VOLUME 11 ISSUE 2 2025

ISSN 2454 – 3055

INTERNATIONAL JOURNAL OF ZOOLOGICAL INVESTIGATIONS

Forum for Biological and Environmental Sciences

Published by Saran Publications, India

International Journal of Zoological Investigations Vol. 11, No. 2, 1067-1072 (2025)

International Journal of Zoological Investigations

Contents available at Journals Home Page: www.ijzi.net

Editor-in-Chief: Prof. Ajai Kumar Srivastav

Published by: Saran Publications, Gorakhpur, India

ISSN: 2454-3055

Optimizing Drug Bioavailability: A Review on Self-Emulsifying Drug Delivery Systems for Poorly Water-Soluble Compounds

Tiwari Pooja[1]* and Dubey Raghvendra[2]

[1]IPS Academy College of Pharmacy, Rajendra Nagar, Bijalpur, Indore 452012, Madhya Pradesh, India
[2]Institute of Pharmaceutical Sciences, Sage University Indore, Dewas Bypass Rd, Kalod Kartal, Machala, Madhya Pradesh 452020, India

**Corresponding Author*

Received: 2nd February, 2025; **Accepted:** 22nd November, 2025; **Published online:** 6th December, 2025

https://doi.org/10.33745/ijzi.2025.v11i02.106

Abstract: Poor water solubility remains a significant challenge in the pharmaceutical development of many active pharmaceutical ingredients (APIs). To address this issue, self-emulsifying drug delivery systems (SEDDS) have emerged as a promising formulation approach to enhance the bioavailability of poorly water-soluble drugs. SEDDS are isotropic mixtures of oils, surfactants, and sometimes co-solvents that spontaneously emulsify upon contact with gastrointestinal fluids, forming fine oil-in-water emulsions that improve drug dissolution and absorption. This review explores the formulation design, mechanisms, advantages, and applications of SEDDS in improving the bioavailability of hydrophobic drugs. By incorporating an appropriate polymer into the formulation, SEDDS can be explored for the development of a sustained-release drug delivery system. Enhancing this technology could open new avenues in the field of medication delivery. SEDDS has proven to be highly effective in improving the oral bioavailability of lipophilic drugs. It represents a promising approach for optimizing the delivery of drugs that are otherwise unsuitable for oral administration. Additionally, SEDDS can be formulated into various solid dosage forms, making them suitable for both oral and parenteral administration.

Keywords: Self-emulsifying drug delivery systems, Active pharmaceutical ingredients, Poorly water-soluble drugs, Bioavailability, Hydrophobic drugs

Citation: Tiwari Pooja and Dubey Raghvendra: Optimizing drug bioavailability: A review on self-emulsifying drug delivery systems for poorly water-soluble compounds. Intern. J. Zool. Invest. 11(2): 1067-1072, 2025.

https://doi.org/10.33745/ijzi.2025.v11i02.106

This is an Open Access Article licensed under a Creative Commons License: Attribution 4.0 International (CC-BY). It allows unrestricted use of articles in any medium, reproduction and distribution by providing adequate credit to the author (s) and the source of publication.

Introduction

Oral drug delivery is the most preferred route for administering therapeutic agents due to its convenience, patient compliance, and cost-effectiveness. However, the effectiveness of oral drug delivery, especially for poorly water-soluble or lipophilic drugs, is often hindered by their low solubility, poor dissolution rate, and limited bioavailability. To overcome these challenges, emulsions and self-emulsifying drug delivery systems (SEDDS) have been developed to enhance

Table 1: Composition and Formulation of SEDDS

Component	Role in SEDDS	Typical Composition Ratio	Types/Example	Key Notes
Oils	Solubilize lipophilic drugs and form the oil phase; influence emulsification and drug absorption	20–80%	Long-chain triglycerides (LCTs): Soybean oil, sesame oil Medium-chain triglycerides (MCTs): Caprylic/capric triglycerides (Miglyol 812) Exotic oils: Fish oil, essential oils.	MCTs generally form smaller droplets and enhance emulsification
Surfactants	Reduce interfacial tension; enable formation of O/W emulsions	30–60%	Non-ionic: Tween 80, Cremophor RH 40, Span 80 Ionic: Sodium lauryl sulfate (SLS)	Surfactants with HLB 12–16 preferred for O/W emulsions
Co-surfactants	Further reduce interfacial tension; improve flexibility of interfacial film; help form microemulsions	10–30%	Ethanol, propylene glycol, PEG 400, Transcutol P	Promote smaller, more stable droplets
Co-solvents	Improve solubility of poorly soluble drugs; enhance self-emulsification	10–30%	Ethanol, propylene glycol, PEG	Modify formulation properties and improve API solubilization
Active Pharmaceutical Ingredient (API)	Drug incorporated into SEDDS, typically poorly water-soluble/ lipophilic	Variable	Cyclosporine (Neoral) Fenofibrate Itraconazole (Sporanox) Tadalafil	SEDDS improves solubility, stability, and oral absorption of lipophilic drugs

the solubility and absorption of such drugs in the gastrointestinal (GI) tract (Salawi, 2022).

An emulsion is a biphasic system consisting of two immiscible liquids, typically oil and water, with one phase dispersed as droplets in the other. Emulsions enhance the solubilization of lipophilic drugs by dissolving them in the oil phase, which then forms fine droplets in the aqueous environment of the GI tract. This increases the surface area for drug dissolution and absorption. Emulsions are categorized into:

- Oil-in-water (O/W) emulsions, where oil droplets are dispersed in an aqueous phase, often used for hydrophobic drugs.
- Water-in-oil (W/O) emulsions, where water droplets are dispersed in an oil phase, typically used for hydrophilic drugs.

While emulsions offer advantages such as enhanced drug solubility and stability, they require energy (e.g., shaking, stirring) to form, and their stability can be a concern due to phase separation or droplet coalescence. To address these limitations, self-emulsifying drug delivery systems (SEDDS), which use self-emulsifying agents, have been introduced as a more efficient approach (Patel *et al*., 2008; Solanki and Prajapati, 2012; Chouhan *et al*., 2015).

Many modern therapeutic compounds exhibit poor water solubility, which limits their bioavailability and therapeutic efficacy. Over 40% of new chemical entities identified through drug discovery are poorly water-soluble, which poses significant challenges for drug delivery and absorption. In such cases, enhancing solubility is critical to improving the bioavailability of these drugs.

SEDDS are lipid-based formulations that form emulsions when exposed to aqueous environments, such as the fluids in the GI tract, without the need for external mechanical energy. They are composed of oils, surfactants, and co-surfactants that self-emulsify upon mild agitation, such as the natural movements of the stomach. These systems have emerged as a promising solution for the oral delivery of poorly water-

Table 2: Types of SEDDS (Kohli *et al*.,2010; Singh *et al*., 2013)

Type	Droplet Size	Appearance	Key Features	Example Drug/Formulation	Advantages	Limitations
SEDDS	100–300 nm	Turbid	Forms O/W emulsions; oil + surfactant (+co-surfactant)	Cyclosporine (Neoral®)	Improves solubility and bioavailability; simple formulation	Larger droplets → lower absorption surface
SMEDDS	< 50 nm	Clear/slightly opalescent	Thermodynamically stable microemulsions; high surfactant content	Itraconazole (Sporanox®)	High surface area → better absorption	May cause GI irritation due to high surfactant
SNEDDS	20–50 nm (generally <100 nm)	Transparent/ translucent	Nanoemulsion formation; optimized for tiny droplets	Fenofibrate (Triglide®)	Faster absorption; enhanced solubilization	Higher complexity and cost
S-SEDDS	20–50 nm (generally <100 nm)	Solid dosage form	Converts liquid SEDDS to powders/tablets using solid carriers	Tadalafil solid SNEDDS	Better stability, easy handling, patient-friendly	Complex formulation; carrier compatibility issues
SDEDDS	Larger than SEDDS	Milky	W/O/W system; encapsulates hydrophilic + lipophilic drugs	Protein/peptide encapsulation	Enables controlled release; protects sensitive drugs	Stability issues; complex dual emulsification

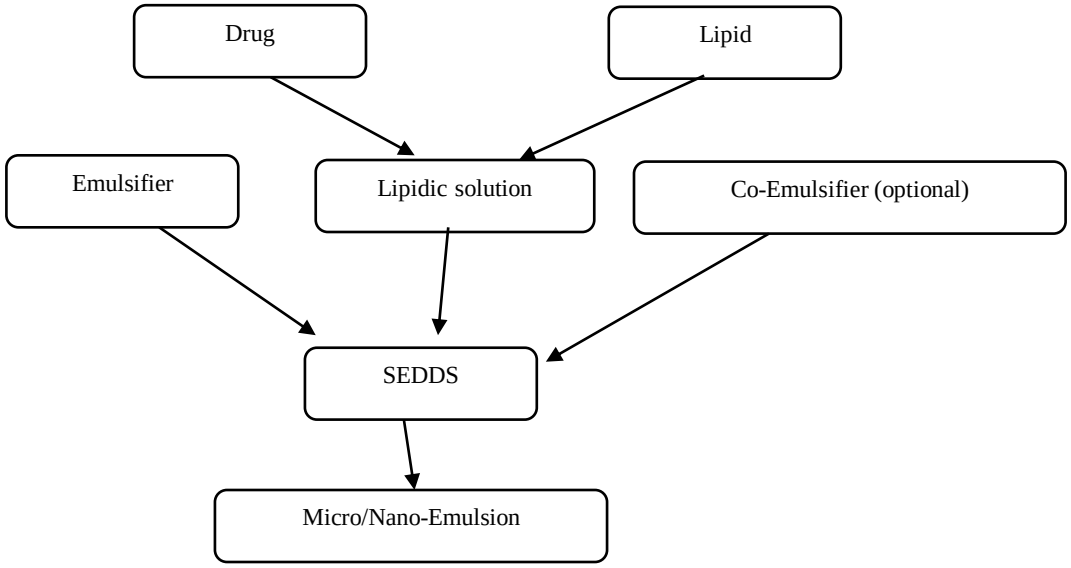


Fig. 1: Mechanism of self-emulsifying drug delivery systems (SEDDS).

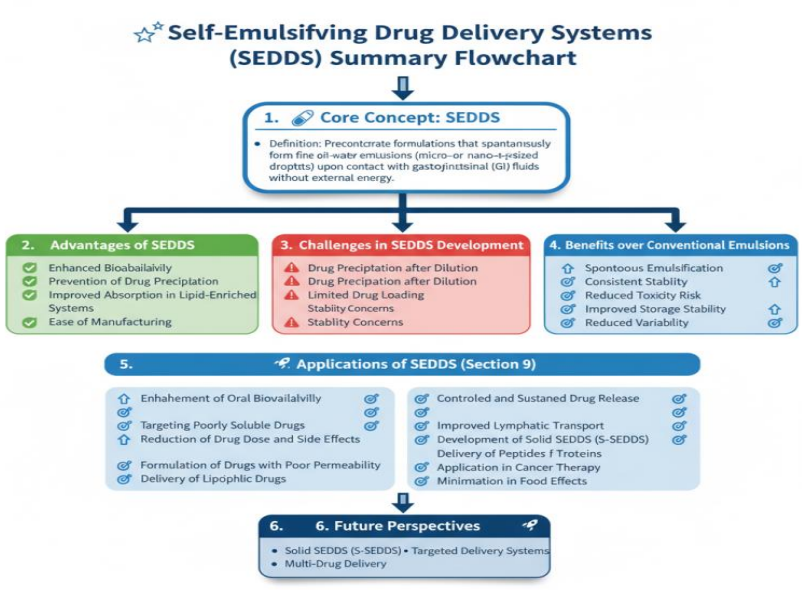
soluble drugs, improving both the rate and extent of drug absorption.

Self-emulsifying agents, which include surfactants and co-surfactants, are critical for the success of SEDDS in oral drug delivery. Their role is to facilitate the spontaneous formation of emulsions or microemulsions upon contact with aqueous environments, thereby improving drug solubilization and absorption (Revathi and Raju, 2012; Reza, 2013; Singh *et al*., 2014; Thakare *et al*., 2016).

Tables 1 and 2 depict the composition and formulation of SEDDS and types of SEDDS, respectively.

Table 3: Methods of prepration of SEDDS (Rawat *et al*., 2014; Chouhan *et al*., 2015; Salawi, 2022)

Method	Description	Equipment Used
Microemulsification	- Process: Combine oil, surfactant, and co-surfactant using high shear mixing to form a microemulsion. - Characteristics: Produces very fine droplets typically less than 100 nm, leading to stable microemulsions.	High-shear mixer, Ultrasonicator, Homogenizer
Self-Homogenization	- Process: Use mechanical shear forces to mix the components to form a self-emulsifying system. This method relies on the natural tendency of the mixture to emulsify upon contact with aqueous media. - Characteristics: Results in spontaneous formation of emulsions or microemulsions when diluted in water.	Homogenizer, High-speed stirrer
Solvent Evaporation	- Process: Dissolve the drug and other components in an organic solvent, then evaporate the solvent under reduced pressure. - Characteristics: Produces a dry residue that, upon hydration, forms an emulsion or microemulsion.	Rotary evaporator, Drying oven
Spray Drying	- Process: Spray a solution of the drug and SEDDS components into a hot gas stream to rapidly evaporate the solvent, forming a dry powder. - Characteristics: Converts liquid SEDDS into a solid form that can be reconstituted into emulsions upon contact with water.	Spray dryer
Melt Extrusion	- Process: Melt the lipid phase and mix with the drug and surfactants using a high-temperature extrusion process. - Characteristics: Produces solid dispersions that can form self-emulsifying systems when mixed with aqueous media.	Extruder
High Pressure Homogenization	- Process: The formulation is subjected to high pressure forces to break down the droplets into nanoscale sizes, enhancing stability and reducing droplet size. - Characteristics: Results in a fine and stable nanoemulsion.	High-pressure homogenizer
Hot Melt extrusion	- Process: Melt the lipid phase with the drug and other excipients, extrude the molten mixture, and cool to form solid pellets. - Characteristics: Useful for creating solid self-emulsifying systems that release the drug upon contact with aqueous fluids.	Hot melt extruder



Mechanism of Action

Self-Emulsifying Drug Delivery Systems (SEDDS) enhance the bioavailability of poorly water-soluble drugs by forming fine micro- or nano-emulsions (Fig. 1) when they come in contact with gastrointestinal fluids. Their components—oils, surfactants, and co-surfactants—lower interfacial tension and produce tiny oil droplets that keep lipophilic drugs dissolved (Rawat *et al*., 2014; Chouhan *et al*., 2015; Salawi, 2022).

The small droplet size increases the drug's surface area, leading to faster dissolution and more efficient interaction with the intestinal membrane. This improves both permeability and absorption, often through transcellular pathways. Together, these effects overcome solubility and dissolution barriers, resulting in higher and more consistent bioavailability.

Conclusion

Self-emulsifying drug delivery systems (SEDDS) have emerged as an effective strategy for improving the oral bioavailability of medicinal compounds with poor water solubility. These systems have proven to significantly enhance the delivery of hydrophobic drugs when administered orally. However, the formulation of SEDDS is highly specific to the drug being used, necessitating careful evaluation of its composition. A key consideration in SEDDS formulations is the high surfactant content, which can lead to toxicity concerns. Therefore, a balance between the surfactant's emulsification efficiency and its potential toxicity must be achieved before clinical application.

Additionally, two crucial factors influencing gastrointestinal absorption are the charge and size of the oil droplets formed during emulsification. In response to the challenges of traditional SEDDS, alternative formulations have been developed, including self-microemulsifying systems, freeze-dried emulsions, surfactant dispersions, micro-encapsulated emulsions, self-emulsifying pellets, solid self-emulsifying systems, and lipid/ polymeric matrices. Upon dilution in water, these formulations produce fine oil droplets or micellar dispersions.

Currently, several pharmaceutical products formulated as SEDDS, such as cyclosporine A, ritonavir, and saquinavir, are commercially available. Given that approximately 40% of new drug candidates exhibit poor water solubility, it is anticipated that the development of SEDDS-based drug products will continue to grow in the pharmaceutical industry.

Ethical Statement

No animal or microbes have been used or sacrificed for this study, hence Ethical Approval not required.

Author Contributions

Each author has contributed equally to the study's planning, analysis, writing, and editing. All authors have read and agreed to the published version of the manuscript.

Conflict of Interest

The authors declare no conflicts of interest.

References

Atef E and Belmonte AA. (2008) Formulation and in vitro and in vivo characterization of a phenytoin SEDDS. European J Pharmaceut Sci. 35(4): 257-263.

Bhattacharya S. (2020) Self-emulsifying drug delivery system (SEDDS) and its pharmaceutical applications. Appl Clin Res Clin Trials Regulatory Affairs 7(3): 206-224.

Chouhan N, Mittal V, Kaushik D, Khatkar A and Raina M. (2015) Self emulsifying drug delivery system (SEDDS) for phytoconstituents: a review. Curr Drug Deliv. 12(2): 244-253.

Elkordy AA, Haj-Ahmad RR, Awaad AS and Zaki Randa M. (2021) An overview on natural product drug formulations from conventional medicines to nanomedicines: Past, present and future. J Drug Deliv Sci Technol. 63: 102459,

Gao P, Akrami A, Alvarez F, Hu J, Li L, Ma C and Surapaneni S. (2009) Characterization and optimization of AMG 517 supersaturatable self-emulsifying drug delivery system (S-SEDDS) for improved oral absorption. J Pharm Sci. 98(2): 516-528.

Khan M, Nadhman A, Sehgal SA, Siraj S and Yasinzai

MM. (2018) Formulation and characterization of a self-emulsifying drug delivery system (SEDDS) of curcumin for the topical application in cutaneous and mucocutaneous Leishmaniasis. Curr Top Med Chem. 18(18): 1603-1609.

Kohli K, Chopra S, Dhar D, Arora S and Khar RK. (2010) Self-emulsifying drug delivery systems: an approach to enhance oral bioavailability. Drug Discov Today 15(21-22): 958-965.

Kumar A, Sharma S and Kamble R. (2010) Self emulsifying drug delivery system (SEDDS): Future aspects. Int J Pharm Pharmaceut Sci. 2(4): 7-13.

Patel PA, Chaulang GM, Akolkotkar A, Mutha SS, Hardikar SR and Bhosale AV. (2008) Self emulsifying drug delivery system: A review. Res J Pharm Tech. 1(4): 313-323.

Pouton CW. (1997) Formulation of self-emulsifying drug delivery systems. Adv Drug Deliv Rev. 25(1): 47-58.

Rawat S, Derle DV, Parve BS and Shinde PR. (2014) Self emulsifying drug delivery system: A method for bioavailability enhancement. Int J Pharmaceut Chem Biol Sci. 4(3): 479-494.

Rehman FU, Farid A, Shah SU, Dar MJ, Rehman AU, Ahmed N, Rashid SA, Shaukat I, Shah M, Albadrani GM, Kamel M, Altyar AE, Abdel-Daim MM and Shah KU. (20220 Self-emulsifying drug delivery systems (SEDDS): Measuring energy dynamics to determine thermodynamic and kinetic stability. Pharmaceuticals (Basel) 15(9): 1064.

Revathi S and Raju MD. (2012) Self-emulsifying drug delivery system: A review. World J Pharm Pharmaceut Sci. 2: 89-107.

Reza J. (2013) Self-emulsifying drug delivery systems: a review. Int J Pharmaceut Life Sci. 2(2): 80-84.

Salawi A. (2022) Self-emulsifying drug delivery systems: a novel approach to deliver drugs. Drug Deliv. 29(1): 1811-1823.

Singh B, Beg S, Khurana RK, Sandhu PS, Kaur R and Katare OP. (2014) Recent advances in self-emulsifying drug delivery systems (SEDDS). Crit Rev Ther Drug Carrier Syst. 31(2):121-185.

Singh P, Verma A, Mittal P and Khinchi MP. (2013) Self emulsifying drug delivery system: An approach to enhance oral bioavailability. Asian J Pharmaceut Res Develop. 1(4): 178-193.

Solanki N and Prajapati S. (2012) Self-emulsifying drug delivery system (SEDDS): A review. Int J Pharmaceut Res Bio Sci. 1(1): 2-7.

Thakare P, Mogal V, Borase P, Dusane J and Kshirsagar S. (2016) A review on self-emulsified drug delivery system. Pharmaceut Bioll Evaluations 3(2): 140-153.

Tiwari R, Tiwari G and Rai AK. (2010) Self-emulsifying drug delivery system: An approach to enhance solubility. Systematic Rev Pharma. 1(2): 133-140.

Ujhelyi Z, Vecsernyés M, Fehér P, Kósa D, Arany P, Nemes D, Sinka D, Vasvári G, Fenyvesi F, Váradi J and Bácskay I. (2018) Physico-chemical characterization of self-emulsifying drug delivery systems. Drug Discov Today Technol. 27: 81-86

Wagh MP, Singh PK, Chaudhari CS and Khairnar DA. (2014) Solid self-emulsifying drug delivery system: Preparation techniques and dosage forms. Int J Biopharmaceut. 5(2): 101-108

Zaslavsky J and Allen C. (2023) A dataset of formulation compositions for self-emulsifying drug delivery systems. Scientific Data 10(1): 914.

Zhang L, Zhang L, Zhang M, Pang Y, Li Z, Zhao A and Feng J. (2015) Self-emulsifying drug delivery system and the applications in herbal drugs. Drug Delivery 22(4): 475-486.