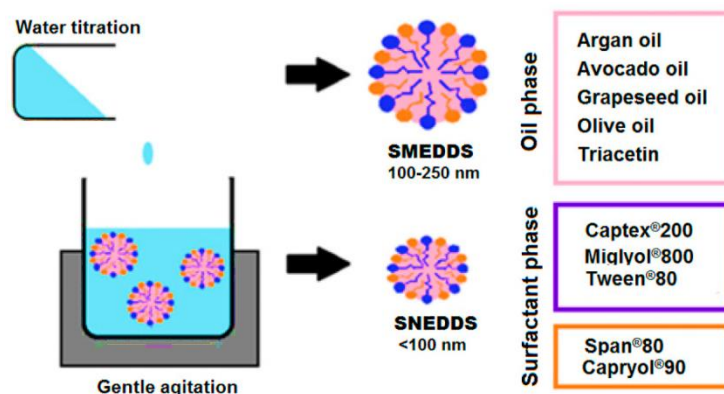


Figure 1. Particle size range of self-micro emulsifying drug delivery system (SMEDDS) and self-nano emulsifying drug delivery system (SNEDDS) and the excipients utilized to formulate them.

Table 2. Significant differentiation between characteristics of systems

Characteristic	SEDDS	SMEDDS	SNEDDS	References
Size of droplet	Higher than 300 nm	Lesser than 250 nm	Lesser than 100 nm	(16)
HLB value	Lesser than 12	Higher than 12	Higher than 12	(17)
System's appearance	Turbidity	Optical clarity	Optical clarity	(17)
Oily phase	B/w 40% to 80%	More than 20%	More than 20%	(18)
Surfactant's concentration	B/w 30% to 40%	B/w 40% to 80%	B/w 40% to 80%	(18)

Advantages of SEDDS

SEDSS have advantage over other formulation techniques because they are characterized by their spontaneous formulation, better and improved patient compliance, less production cost and simplicity of process control, high stability and accuracy. SEDSS offer more consistent and uniform drug absorption profile and thus improved solubilization of poorly soluble drugs and thermodynamic stability. Drug is prevented from the drastic effects of gastrointestinal system. So, SEDSS lead to improvements in absorption process, as well as improve plasma profiles. They also enhance dissolution for lipid drug substances having absorption issues (19).

Limitations of SEDDS

Since, SEDSS formulation have many advantages but are also associated with some disadvantages of the systems. There is a risk of toxicity as this system require large amounts of surfactant or co-surfactants for stabilizing droplets. These systems have limited capacity of solubilization for some drugs being used in system. Environmental parameters can influence micro emulsion stability such as pH and temperature. SEDSS may undergo the problem of phase separation when converted to micro emulsion. High inter and intra-subject variability can arise from environmental parameters like pH and temperature are two factors that influence stability of product. There have been very few studies for intravenous use reported so far and these formulations should be tested for toxicity. The substance having limited solubility as well as high-melting point are difficult to formulate as SEDSS (20-22).

Suitable drug candidates for SEDDS

High melting point drugs are not good candidates for SEDSS. Drug substances that undergo hepatic degradation can be effectively given through SEDSS. High amounts of drugs are not suitable candidates in case of SEDSS. For lipophilic pharmaceutical compounds with limited rate of dissolution and absorption, SEDSS can increase absorbance rate and intensity.

Mechanism of SEDDS

Exact phenomenon by which the emulsification process operates has not been fully explained and clarified (23). Emulsification process takes place when energy change which aids dispersibility are larger than the power necessary to enhance dispersion's contact area. Energy of a typical dispersion is directly related to amount of energy necessary to form newer oil and water surface as shown by the equation below.

$$DG = SN_i pr_i 2S$$

Here, DG is process's free energy, S represents energy at interface, N represents number of globules having radius (R). This results in the formation of emulsion particles monolayer, which lowers the energy at interface and additionally limits coalescence (24).

The oil from the solid support dislodges upon the initial agitation to form a system that's having lesser amount of free energy due to less interfacial tension. After more agitation, the power required for increasing the dispersion surface area is greater than the energy change which favours the formation of dispersion. The surfactants have a tendency to lower interface tension, which lowers the energy and maintains smaller droplet size. In the absence of surfactants, the oil droplets coalesce once the system's free energy is reduced as described in Figure 2 (25).

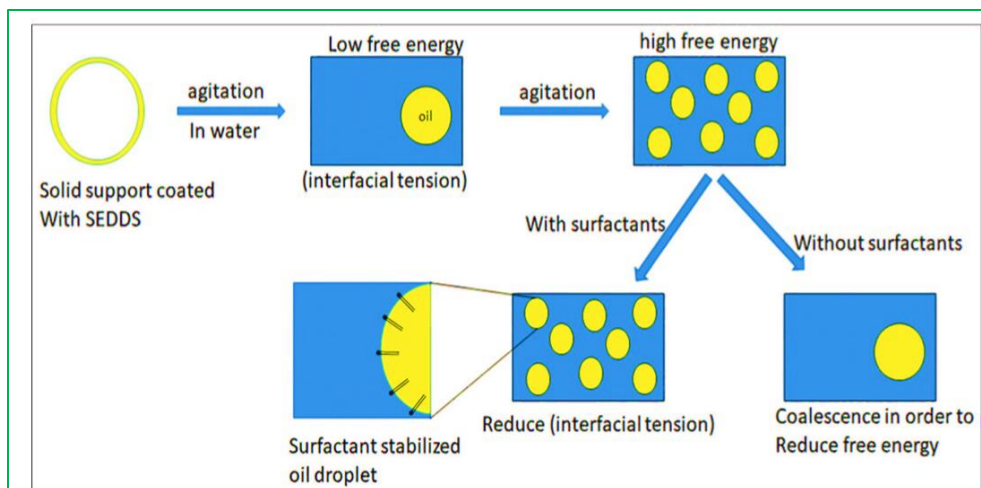


Figure 2. Mechanism of emulsion formation after interaction with aqueous media

COMPOSITION OF SEDDS

The active ingredient or drug must have sufficient solubility in pharmaceutically acceptable lipid substances, surfactants and co-surfactants. In addition to the active pharmaceutical ingredient, SEDDS have three following main components that include surfactants, lipids or oils and co-surfactants as shown in figure 3 (26).

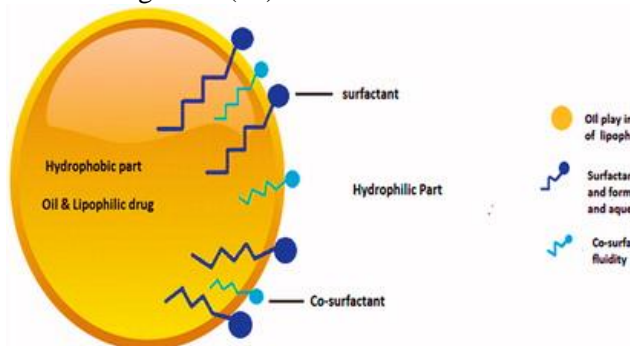


Figure 3. Main components of SEDDS

A few considerations should be taken into account while choosing the lipid excipients for example irritancy and toxicity, regulatory concern, miscibility, self-dispersibility, morphology at room temperature, chemical stability, purity and cost, digestibility and the effect of digested products (27).

Oils

One of the most essential excipient included in SEDDS is oil because it does not only help in emulsification, but it can also enhance the amount of lipophilic drug that is passing through

the intestine and thus elevating the amount of absorbance through gastrointestinal region (28). Medium and long chain oils both were employed in designing of these systems. In previously formulated self-emulsifying system, medium chain triglycerides were preferred because of their self-emulsification property, ability of better solubility and higher fluidity. But, the new medium-chain derivatives that are semi-synthetic are considered more attractive than these triglycerides because they are amphiphilic compounds that exhibit properties of surface active agents. Most commonly used oils in SEDDS include corn oil, cotton seed oil, soybean oil, peanut oil, sesame oil, castor oil, labrafil etc (29).

Surfactants

The bioavailability of various formulations can be improved by the use of surfactants in SEDDS. The two major considerations including hydrophilic-lipophilic balance (HLB) and drug's maximum solubility in surfactant has to be taken into account while choosing surfactant in SEDDS. Emulsion droplet size is majorly influenced by both value of HLB and the surfactant's concentration. Viscosity, cloud point measure, value of HLB and affinity for oil phase are the properties of surfactants that has strong influence on the droplet size and emulsification process. So, it can be concluded that concentration of surfactants need to be in between of 30-60 percent in SEDDS. The highly structured emulsions can be developed by

mixture of non-ionic surfactants with lipophilic and hydrophilic properties (30) (31). Surfactants can be divided into the four major categories as shown in table 3 (32).

Co-solvents

In SEDDS, the main function of co-solvents in these lipid based formulation is the facilitation of the dispersion process that results in faster rates of dispersion. It should be noted that the smaller quantities of co-solvents should be used in SEDDS because the larger quantities can lead to drug precipitation on dispersion into aqueous phase. Propylene glycol, glycerol, ethanol and polyethylene glycol are the examples of organic co-solvents used in SEDDS (36).

Consistency builder

The consistency of the emulsion can be altered by incorporating the additional materials to it such materials include; stearic acid or beeswax, tragacanth, cetyl alcohol etc.

Polymers

Generally, polymers are used in the concentration of about five to forty percent

which are not ionizable at physiological pH and has matrix formation capability. These polymers include ethyl cellulose, hydroxypropyl methylcellulose etc.

Co-surfactant

In SEDDS, co-surfactants with HLB values of 10-14 are commonly employed. Co-surfactants of hydrophilic nature are alcohols with average chain lengths, such as octanol, hexanol, and pentanol. Glycofurool and Transcutol P are newer co-surfactants that can decrease the interface of oil and water, allowing for the immediate development of microemulsions (37). In conventional SEDDS formulations, co-solvents of volatile nature and alcohol have the limitation because of evaporation to enclosed gelatin capsule shells, causing drug precipitation. To address this issue, preparations free from alcohol should be developed, however ability to dissolve lipid drugs is limited.

Table 3. Different types of surfactants and their examples

Surfactant type	Explanation	Example	References
Cationic Surfactants	Surfactants that have a hydrophilic group with positive charge are named as cationic surfactants.	Quaternary ammonium halide	(33)
Anionic Surfactants	Those in which hydrophilic group is negatively charged like sulphate group (ROSO ₃), carboxyl group (RCOO) or sulphonate group (RSO ₃) are known as anionic surfactants	Sodium lauryl sulphate, Potassium laurate	(34)
Ampholytic Surfactants	Ampholytic surfactants, which have a positive and a negative charge, are also known as zwitter ionic surfactants.	Sulfobetaines	(35)
Non-ionic Surfactants	Non-ionic surfactants have hydrophilic groups with no charges that have their water solubility from groups that are very polar in nature such as polyoxyethylene or OH group.	Tweens (Polysorbates), Spans	(35)

METHOD OF PREPARATION FOR SEDDS

SEDDS can be generated using diversity of waxy and liquid ingredients like lipids, biological oils, hydrophilic as well as hydrophobic surface active agents, and co-solvents which are soluble in water. SEDDS can be formulated with many different excipient combinations that are used for their encapsulation into soft or hard gelatin capsules. The solubilization of drugs in many surfactants, lipids and co-surfactants and solvents is considered while formulating SEDDS, in particular (38, 39). The most popular technique for making SEDDS involves adding a pharmacological ingredient to blend of co-surfactants, oil and surfactant before vortexing of mixture. However, the material may be

dissolved in any one excipient, and in some situations, rest of excipients may be incorporated to solution of drug. After the developed solution has been correctly stirred, a test is run to check for any turbidity. Then, if necessary, heat the solution to achieve the clear solution after the solution has reached equilibrium at room temperature for roughly 48 hours. The finalized mixture should be packaged within capsules of the appropriate diameter depending on volume made (40). Various techniques (Table 4) are used depending on the properties of the lipid excipients to convert semi-solid and liquid pharmaceutical formulations to solid forms that can be filled into tablets, capsules, or sachets (41, 42).

Table 4. Different techniques for solidification of SEDDS

Techniques	Explanation	Reference
Spray cooling	Spraying molten droplets into the cooling chamber causes them to solidify, re-crystallizing to sphere shaped particles which drop on bottom of assembly which are eventually recovered in form of powder of fine appearance. These are then used to form tablets or are directly filled into capsules.	(43-45)
Adsorption on solid carriers	Formulations can bind onto appropriate carriers with higher concentrations of about seventy percent. Gentamicin and erythropoietin formulations with Labrasol have been successfully developed by the adsorption technique.	(46)
Melt granulation process	It is a method that converts a drug-containing powder mixture into spheronized pellets or granules. This process necessitates higher speed mixing with use of a meltable binding material. Under controlled conditions, melting binder material would form linkage of liquid with powder which are shaped to smaller granules that could be mixed to form spheronized pellets.	(47)
Extrusion/Spheronization	Solid SEDDS can also be developed in form of pellets <i>through</i> extrusion or spheronization process. This technique involves the wet granulation of liquid SEDDS with solid excipients via wet mass extrusion, followed by spheronization of extrudates, drying of spheroids, sizing process, and optional pellet coating	(48)
Lyophilization Technique	A lyophilized molecular dispersion is created by co-dissolving the carrier and drug in a single solvent, freezing it, and then sublimating it. Mostly stabilizing properties during the lyophilizing of emulsions of oil in water were reportedly achieved by using a gentle rate of cooling and by adding cryoprotective agents	(49)
Liquid SEDDS filling in capsules	Two steps are required to formulate the liquid formulations. First, substance must be filled inside capsules; next, the cap plus body of the capsule must be sealed through sealing by micro spray and banding	(50-52)

CHARACTERIZATION PARAMETERS OF SEDDS

Chemical and physical stability

Liquid self-emulsifying drug delivery systems were stored at temperatures between 4 and 8 degrees Celsius (refrigerator) and 25 degrees Celsius for up to six months to assess their physical and chemical stability. The samples were then taken at pre-defined intervals of up to duration of six months. After dilution by distilled water at a one in hundred ratio, the physical compatibility of compound in system was assessed by means of examining separation of phase, zeta potential and size of particle.

Testing of thermodynamic stability

Centrifugation testing, cycles of heating cooling and freeze thaw stress test were used to evaluate formulation's thermodynamic stability. Throughout the study, physical stability was examined to determine the impact of formulation factors on stability of compound.

Heating cooling cycle

In heating cooling cycle, three phases of the investigation to be carried out between the stability chamber temperature (45°C) and refrigerator temperature (4°C), with each being stored for at least 48 hours. Then, centrifugation test was performed at these temperatures for stable formulations. The formulations that were successful were subjected to centrifugation at speed of 3500 rpm for thirty minutes. When there was no evidence of separation of phase, the formulation was submitted to a stress test.

Freeze-thaw stress test

The compounds were put through a freeze-thaw test by being stored at various temperatures between 21 and +25°C with a minimum of 48 hours at a time. The compounds which cleared the stress testing were put through a test for dispersibility to evaluate effectiveness of the self-emulsification process worked. The formulation were tested visually for any colour change or phase separation (53, 54).

Turbidimetric/Nephelometric evaluation

The main purpose of turbidimetric analysis is to assess emulsification activity. A predetermined volume of suitable medium of HCl 0.1 N is mixed with the preparation at the proper temperature while being continuously mixed at speed of 50 rpm at a hot plate. Since measuring

the rate of turbidity (emulsification) is difficult, turbidimeters can be used to achieve it effectively (55).

Droplet size measurement

Particle size can be determined using a Zeta sizer instrument, which operates on the theory of particle diffusion brought on by Brownian motion. The Stokes-Einstein equation can be used to get the translational diffusion coefficient, which determines particle size. The aqueous phase was used to dilute the formulation by around 100 times. The solution's globule size and PDI (polydispersity index) were then determined (56-58).

Resistance to dilution

To test SEDDS resistance to dilution, a specified amount of the formulation was diluted a number of times using different mediums including HCl 0.1 N, water, phosphate buffers of 7.4 pH. Dilute micro-emulsions then were observed over twelve hours for indication for drug precipitation or separation of phase. These are assigned as clear, unclear (turbid), stable (does not precipitate at the end of twelve hours), or unstable (precipitate in twelve hours) (59, 60).

Polarity

Polarity can be assessed by means of polarimeter that is a sensitive and non-destructive technique. Linear and polarized light when moving towards a test sample is rotated, it is considered polar. Polarity increases the affinity of drug molecule towards oily or water phase. The following factors can influence polarity: length of chain, unsaturation degree of fatty acid, HLB value, emulsifier concentration, and hydrophilic part molecular weight (61).

Zeta potential measurement

Using a Zeta sizer, the particle's surface-level electrical charge is measured to determine the Zeta potential, which measures the physical stability of systems. This operates on the basis of the particle's electrophoretic mobility (m/s), which was transformed into the zeta potential. Every test sample was then 100 times made dilute in distilled water before being put to the single-use cell (19, 62).

Electrical conductivity measurements

In order to identify dispersion medium nature, also to identify the occurrence of inversion of phases, studies for electrical

conductivity are made. Sudden conductivity increase was seen for several water-in-oil (w/o) micro-emulsion systems at low volume fractions, which was attributed to "percolative behaviour" and the movement of ions across globules prior to emergence of structures of bicontinuous form. Electrical conductivity studies can also determine if the diluted SEDDS contain an oil or water as continuous phase. Electrical conductivity was used to monitor the water phase solubility in the specified oil combination on a qualitative level using an electro conductometer (27, 63).

Measurement of % Transmittance

The visual clarity of SEDDS in diluted form using purified water up to about 100 times is measured as in terms of % Transmittance. While setting the transmittance in the UV visible spectroscopy to 100%, pour the distilled water into both cells. Then, using a UV spectrophotometer, the previously diluted SEDDS solution was placed in one of the cells, and the % transmittance was measured at 650 nm (64, 65).

Viscosity measurement

To measure the fluidity of SEDDS in dilute form, viscometer apparatus was employed. In particular, viscosity is a crucial characteristic for undiluted SEDDS to distinguish between Newtonian flow and non-Newtonian flow.

Because of spilling at the instrument's dosage tip, filling material can be lost while filling capsules with a very low viscosity substance. Therefore, there is a considerable likelihood that both the rate of capsule leakage and the weight fluctuation of units will increase (66) (67).

Measurement of cloud point

Cloud point refers to measurement of temperature where an emulsion breaks. SEDDS was diluted in water at a 1:100 ratio, and the sample was put into a bath that steadily increased in temperature. The percentage of the sample was then determined using spectrophotometric analysis. The temperature at which a rapid drop in transmission percentage was observed was recorded (68, 69).

Test for dispersibility

The performance of oral nano emulsion or microemulsion was evaluated through widely used dissolution apparatus II. A millilitre of the system was incorporated in water (500 ml) at a temperature of 37°C, with mild stirring by using paddle that rotates at speed of 50 rpm (70).

RECENT SEDDS FORMULATIONS

List of recent drug formulations of SEDDS, their components and their results they had in terms of drug release, dissolving rate, rate of absorption, and bioavailability is described in Table 5.

Table 5. Literature data for SEDDS

Drug/BCS class	Oil, surfactant, and co-surfactant	Results	References
Atorvastatin calcium (Class II drug)	Propylene glycol, Cremophor RH 40, Sefsol 218	Increase in bioavailability	(71)
Fexofenadine hydrochloride (Class II drug)	Aconon MC8, Oleic acid, Polyethyleneglycol 400	Drug was completely released in 90 minutes	(72)
Meloxicam (Class II drug)	Tween 80, Sunflower oil, Polyethyleneglycol 400	Fast dissolution of optimized formulation than marketed product	(73)
Domperidone (Class II drug)	Tween 80, Labrafac CC, Transcutol	More dissolution rate and increase in bioavailability	(74)
Olmесartan Medoxomil (Class II drug)	Tween, Acrysol EL135, Transcutol P	The drug's diffusion rate was higher than simple suspension	(75)
Glibenclamide (Class II drug)	Cremophor RH 40, Transcutol, Capmul MCM C8, Aerosil 200	Dissolution rate increased	(76, 77)

Carvedilol (Class II drug)	Oleic acid, labrafac PG labrafil,	Dissolution rate and bioavailability, drug permeability increased through rat intestine	(78)
Ritonavir (Class II drug)	Cremophor EL, Imwitor988, Capmul GMS K-50, Cremophor RH 40 (1:1)	Oral bioavailability and solubility was enhanced	(79)
Telmisartan (Class II drug)	Kolliphor ELP: Span 80 (1:1), Labrafil 1944, PEG 400: Ethanol (1:1)	Increased dissolution rate in comparison to pure drug	(80)
Bosentan (Class II drug)	Cremophor EL, Bosentan/II Gelucire 44/14, PEG 400	Enhanced rate of dissolution	(81)
Efavirenz (Class II drug)	Tween 80, Labrafac PG Labrasol	Improved bioavailability and systemic absorption	(82)
Avanafil (Class II drug)	Tween 80, Dill oil, Propylene glycol	When compared to pure drug, bioavailability was increased by 1.4 fold	(83)
Lornoxicam (Class II drug)	Transcutol H, Labrafil M 1944 CS,	Dissolution rate and bioavailability improved	(84)
Simvastatin (Class II drug)	Tween 80, Capryol 90	Decrease in cholesterol level	(85)
Etofibrate (Class II drug)	Tween 80, Oleic Acid, Isopropanol	Dissolution rate increased	(86)
Lovastatin (Class II drug)	Nikkol HCO-50, Capmul MCM, Lutrol F127	Enhanced drug absorption	(87)

CONCLUSION

SEDDS are the lipidic formulations that, when produced carefully with the right excipient choices, have been shown to have advantages and properties such as increased drug stability and loading capacity, reproducibility, and a good absorption profile. SEDDS are primarily used to increase the bioavailability of BCS class II compounds, which typically have low water solubility and high permeability. Co-surfactants, oils, surfactants, and co-solvents are used in the formulation of SEDDS as principal excipients. The type of the oil, the surfactant, the cosurfactant, the oil/surfactant proportion, and the polarity of the emulsion are some of the variables that affect the self-emulsification process. The materials utilized should possess the qualities of being inert, compatible, having no effect on the emulsification capabilities, and no effect on the release profile of the medication.

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DECLARATIONS

Authors' Contributions

SI, MAW and AQ contributed to study concept, study design and data collection. MAW and AQ contributed in data analysis and interpretation. SI, NT and TM did the literature review and critically reviewed the manuscript. All the authors read and approved the final manuscript.

Ethical Approval

Not applicable

Conflict of Interest

The authors declared no conflict of interest among them.

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