WORLD JOURNAL OF PHARMACEUTICAL RESEARCH
Coden USA: WJPRAP Impact Factor 8.63
Volume 15, Issue 21, 141-156. Review Article ISSN 2277–7105

# BEYOND CONVENTIONAL FORMULATIONS: THE EXPANDING ROLE OF SELF-EMULSIFYING DRUG DELIVERY SYSTEMS

**Mr. Yash Sheth*, Dr. Nidhi Chauhan, Manav Upadhyay, Het Patel, Ayush Mallik, Azba Patel**

Laxminarayandev Collage of Pharmacy, Bholav, Bharuch-392012.

Article Received on 26 Sept. 2026,
Article Revised on 16 October. 2026,
Article Published on 01 Nov. 2026

https://doi.org/10.5281/zenodo.23757044

***Corresponding Author**
**Mr. Yash Sheth**
Laxminarayandev Collage of Pharmacy, Bholav, Bharuch-392012.

**How to cite this Article:** Mr. Yash Sheth*, Dr. Nidhi Chauhan, Manav Upadhyay, Het Patel, Ayush Mallik, Azba Patel. (2026). Beyond Conventional Formulations: The Expanding Role Of Self-Emulsifying Drug Delivery Systems. World Journal of Pharmaceutical Research, 15(21), 141–156.
This work is licensed under Creative Commons Attribution 4.0 International license.

## ABSTRACT

Lipid-based formulations known as self-emulsifying drug delivery systems (SEDDS) are intended to increase the oral bioavailability of medications that are poorly soluble in water. When these systems are exposed to gastrointestinal fluids and gently stirred, oils, surfactants, co-surfactants, and co-solvents spontaneously create fine oil-in-water emulsions. This procedure improves intestine absorption, medication solubility, and dissolution, which increases therapeutic efficacy. Excipients must be carefully chosen for SEDDS formulation based on the drug's physicochemical characteristics. Several solidification techniques, including capsule filling, spray drying, spray chilling, adsorption onto carriers, and Lyophilization, are utilized to create solid SEDDS in order to address stability and handling concerns related to liquid systems. To assure quality and performance, SEDDS are evaluated using droplet size analysis, zeta potential, thermodynamic stability tests, Dispersibility testing, viscosity measurement, and in vitro drug release studies. Lipid-based formulations known as self-emulsifying drug delivery systems (SEDDS) are intended to increase the oral bioavailability of medications that are poorly soluble in water. When these systems are exposed to gastrointestinal fluids and gently stirred, oils, surfactants, co-surfactants, and co-solvents spontaneously create fine oil-in-water emulsions. This procedure improves intestine absorption, medication solubility, and dissolution, which increases therapeutic efficacy.

**KEYWORDS:** Self-emulsifying drug delivery system, poorly water soluble, surfactant and co-surfactant, solidification techniques.

## INTRODUCTION

Self microemulsifying drug delivery systems are widely recognized as an effective strategy for improving the delivery of hydrophobic drugs. system offer an alternative approach for drugs with poor water solubility and low oral bioavailability, helping to enhanced their absorption and overall therapeutic effectiveness.[3] SEDDS formulation may consist of simple binary system containing a lipophilic phase and the drug or ternary system that include a lipophilic phase, surfactant, and drug. In many cases, co-surfactant is added to facilitate the formation of a microemulsion. These formulations typically produce lipid droplets ranging from 200nm to 5µ during in vitro testing and SEDDS also composed of oils and surfactant usually in a isotropic mixture and may also contain co-solvents. When introduced into and aqueous medium under gentle agitation they spontaneously form the oil in water emulsion.[6] the oral delivery of many proteins and therapeutic peptides remains challenging because of enzymatic degradation in the GI tract and poor permeability across the intestinal membrane. To overcome these barriers, various drug delivery technologies have been explored. In recent year SEDDS have a gained significant attention as promising carrier for the oral administration of peptides and proteins.[1] among lipid-based delivery system, SEDDS has a promising approach for enhancing the bioavailability of poorly water soluble drug(PWSD). Important for formulating lipophilic compound and improving their oral absorption and also increasing drug bioavailability.[4] recent advances in in vitro screening techniques, such as combinatorial chemistry has led to the discovery of many potential chemical compound with significant therapeutic activity. However, nearly 40% of these compound exhibit poor water solubility. which limits their dissolution rate, reduce absorption and result in low oral bioavailability.[2]

### Components of SEDDS

#### 1. Drug

Important factor in designing a SEDDS formulation is the drug's lipophilic and hydrophilic nature. For effective formulation the drug should ideally have a lop p value greater than 2, which indicates good lipid solubility. It should also be effective at a relatively low dose and should not undergo extensive first-pass metabolism as these properties make it a suitable candidate for SEDDS delivery.[1]

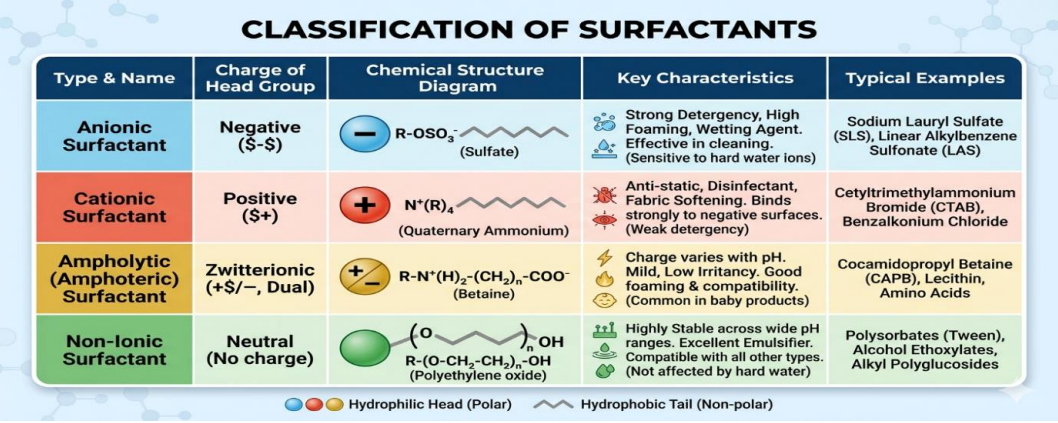
### 2. Oil

Natural oils and fats are made up of mixtures of triglycerides that contain fatty acid with different chain length and varying levels of unsaturation. As the degree of unsaturation increases, these oils become more prone to oxidation. To improve their stability and modify their physical properties, triglycerides are often chemically hydrogenated, which reduce the level of unsaturation.[3]

### 3. surfactant

Various compound with surfactant properties can be used in the formulation of self-emulsifying system. However, the selection is limited because only a small number of surfactant are considered safe and suitable for oral use. Among these, non-ionic surfactant with a relatively high hydrophilic-lipophilic balance(HLB) are the most commonly preferred as they offer better emulsification and improve compatibility. Safety remains one of the most important factor when selecting a surfactant for formulation purpose.[6]

1. Anionic surfactant
2. Cationic surfactant
3. Ampholytic surfactant
4. Non-ionic surfactant




### 4. co-solvents

Organic solvent such as ethanol, propylene glycol(PG) and polyethylene glycol(PEG) are commonly used in formulation to enhanced the solubility of hydrophilic surfactant and lipophilic drug. Their inclusion helps create a more stable effective system by improving the dissolution of formulation components.[7]

**for self-emulsifying**

the exact mechanism behind self-emulsification is not yet fully understood. It has been proposed that the process occurs when changes in entropy provide enough energy to expand the surface area of the dispersion beyond its equilibrium state.

In conventional emulsion free energy represent the energy required to create a new interface between the oil and water phase. Since system naturally tends to minimize free energy, the emulsion eventually separates into two distinct phase in order to reduce the interfacial area.[12]

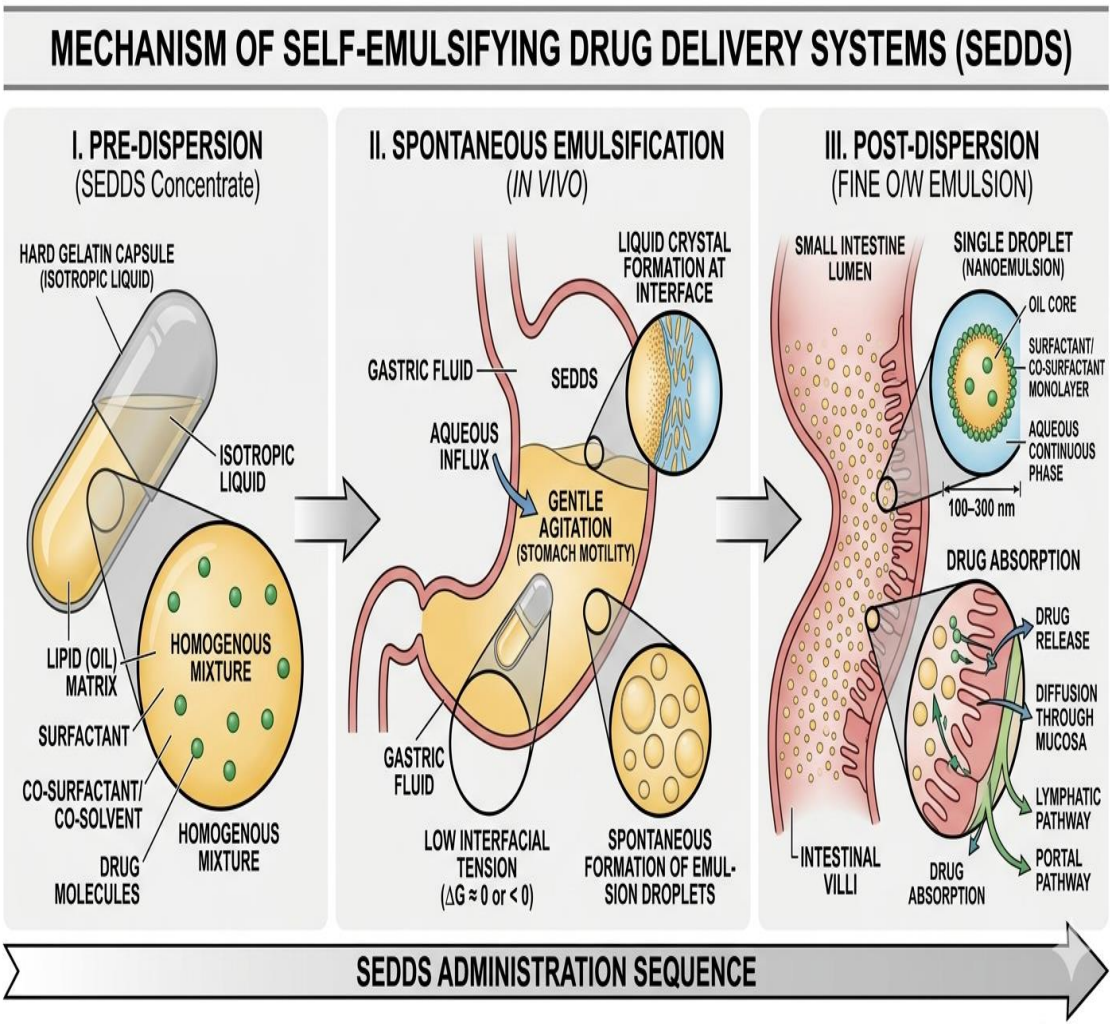



**Figure 1: Mechanism Of Self-Emulsifying Drug Delivery System.**

**Solidification of self-emulsified formulation**

1. Encapsulation of liquid and semi solid self-emulsified

widely use method for incorporating low doses of highly potent drugs involves filling capsule with liquid self-emulsifying formulation. Technique such as a micro-spraying and banding are commonly applied for this purpose.

For semi-solid self-emulsifying preparation, the excipients are heated to around 20°C above their melting point. Once melted the drug is mixed thoroughly into the molten base. This warm mixture is then filled into capsule shells and allow to cool at room temperature where it solidifies. Finally, the capsule is sealed using bending or micro-spray technique to prevent leakage and ensure product stability.[1]

2. Spray cooling

The molten formulation is sprayed as tiny droplets into a cooling chamber, where the droplets rapidly solidify and recrystallized into a spherical particle. These solid particle settle at the bottom of the chamber and are collected as a fine powder.

The resulting powder can be sued to prepare solid dosage form or filled directly into hard gelatin capsule. various type of atomizing equipment is available to convert the liquid mixture into droplets, including rotary, pressure, two fluid and ultrasonic atomizer.[3]

3. Adsorption on solid carriers

Formulation can be adsorbed onto suitable carrier material at high concentration, often up to about 70%. Drug formulation containing gentamicin and erythropoietin have also been successfully prepared using labrasol as an excipient.[9]

4. Spray drying:

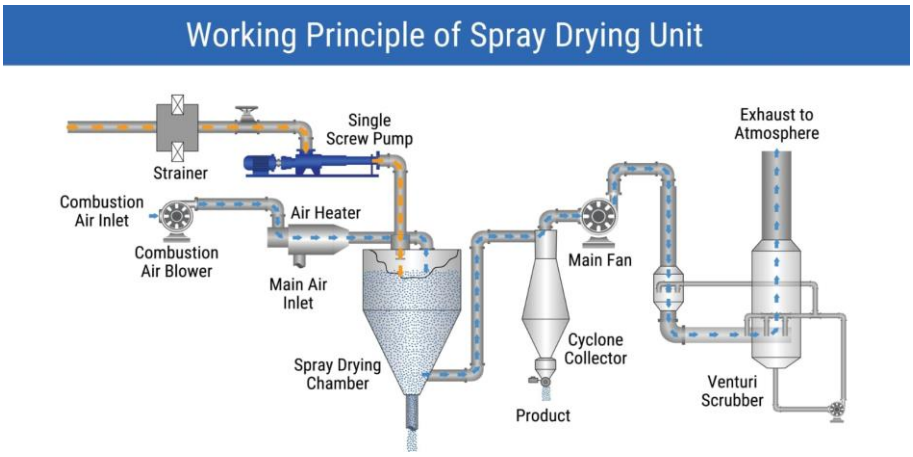



**Figure 2: spray drying.**

Spray drying is a commonly used continuous manufacturing process in pharmaceutical industry that convert liquid formulation into the fine solid particle. It is considered one of the most efficient technique for transforming liquid SEDDS in to solid dosage form the process generally, consist of 4 key stage: atomization, hot air, solvent evaporation and product collection.

In this method liquid SEDDS is mixed with solid carriers in suitable solvent usually ethanol to prepare sprayable solution. For poorly water soluble drug, organic solvent is often required and the process may be carried out under an inert nitrogen atmosphere for safety and stability.

The prepare solution is passed through a spray nozzle, where it is converted into a tiny droplet. This droplet exposed to hot drying gas, causing the solvent evaporate quickly and leaving behind dry solid particle. Finally, the powder is separated from the gas steam and collected using a cyclone separator.[14]

5. Lyophilization technique

A lyophilized molecular dispersion is prepared by dissolving both the drug and carrier in a common solvent, followed by freezing the solution through sublimation during freeze-drying.

Improve stability during the Lyophilization of oil in water emulsion has been reported when a slow and control cooling rate is used. The addition of antifreeze agents also helps protect the formulation and maintain its stability throughout the freeze-drying process.[9]

**Evaluation of SEDDS**

1. Drug content

The drug is extracted from pre-weighed SEDDS by dissolving it in an appropriate solvent. A suitable analytical method is used to determine the drug content in the solvent extract.[8]

2. Droplet size analysis particle size measurement

Using a Zetasizer that can measure sizes between 10 and 5000 nm, photon correlation spectroscopy—which examines variations in light scattering caused by Brownian motion of the particles—determines the droplet size of the emulsions.[6]

3. Thermodynamic stability studies

Formulations are tested for stability via freeze-thawing. Three to four freeze-thaw cycles—freezing at -4°C for 24 hours and thawing at 40°C for 24 hours—are applied to the formulations. For five minutes, centrifugation is carried out at 3000 rpm. Phase separation is

then detected in the formulations. For additional research, only formulations that are resistant to phase separation are chosen.[14]

4. Cloud point determination

The stability of the optimized HME S-SEDDS formulation was assessed after it underwent thermal treatment. Using a tiny magnetic stirrer, the HME-S SEDDS was first added to 0.14% SLS (1000X dilution) at 25 °C and 50 RPM. The glass beaker containing the emulsion was put on a hot plate after it had formed, and the temperature was raised at a pace of five degrees Celsius per minute. Cloud point was the first indication of turbidity or phase separation.[21]

5. Zeta potential

The Zeta potential, which gauges the physical stability of systems, is calculated by measuring the particle's surface-level electrical charge using a Zeta sizer. This is based on the electrophoretic mobility (m/s) of the particle, which was converted into the zeta potential.

Before being placed in the single-use cell, each test sample was diluted 100 times in distilled water.[9]

6. In vitro release

Based on the USP XXIV dissolving procedure, the quantitative in vitro release test is carried out in 900 milliliters of purified distilled water. To compare the release profile with a traditional tablet, SMEDDS is placed in a dialysis bag during the release period. At prearranged intervals, 10 ml of the sample solution is taken out, filtered through a 0.45µ membrane filter, appropriately diluted, and subjected to spectrophotometric analysis. As soon as the test sample is removed, an equal volume of new dissolving medium is added. The Beer Lamberts equation was used to determine the percentage of medication dissolved at various time periods.[17]

**Characterization of SEDD**

1. Visual evaluation

The evaluation of self-emulsification is aided by visual observation. After diluting SEDDS with water, the presence of a clear, isotropic, transparent solution indicates the formation of micro emulsions, whereas an opaque, milky white appearance shows the generation of macro emulsions. The formulation may be stable if there is no precipitation or phase separation.[1]

2. Chemical and physical stability

For up to six months, liquid self-emulsifying drug delivery systems were kept in a refrigerator between 4 and 8 degrees Celsius and at 25 degrees Celsius to evaluate their chemical and physical stability. After that, the samples were collected at predetermined intervals for a maximum of six months. The physical compatibility of the substance in the system was evaluated by looking at phase separation, zeta potential, and particle size following dilution by distilled water at a ratio of one to one hundred.[9]

3. Turbidity measurement

By determining if the dispersion approaches equilibrium quickly and in a consistent amount of time, effective self-emulsification can be identified.

Nepheloturbidimetric assessment is used to track the development of emulsification. A turbidimeter is used to measure the rise in turbidity when a fixed amount of self-emulsifying system is added to a fixed quantity of suitable medium (0.1N hydrochloric acid) on a magnetic plate at room temperature while being continuously stirred at 50 rpm.[3]

4. Dispersibility test:[3,7]

The self-emulsification efficiency of oral nano or microemulsion systems is commonly assessed using the conventional USP XXII dissolution apparatus II. In this method, 1 mL of the formulation is introduced into 500 mL of water maintained at 37 ± 0.5°C. Gentle agitation is provided using a standard stainless-steel paddle rotating at 50 rpm.

The in vitro performance of the formulations is then visually evaluated and classified according to the following grading system.

Grade A: A nano emulsion forms rapidly within 1 minute and shows a clear or slightly bluish appearance.[3]

Grade B: The emulsion forms quickly but is slightly less transparent, with a bluish-white appearance.[7]

Grade C: A fine milky emulsion develops within 2 minutes.[3,7]

Grade D: The emulsion appears dull, greyish-white, and somewhat oily, requiring more than 2 minutes for emulsification.[3]

Grade E: These formulations show poor emulsification, with large oil droplets visible on the surface.[7]

Generally, Grade A and Grade B formulations are considered ideal, as they are likely to remain as nano emulsions after release in the gastrointestinal tract. Grade C formulations may also be acceptable for use in SEDDS preparations.

5. viscosity measurement

The viscosity of diluted SMEDDS formulations that are micro emulsions is measured using a rheometer, a Brookfield viscometer with a cone and plate with a revolving spindle.[1]

**Advantage of SEDDS[3,6,7,8,18]**

1. SMEDDS provides the same benefit as emulsions in that it makes hydrophobic medications more soluble. While macro emulsions cream over time, SMEDDS can be preserved with ease due to their thermodynamic stability.
2. Increased bioavailability when taken orally.
3. The lipid digesting process has no effect.
4. the capacity to transport peptides that are vulnerable to GI tract enzymatic hydrolysis.
5. Because SMEDDS only needs basic and affordable manufacturing facilities, like a mixer with an agitator and volumetric liquid filling equipment, it may be produced on a wide scale.
6. Rapid Start of Action.
7. No impact on the process of lipid digestion.
8. Variability within and between subjects as well as the impact of food.
9. The biggest benefit is that it is simple to scale up and manufacture.
10. This avoids sluggish drug disintegration, which is its primary advantage over alternative solid dose formulations.
11. The capacity of lipid-based formulations to carry macromolecules including peptides, hormones, enzyme substrates, and inhibitors as well as to provide protection from enzymatic hydrolysis is one distinctive feature that sets them apart from other drug delivery systems.
12. Consistent medication absorption temporal profiles.
13. It shields the medications from the gut's hostile environment.

**Disadvantage of SEDDS[1,3,6,7,8,18]**

1. In gastrointestinal fluid, diluted SMEDDS experience drug precipitation. The ability of lipid formulations to maintain the medicine in its solubilized form in the gastrointestinal

tract (GIT) is a common need. The benefit of the lipid-based formulation technique is eliminated if the drug precipitates out of the system.

2. Handling, storage, and stability issues are present with liquid SMEDDS. Therefore, developing sound SMEDDS appears to be a sensible way to deal with these issues.
3. One of the obstacles to the development of SEDDSs and other lipid-based formulations is the lack of trustworthy predictive in vitro models.
4. Drug chemical instability.
5. One major challenge is the absence of reliable prognostic in vitro models for formulation evaluation.
6. Only in vitro-in vivo correlations are used to guide further formulation development.
7. Because these formulations may depend on digestion before the medicine is released, traditional dissolving techniques are ineffective.
8. GI adverse effects may result from adding more surfactants to the SEDDS formulation.
9. Manufacturing it might be costly.
10. Formulations need to be developed and tested in vivo in a suitable animal model.
11. Because these formulations rely on digestion before the medicine is released, the standard in-vitro dissolving approach is ineffective.
12. Validating the formulations with several components is debatable.




**Example of marketed product formulated as self-emulsifying system.[3]**

## Application of SEDDS[6,7,14,17]

### Control the drug release

1. Various formulation strategies have been used to boost bioavailability, achieve sustained release, and reduce the Making matrix pellets of nanocrystalline ketoprofen, sustained release ketoprofen microparticles, and floating oral Transdermal and ketoprofen systems of ketoprofen. Getting ready and stabilizing forms with enhanced solubility or nanocrystals of medicines may present issues with stability, processing, and finances.
2. When ketoprofen is included in SEDDS, this issue can be effectively resolved. formulation. This formulation reduced gastrointestinal discomfort and improved bioavailability by increasing the drug's solubility. Additionally, adding a gelling agent to SEDDS maintained the release of ketoprofen.
3. Lipophilic medications can be administered orally thanks to SEDDS.
4. Surfactant side effects can be mitigated by super saturable SEDDS (S-SEDDS). Compared to the conventional SEDDS formulation, the S-SEDDS formulation has an improved toxicity and safety profile.

5. SEDDS primary function is to improve the absorption of hydrophobic medications by creating an oil-in-water emulsion that is nanoscale.
6. SEDDS can also be used to transport proteins and peptides, which are challenging to take orally because of their high hydrophilicity and poor stability.
7. The viability of solid SEDDS for oral protein and peptide administration has been shown by recent research. When lysozyme was complexed with sodium dodecyl sulfate and adsorbed onto solid carriers, it maintained its bioactivity and self-emulsification characteristics, resulting in a stable powder that could be taken orally.
8. is a rate-limiting step in the drug's dissolution and bioavailability, however SMEDDS can present the drug to the GIT in globule sizes ranging from 1 to 100 nm. Due to the small oil droplets' quick emptying from the stomach, the medication is widely distributed throughout the digestive system, lessening drug-related discomfort. SMEDDS improve the drug's bioavailability, allowing for a dose reduction.

## CONCLUSION

self-emulsifying drug delivery systems (SEDDS) are a useful method for enhancing the oral bioavailability, solubility, and dissolving of medications that are poorly soluble in water. They improve therapeutic responsiveness, increase medication absorption, and give formulation design flexibility. Solid SEDDS are a viable and useful lipid-based drug delivery system despite certain drawbacks such stability and precipitation problems, as well as ongoing improvements in evaluation methods.

## REFERENCE

1. Salawi A. Self-emulsifying drug delivery systems: a novel approach to deliver drugs. Drug Deliv., 2022; 29(1): 1811-1823. doi: 10.1080/10717544.2022.2083724.
2. Akula S, Gurram AK, Devireddy SR. Self-microemulsifying drug delivery systems: an attractive strategy for enhanced therapeutic profile. Int. Sch. Res. Notices., 2014; 2014: 964051.
3. Revathi S, Dhana Raju MD. Self-emulsifying drug delivery system: a review. World J Pharm. Sci., 2013; 2(1): 89-107.
4. Zanchetta B, Chaud MV, Santana MHA. Self-emulsifying drug delivery systems (SEDDS) in pharmaceutical development. J Adv. Chem. Eng., 2015; 5(3): 130. doi: 10.4172/2090-4568.1000130.

5. Singh B, Bandopadhyay S, Kapil R, Singh R, Katare OP. Self-emulsifying drug delivery systems (SEDDS): formulation development, characterization, and applications. Crit Rev Ther. Drug Carrier Syst., 2009; 26(5): 427-521.
6. Nigade PM, Patil SL, Tiwari SS. Self-emulsifying drug delivery system (SEDDS): a review. Int. J. Pharm. Bio. Sci., 2012; 2(2): 42-52.
7. Nasikkar Z, Kamble R, Choudhary P, Chidrawar K, More A, More P. Self-emulsifying drug delivery system (SEDDS) - an overview. Int. J Pharm. Sci. Rev. Res., 2024; 84(11): 48-56. doi: 10.47583/ijpsrr. 2024.v84i11.007.
8. Verma R, Rathore KS, Saurabh SS. Review article on self-emulsifying system. IP Int J Comprehensive Adv. Pharmacol., 2024; 9(3): 196-201. doi: 10.18231/j.ijcaap.2024.027.
9. Iqbal S, Waqar MA, Riaz T, Qureshi A, Tabassam N, Mehboob T. A comprehensive review of the self-emulsifying drug delivery system (SEDDS) and its recently developed formulations. Int J Pharm. Integr Health Sci., 2024; 5(1): 45-56. doi: 10.56536/ijpihs. v5i1.119.
10. Vaghela S, Chaudhary S, Chaudhary A. A systemic review on the self-micro emulsifying drug delivery system. Int. J Pharm. Sci. Rev. Res., 2021; 69(1): 184-193.
11. Giri RR, Rakte AS, Pole MN. Advancement in formulation strategies for microemulsion and self-emulsifying system: a comprehensive review. Acta. Sci. Med. Sci., 2025; 9(7): 05-13.
12. Czajkowska-Kośnik A, Szekalska M, Amelian A, Szymańska E, Winnicka K. Development and evaluation of liquid and solid self-emulsifying drug delivery systems for atorvastatin. Molecules, 2015; 20(12): 21010-21022. doi: 10.3390/molecules201219745.
13. Baek K, Jin SG. Solidification materials and technology for solid self-emulsifying drug delivery systems. Pharmaceuticals., 2025; 18(10): 1550. doi: 10.3390/ph18101550.
14. Mohsin K, Shahba AA, Alanazi FK. Lipid based self-emulsifying formulations for poorly water soluble drugs-an excellent opportunity. Indian J Pharm Educ Res., 2012; 46(2): 88-96.
15. Jaiswal P, Aggarwal G, Harikumar SL, Singh K. Development of self-microemulsifying drug delivery system and solid-self-microemulsifying drug delivery system of telmisartan. Int J Pharm Investig., 2014; 4(4): 195-206. doi: 10.4103/2230-973X.143127.
16. Pattewar S, Kasture S, Pande V, Sharma S. Self microemulsifying drug delivery system: a lipid based drug delivery system. Int. J Pharm. Sci. Res., 2016; 7(2): 443-52. doi: 10.13040/IJPSR.0975-8232.7(2).443-52.

17. Dokania S, Joshi AK. Self-microemulsifying drug delivery system (SMEDDS) - challenges and road ahead. Drug Deliv., 2015; 22(6): 675-690.
18. Gahlawat N, Verma R, Kaushik D. Recent developments in self-microemulsifying drug delivery system: an overview. Asian J Pharm., 2019; 13(2): 59-67.
19. Buya AB, Beloqui A, Memvanga PB, Préat V. Self-nano-emulsifying drug-delivery systems: From the development to the current applications and challenges in oral drug delivery. Pharmaceutics., 2020; 12(12): 1194.
20. Kallakunta VR, Dudhipala N, Nyavanandi D, Sarabu S, Janga KY, Ajjarapu S, et al. Formulation and processing of solid self-emulsifying drug delivery systems (HME S-SEDDS): A single-step manufacturing process via hot-melt extrusion technology through response surface methodology. Int. J Pharm. 2023 Jun 25; 641: 123055. doi: 10.1016/j.ijpharm.2023.123055.
21. Silva LAD, Almeida SL, Alonso ECP, Rocha PBR, Martins FT, Freitas LAP, et al. Preparation of a solid self-microemulsifying drug delivery system by hot-melt extrusion. Int J Pharm., 2018; 541(1-2): 1-10.
22. Protopapa C, Tsichlis I, Kolipaka SS, Douroumis D, Demetzos C, Vlachou M. Formulation and in vitro evaluation of liposomal and self-microemulsifying drug delivery systems for oral delivery of cannabidiol. J Pharm. Sci., 2026; 115: 104053. doi: 10.1016/j.xphs.2025.104053.
23. Xia F, Chen Z, Zhu Q, Qi J, Dong X, Zhao W, Wu W, Lu Y. Gastrointestinal lipolysis and trans-epithelial transport of SMEDDS via oral route. Acta Pharm Sin. B. 2021; 11(4): 1010-1020.
24. Shaker DS, Ishak RAH, Ghoneim A, Elhuoni MA. Nanoemulsion: A Review on Mechanisms for the Transdermal Delivery of Hydrophobic and Hydrophilic Drugs. Sci. Pharm. 2019; 87(3): 17.
25. Uttreja P, Karnik I, Adel Ali Youssef A, Narala N, Elkanayati RM, Baisa S, Alshammari ND, Banda S, Vemula SK, Repka MA. Self-Emulsifying Drug Delivery Systems (SEDDS): Transition from Liquid to Solid—A Comprehensive Review of Formulation, Characterization, Applications, and Future Trends. Pharmaceutics., 2025; 17(1): 63.
26. Ke Z, Hou X, Jia XB. Design and optimization of self-nanoemulsifying drug delivery systems for improved bioavailability of cyclovirobuxine D. Drug. Des. Devel Ther., 2016; 10: 2049-2060.
27. Nazzal S, Khan MA. Response surface methodology for the optimization of ubiquinone self-nanoemulsified drug delivery system. AAPS Pharm. Sci. Tech., 2002; 3(1): E3.

28. Park H, Ha ES, Kim MS. Current status of supersaturable self-emulsifying drug delivery systems. Pharmaceutics., 2020; 12(4): 365.
29. Pan-On S, Pham DT, Tiyaboonchai W. Development of curcumin-loaded solid SEDDS using solid self-emulsifying drug delivery systems to enhance oral delivery. J Appl. Pharm. Sci., 2024; 14(09): 111-119. doi: 10.7324/JAPS.2024.168338
30. Potphode VR, Tapadiya SG. A Systematic Review on "Self- Micro Emulsifying Drug Delivery Systems (SMEDDS) for Herbal and Plant-Based Drugs: Enhancing Solubility and Bioavailability". J Chem. Health Risks., 2025; 15(4): 780-802.
31. Patel PA, Chaulang GM, Akolkotkar A, Mutha SS, Hardikar SR, Bhosale AV. Self-emulsifying drug delivery system: a review. Res. J Pharm. Technol., 2008 Oct-Dec; 1(4): 313-23.
32. Bahadur S, Yadu K, Baghel P, Naurange T, Sahu M. Review of formulation and evaluation of self-micro emulsifying drug delivery system (SMEDDS). Sci Rise Pharm. Sci., 2020; 4(26): 25-31.
33. Gupta S, Kesarla R, Omri A. Formulation Strategies to Improve the Bioavailability of Poorly Absorbed Drugs with Special Emphasis on Self-Emulsifying Systems. ISRN Pharm., 2013; 2013: 848043.
34. Baghel P, Roy A, Verma S, Satapathy T, Bahadur S. Amelioration of lipophilic compounds in regards to bioavailability as self-emulsifying drug delivery system (SEDDS). Future J Pharm. Sci., 2020; 6: 21. https: //doi.org/10.1186/s43094-020-00042-0
35. Gurram AK, Deshpande PB, Kar SS, Nayak UY, Udupa N, Reddy MS. Role of Components in the Formation of Self-microemulsifying Drug Delivery Systems. Indian J Pharm. Sci., 2015; 77(3): 249-257.
36. Salimi A, Sharif Makhmal Zadeh B, Hemati AA, Akbari Birgani S. Design and evaluation of self-emulsifying drug delivery system (SEDDS) of carvedilol to improve the oral absorption. Jundishapur J Nat Pharm. Prod., 2014 Aug; 9(3): e16125.
37. Le-Vinh B, Nguyen Le NM, Phan TNQ, Lam HT, Bernkop-Schnürch A. Effects of excipients on the interactions of self-emulsifying drug delivery systems with human blood plasma and plasma membranes. Drug Deliv Transl Res. 2024 Oct; 14(10): 3200-3211. doi: 10.1007/s13346-024-01541-w.
38. Lee YZ, Seow EK, Lim SC, Yuen KH, Abdul Karim Khan N. Formulation and in Vivo Evaluation of a Solid Self-Emulsifying Drug Delivery System Using Oily Liquid

Tocotrienols as Model Active Substance. Pharmaceutics. 2021 Oct 25; 13(11): 1777. doi: 10.3390/pharmaceutics13111777.

39. Cholakova D, Vinarov Z, Tcholakova S, Denkov N. Self-emulsification in chemical and pharmaceutical technologies. Curr Opin Colloid Interface Sci., 2022 Jun; 59: 101576. doi: 10.1016/j.cocis.2022.101576.
40. Gahlawat N, Verma R, Kaushik D. Recent developments in self-microemulsifying drug delivery system: An overview. Asian J Pharm. 2019 Apr-Jun; 13(2): 59-67.
41. Bhatt N, Patel H. Formulation and optimization of Ambrisentan self-micro emulsifying drug delivery system (SMEDDS) tablet by wet granulation. J Med Pharm Allied Sci. 2023 Sep-Oct; 12(5): 6110-6117. doi: 10.55522/jmpass. V1215.5673.
42. Postina A, To D, Zöller K, Bernkop-Schnürch A. Oral peptide drug delivery: design of SEDDS providing a protective effect against intestinal membrane-bound enzymes. Drug Deliv Transl Res. 2025 Oct; 14(10): 3200-3211. doi: 10.1007/s13346-025-01852-6.