Available online on 15.8.2025 at http://ajprd.com

Asian Journal of Pharmaceutical Research and Development

Open Access to Pharmaceutical and Medical Research

Open Access

Review Article

A Review on Self Nano-Emulsifying Drug Delivery System

Shivangi Purohit[1*], Dr. Meenakshi Bharkatiya[2]

[1]B.N. Institute of Pharmaceutical Sciences, B.N. University, Udaipur, Rajasthan, India

[2] Associate Professor B.N. Institute of Pharmaceutical Sciences, B.N. University, Udaipur, Rajasthan, India

A B S T R A C T

Self-nanoemulsifying drug delivery systems (SNEDDS) have gained traction as an effective solution for enhancing the solubility of hydrophobic medications. These systems aim to overcome challenges associated with the limited bioavailability of poorly soluble and highly permeable compounds. SNEDDS are composed of isotropic blends of oil, surfactants, solvents, and co-solvents. They have proven to be successful in improving the solubility and bioavailability of drugs that struggle with water solubility. Typically formulated as liquids, various techniques such as extrusion, melting, spray-drying, and freeze-drying have been developed to convert liquid SNEDDS into solid forms. SNEDDS not only demonstrate a notable increase in dissolution rate but also minimize interfacial tension. The continuous advancement of SNEDDS technology is poised to open up innovative applications in drug delivery, offering solutions to challenges associated with the distribution of poorly soluble drugs.

Keywords: Biopharmaceutical classification system, Diffusion, Poor bioavailability, SNEDDS, Surfactant

A R T I C L E I N F O: Received 12 Feb. 2025; Review Complete 28 April, 2025; Accepted 12 July 2025. ; Available online15 August. 2025

Cite this article as:

Purohit S, Bharkatiya M, A Review on Self Nano-Emulsifying Drug Delivery System, Asian Journal of Pharmaceutical Research and Development. 2025; 13(4):159-165 DOI: http://dx.doi.org/10.22270/ajprd.v13i4.1548

*Address for Correspondence:

Shivangi Purohit, India B.N. Institute of Pharmaceutical Sciences, B.N. University, Udaipur, Rajasthan, India

INTRODUCTION

Oral administration stands out as the most practical and favored route for medication delivery, thanks to its high level of patient compliance. However, a significant drawback arises from the poor water solubility of over 50% of orally administered medications, leading to limited therapeutic effectiveness. Traditional approaches to enhance oral bioavailability, such as salt formation, micronization, solubilization using cosolvents, permeation enhancers, and cyclodextrin complexation, have yielded only partial success and are often specific to particular medication candidates. In response to these challenges, nanotechnology has emerged as a promising avenue in medication delivery research over the past few decades.[1-4]

One notable advancement in this field is the Self Nano-emulsifying Drug Delivery System (SNEDDS), characterized by its isotropic mixture of natural or synthetic oil, surfactants, and co-surfactants. SNEDDS possesses a unique capability to form fine oil-in-water (O/W) nano-emulsions in an aqueous medium with moderate stirring. With globule sizes below 100 nm, SNEDDS disperses effectively in water. Recently, poorly water-soluble drugs have seen improved aqueous solubility through the application of SNEDDS, along with its variants such as Self-Micro Emulsifying Drug Delivery System (SMEDDS) and Self-Emulsifying Drug Delivery System (SEDDS).[5-7]

The formulation of the self-nano-emulsifying medication delivery system for oral consumption involves the use of medium-chain triglyceride oils and nonionic surfactants. SNEDDS proves beneficial in enhancing the rate of drug absorption and maintaining repeatability in drug concentration plasma profiles. Stability of the nanoemulsion is crucial for providing a large interfacial area for drug partitioning between the oil and aqueous phases. To achieve this stability, surfactant and cosurfactant molecules are incorporated into the SNEDDS, resulting in a thermodynamically stable, transparent or translucent, non-ionized dispersion of oil-in-water (o/w) and water-in-oil (w/o) nanoemulsion.[8-10]

The term "Self Nanoemulsifying Drug Delivery System" encompasses various types of stable nanoemulsions, including nanoemulsion, mini-emulsion, ultrafine emulsion, and submicron emulsion. Under moderate agitation, SNEDDS

forms a stable oil-in-water nanoemulsion in aqueous media, demonstrating its potential as a versatile and effective approach in overcoming the challenges associated with poor water solubility in oral medication delivery.

Features of SNEDDS[11]

- Able to self-emulsify quickly in GI fluids and with gentle agitation provided by peristaltic movements of GIT, they form fine oil in water emulsion.
- Can efficiently integrate hydrophobic drug or hydrophilic drug inside the mixture of oil surfactant.
- Can be employed for solid as well as liquid dosage forms.
- Require lesser drug dose with respect to conventional dosage forms.

Advantages of SNEDDS[12-13]

- Oral bioavailability enhancement.
- Safe delivery of peptides which are degraded due to enzymatic hydrolysis in GIT.
- Enhanced drug loading capacity with SNEDDS
- Easy in scale up (pilot plant) process.
- No impact on digestion process of lipid.

Disadvantages of SNEDDS [13-15]

- Production costs are high.
- Challenges regarding the validation of different components.
- Problems with drug compatibility.
- Less drug loading due to leakage.
- Traditional dissolution methods do not work.
- High concentration of surface active agent in formulation may cause irritation to GIT.
- Volatile co solvents of SNEDDS migrate into capsule shells, cause precipitation of hydrophobic drugs

Types of Nano-emulsion:

Several Types of Nano emulsions are present which are mentioned in table no. 1

Table 1: Classification of Nano-Emulsion[14-15]

Sr. No.	Type	Definition
1.	Water in oil (W/O) Nanoemulsion	In which droplet of water in Continuous Phase oil was dispersed.
2.	Oil in water (O/W) Nanoemulsion	The Oil droplet in Continuous Phase Water was distributed.
3.	Bi-continuous Nanoemulsion	In which surfactant in both the oil and water phase was soluble and droplet was distributed in both the oil and water phase.

Standard Composition of SNEDDS:

Consider the following factors during the development of SNEDDS: entropy changes can lead to increased dispersion, surpassing the energy needed to elevate the dispersion surface. This phenomenon elucidates the conventional emulsion free energy.[16,18]

1. Oil Phase:

SNEDDS, or self-emulsifying drug delivery systems, are blends of oil, surfactants, and cosurfactants that form uniform mixtures. When gently agitated, they produce fine oil-in-water nanoemulsions, suitable for injection into aqueous environments like gastrointestinal fluids. The selection of the appropriate oil is crucial for optimizing drug solubility, influencing emulsion droplet size, and emulsification speed. Effective emulsification requires achieving a small droplet size. To determine drug solubility, High-Performance Liquid Chromatography (HPLC) is employed after medications are mixed with a substance and various oils for an entire night. Evaluating a range of oils aids in identifying the most suitable one, and combinations of oils can be utilized to enhance drug dissolution.

2. Surfactant:

Considering safety as a pivotal factor in surfactant selection for self-emulsifying systems, the formulation may incorporate various compounds exhibiting surfactant properties. However, the options are limited due to the requirement for edibility, favoring emulsifiers of natural origin over synthetic ones for their perceived safety. Non-ionic surfactants with a relatively high hydrophilic-lipophilic balance (HLB) are commonly recommended. Achieving stable self-emulsifying drug delivery systems (SEDDs) typically involves utilizing a surfactant concentration ranging from 30% to 60%..(Table No. 2)[19,22]

Table 2: Surfactant Group [21]

Sr. No.	Group	Examples
1.	Anionic surfactants	Potassium laurate, sodium lauryl sulphate.
2.	Cationic surfactant	Quaternary ammonium halide.
3.	Ampholytic surfactants	Sulfobetaines.
4.	Nonionic surfactants	Sorbitan esters (Spans), poly – sorbates (Tweens)

3. Co-Surfactant:

In order to achieve a stable interfacial tension, it is often necessary to incorporate co-surfactants alongside a single surfactant. The presence of a co-surfactant is essential as it diminishes the bending stress at the interface, providing flexibility to the interfacial layer. This flexibility is crucial for adopting various curvatures, facilitating the formation of microemulsions and nanoemulsions. Specifically, an HLB cosurfactant in the range of 10-14 is employed in conjunction with surfactants to minimize the oil-water interface, enhance fluidity in the hydrocarbon area of the interfacial film, and promote the spontaneous generation of microemulsions. The careful selection of both cosurfactant and surfactant is pivotal not only for solubilization in microemulsions but also for determining the overall morphology of the microemulsion.[22] (Table No. 3)

Table 3: Roles of polymer used in SNEDDS[23,28]

Sr. No.	Category	Examples
1.	Oil Phase	• Fatty acids: Oleic acid, stearic acid, palmitic acid • Fatty acid esters: Glyceryl monooleate, Ascorbyl palmitate, Glyceryl dilaurate, Glyceryl behenate • Propylene glycol esters: Propylene glycol monocaprylate, Propylene glycol dicaprylocaprate • Miscellaneous: Vitamin E, Bees wax, Phospholipids, Stearyl alcohol
2.	Surfactant	• Anionic surfactants: Potassium laurate, sodium lauryl sulphate. • Cationic surfactant: Quaternary ammonium halide. Ampholytic surfactants: Sulfobetaines. • Nonionic surfactants: Sorbitan esters (Spans), poly – sorbates (Tweens)
3.	Co-surfactant	Propylene glycol, polyethylene glycol, polyoxyethylene, Lauroglycol TM, Transcutol

Ideal characteristics of APIs to be incorporated into SNEDDS:

To optimize the oral bioavailability of pharmaceuticals categorized as biopharmaceutical II and IV, self-nano emulsification formulas should meet specific criteria. These include ensuring oil droplet size remains below 100 nm, achieving optical clarity upon dispersion, and having a high HLB value exceeding 12. Table 04 enumerates potential components suitable for incorporation into SNEDDS formulations.[27]

Table 4: Suitable drug candidates for SNEDDS [28,34]

Sr. No.	Drug Candidate	BCS Class	Medicated Indications
1.	Valproic acid	I	Anticonvulsants
2.	Calcitriol	II	Vitamin D analogs
3.	Cyclosporin A/I	II	Calcineurin inhibitor
4.	Cyclosporin A/III	II	Calcineurin inhibitor
5.	Saquinavir	IV	Protease inhibitors
6.	Ritonavir	II	Protease inhibitors
7.	Amprenavir	II	Protease inhibitors
8.	Cyclosporine	IV	Immunosuppressive agents
9.	Bexarotene	II	Retinoids
10.	Tipranavir	II	Protease inhibitors

Formulation Techniques for preparation of SNEDDS:

The active medicinal component, excipient, polymers, and emulsifier are all part of the SNEDDS production process. There are several ways to make a self-nanoemulsifying drug delivery system, however they may be essentially split into two categories:

A. High-energy-emulsification.

B. Low-energy-emulsification

High-pressure homogenization (HPH), ultrasonication, and micro-fluidization are integral aspects of the high-energy emulsification process. In contrast, spontaneous emulsification and phase-inversion represent low-energy methods. Reverse Self Nano-emulsifying Drug Delivery Systems are developed by synergizing high-energy emulsification and low-energy emulsification techniques, resulting in the formation of a highly viscous solution.[35,38]

High Energy Emulsification Method:

1. High pressure homogenisation (HPH):

High-pressure homogenization (HPH), ultrasonication, and micro-fluidization are integral aspects of the high-energy emulsification process. In contrast, spontaneous emulsification and phase-inversion represent low-energy methods. Reverse Self Nano-emulsifying Drug Delivery Systems are developed by synergizing high-energy emulsification and low-energy emulsification techniques, resulting in the formation of a highly viscous solution.

2. Ultra-sonication:

Reducing drop size through the utilization of the Sonicator-probe method proves to be a more practical approach, as it leverages the energy range provided by sonotrodes. These sonotrodes, acting as Sonicator-probes, can control a piezoelectric quartz stone, regulating the dispersion and constriction of the excited volt. The end tip of the Sonicator makes contact with the liquid medium, inducing a mechanical pulse that captures and confines particles. The formation of captive structures closes vapor cavities in the liquids, resulting in the creation of an emulsion. This technique finds prominent application in laboratories, consistently yielding mixed drops with a canister size of 0.2mm or smaller.

3. Micro-fluidization:

The initial method for incorporating additives in microfluidization involves utilizing a microfluidizer. A disarticulation pump, operating within a pressure range of 500 to 20000 psi, is employed to disrupt the product in the interaction chamber, yielding extremely fine particles in the submicron range. This approach has been consistently applied over many years to achieve the desired range and establish a uniform Nano-emulsion system.[39,42]

Low Energy Emulsification:

1. Phase inversion emulsification method:

Here is a technique used to induce a phase change during emulsification by using a very high temperature pathway.

2. Continuous emulsification:

Emulsification always forms in this system. In which the foundation of consistent and standardised organic resolution is composed of a phase of hydrophilic and miscible

surfactants and a grease and lipophilic surfactant infill. Under continuous enticing stirring, the organic point was introduced into the aqueous stage, and string Oil-in-Water was created. As it faded beneath concentrated pressure, the aqueous stage was indifferent.[43,45]

Evaluation Parameters:

Morphology:

Transmission electron microscopy (Cryo-TEM) and small-angle neutron scattering can be used to analyse the SNEDDS morphology (SANS).

Viscosity:

When determining the viscosity of liquid SNEDDS, the Brookfield cone and plate viscometer is typically used. Centipoises (CP), a unit of measure for viscosity that relates to shear rate.

Droplet size and poly dispersity index (PDI):

Using a photon correlation spectroscopy approach, the droplet size and PDI may be determined. To create the preparation, the sample is dissolved at a given concentration in the suitable solvent.

The refractive index (RI):

RI is typically employed to look for transparent formulations. Usually, the refractometer is used to measure the RI. It is also employed to assess the formulation's thermodynamic stability. The minor change in the RI at the various time points of the storage indicates the enduring structure and thermodynamic stability of the SNEDDS.[46]

Zeta potential:

In order to ascertain the particle charge of produced SNEDDS, the Smoluchowski theory is used. The zeta potential indicates the stability of colloidal dispersion. The manufactured formulation is considered stable if the zeta potential is high or greater than 30 mV.

Percentage transmittance:

A UV spectrophotometer is used to measure the system's % transmittance after diluting the formulation at a wavelength of 638 nm and using water as a control. A clear and transparent nature would be indicated by the formulation if the percentage transmittance number is closer to 100%.[47,48]

Self Nano-emulsification time:

With the use of dissolving equipment, the effectiveness of self-nano-emulsification is evaluated. Typically, 1 mL of SNEDDS is dissolved in 250 mL of water at a temperature of 370.5°C. A paddle spinning at 50 rpm gives gentle agitation. According to the rate of emulsification and the emulsion's ultimate appearance, SNEDDS are evaluated visually. It is indicated how long the emulsification process took. After emulsification is complete, samples are collected for particle size by photon correlation spectroscopy and further processing by various characterizations.

Thermodynamic stability of emulsion:

The metastable formulation issue is solved using the thermodynamic stability test. For thirty minutes, liquid SNEDDS were centrifuged at 3,500 rpm. For the formulation that showed no evidence of phase separation, the heating and cooling cycle is carried out. With temperatures ranging from 5 to 45 degrees, six cycles will be run over the course of two days. The stable formulation undergoes a freeze-thaw stress test over the course of three cycles over the course of two days at temperatures between -22°C and 25°C. Following this, the formulation that survived or shown stability was chosen as the formulation for subsequent investigations.

Fourier-transform infrared spectroscopy (FTIR) spectral analysis:

FTIR analysis can be used to evaluate drug excipient interactions, polymerization, crosslinking, and drug loading in the formulation. In addition, the molecular fingerprint and the functional groups' modes of attachment are employed to identify them. At low temperatures, molecules are in their ground state, and when they absorb radiant energy, they are stimulated to higher energy levels. IR spectroscopy is used to calculate the energy difference (E) between the excited and ground states of the molecule. The sample can be prepared for FTIR by using an appropriate technique, such as the potassium bromide pellet method or Nujol mulls, and is then scanned in FTIR at a moderate scanning speed between 400 and 400 cm-1.[46,49]

In *vitro* Diffusion study:

For all the formulations created, in vitro diffusion experiments were carried out utilising a diffusion method. The dialysis media was phosphate buffer, pH 6.8. One end of the pretreatment cellulose diffusion tubing (7 cm in length) was attached to the thread before 1 ml of the self-nanoemulsifying formulation and 0.5 ml of the diffusion medium were placed inside of it. Additionally, a thread was used to secure the other end of the tube, which was then allowed to freely rotate in 200 ml of diffusion medium while being constantly stirred at 100 rpm with a magnetic bead on a 37 °C magnetic plate. At different times, 1 ml aliquots were taken out and further diluted. These samples were analyzed quantitatively for drug diffused across the membrane at corresponding time by using UV-visible spectrophotometer.

In *vitro* dissolution profile:

Using a dissolving apparatus Type II in different dissolution media related to the intended route of administration, such as pH 1.2 and pH 6.8 for oral use, the in vitro dissolution profile of the SNEDDS should be assessed. A certain amount of time would be used to collect and analyse the medication that had been dissolved in the dissolving fluid. In comparison to the pure drug, cumulative quantities of drug dissolved versus the periods of the SNEDDS would be shown.

Stability study:

The International Council for Harmonization (ICH) guidelines employed to determine the stability study. The sensitivity towards the moisture and thermal stability tested under different storage conditions for SNEDDS. Usually The ICH storage guidelines for long-term and accelerated stability study are 25°C ± 2°C/ 60% RH ± 5%RH and 40°C ± 2°C/ 75% RH ± 5%RH, respectively.[48, 50].

Market Formulated Product of SNEDDS (refer no. Table no. 5):

Table 5: List of Marketed Product

Sr. No.	Brand Name	Drug	Type of Formulation	Application
1.	Convulex/Pharmacia	Valproic acid	Soft gelatin capsules	Anticonvulsant2
2.	Fortovase®	Saquinavir	Soft gelatin capsules	Protease inhibitors2
3.	Rocaltrol/Roche	Calcitriol	Soft gelatin capsules	Vitamin D analogs2
4.	Norvir®	Ritonavir	Soft gelatin capsules	Protease inhibitors3
5.	Agenerase®	Amprenavir	Soft gelatin capsules	Protease inhibitors3
6.	Aptivus®	Tipranavir	Soft gelatin capsules	Protease inhibitors3
7.	Targretin®	Bexarotene	Soft gelatin capsules	Retinoids1

Applications of SNEDDS Drug Delivery Systems:

SNEDDS with pharmaceutically active substances can be employed to create pharmacological formulations. If desired, the combination might be given a particular kind of galena. ampoules, particularly for sterile injection and infusion solutions; Aerosols, which may also contain propellant gas and stabilisers in addition to nanoemulsion, without metering features, and dosing aerosols; hydrophilic and hydrophobic gels, and ointments containing nanoemulsion; solutions, in particular oral liquids, eye drops, and nose drops, which may contain various auxiliary substances; There are creams, lotions, and pastes that include nanoemulsions that are either o/w or w/o.[51, 52]

CONCLUSION

With the use of SNEDDS, the dissolution and absorption rates of weakly water soluble pharmaceuticals might be increased, particularly when absorption rate is constrained by dissolution rate. The methods and excipients used for SNEDDS formulation are low-cost and straightforward. Due to its superior physical stability and simpler manufacture, SNEDDS are becoming more widely used in research. The addition of newer technologies, such as polymer science and biological targeting, to SNEDDS will, from a future viewpoint, significantly advance pharmaceutical research and development.

REFERENCES

1. Akiladevi D, Prakash H, Biju GB, Madumitha N. Nano-novel approach: Self nano emulsifying drug delivery system (SNEDDS)-Review article. Research Journal of Pharmacy and Technology. 2020 Feb 1;13(2):983-90.
2. Rehman FU, Shah KU, Shah SU, Khan IU, Khan GM, Khan A. From nanoemulsions to self-nanoemulsions, with recent advances in self-nanoemulsifying drug delivery systems (SNEDDS). Expert opinion on drug delivery. 2017 Nov 2;14(11):1325-40.
3. Cherniakov I, Domb AJ, Hoffman A. Self-nano-emulsifying drug delivery systems: an update of the biopharmaceutical aspects. Expert opinion on drug delivery. 2015 Jul 3;12(7):1121-33.
4. Date AA, Desai N, Dixit R, Nagarsenker M. Self-nanoemulsifying drug delivery systems: formulation insights, applications and advances. Nanomedicine. 2010 Dec;5(10):1595-616.
5. Park EJ, Choi SA, Min KA, Jee JP, Jin SG, Cho KH. Development of Alectinib-Suspended SNEDDS for Enhanced Solubility and Dissolution. Pharmaceutics. 2022 Aug;14(8):1694.
6. Schmied FP, Bernhardt A, Baudron V, Beine B, Klein S. Development and Characterization of Celecoxib Solid Self-nanoemulsifying Drug Delivery Systems (S-SNEDDS) Prepared Using Novel Cellulose-Based Microparticles as Adsorptive Carriers. AAPS PharmSciTech. 2022 Aug;23(6):1-2.
7. Chaudhuri A, Shrivastava N, Kumar S, Singh AK, Ali J, Baboota S. Designing and development of omega-3 fatty acid based self-nanoemulsifying drug delivery system (SNEDDS) of docetaxel with enhanced biopharmaceutical attributes for management of breast cancer. Journal of Drug Delivery Science and Technology. 2022 Feb 1;68:103117.
8. Rathore C, Hemrajani C, Sharma AK, Gupta PK, Jha NK, Aljabali AA, Gupta G, Singh SK, Yang JC, Dwivedi RP, Dua K. Self-nanoemulsifying drug delivery system (SNEDDS) mediated improved oral bioavailability of thymoquinone: optimization, characterization, pharmacokinetic, and hepatotoxicity studies. Drug Delivery and Translational Research. 2022 Jul 13:1-6.
9. Ashfaq M, Shah S, Rasul A, Hanif M, Khan HU, Khames A, Abdelgawad MA, Ghoneim MM, Ali MY, Abourehab MA, Maheen S. Enhancement of the Solubility and Bioavailability of Pitavastatin through a Self-Nanoemulsifying Drug Delivery System (SNEDDS). Pharmaceutics. 2022 Feb 22;14(3):482.
10. Vincent M, Simon L, Brabet P, Legrand P, Dorandeu C, Him JL, Durand T, Crauste C, Begu S. Formulation and Evaluation of SNEDDS Loaded with Original Lipophenol for the Oral Route to Prevent Dry AMD and Stragardt's Disease. Pharmaceutics. 2022 May 10;14(5):1029.
11. Khan AA, Akhtar S, Yadav Y, Akhtar A, Alelwani W, Bannunah AM, Mahmood S. Lopinavir-Loaded Self-Nanoemulsifying Drug Delivery System for Enhanced Solubility: Development, Characterisation and Caco-2 Cell Uptake. Current drug delivery.
12. Gowripattapu S, SathisKumar D, Selvamuthukumar S. Formulation and Statistical Evaluation of Tablets Containing Pitavastatin-Self Nano Emulsifying Drug Delivery Systems. Current Drug Delivery. 2022 May 17.
13. Kusumorini N, Nugroho AK, Pramono S, Martien R. Spray-dried self-nanoemulsifying drug delivery systems as carriers for the oral delivery of piperine: Characterization and *in-vitro* evaluation. Journal of Applied Pharmaceutical Science. 2022 Jun 22(Notice: Undefined offset: 3 in/home/japsonli/public_html/abstract. php on line 189).
14. Suhery WN, Sumirtapura YC, Pamudji JS, Mudhakir D. Solid Self Nano Emulsifying Drug Delivery System of Fenofibric Acid: Physicochemical Properties and *In-vitro* Evaluation.
15. Nair AB, Singh B, Shah J, Jacob S, Aldhubiab B, Sreeharsha N, Morsy MA, Venugopala KN, Attimarad M, Shinu P. Formulation and

evaluation of self-nanoemulsifying drug delivery system derived tablet containing sertraline. Pharmaceutics. 2022 Jan 31;14(2):336.

16. Usta DY, Timur B, Teksin ZS. Formulation development, optimization by Box-Behnken design, characterization, *in-vitro*, ex-vivo, and *in-vivo* evaluation of bosentan-loaded self-nanoemulsifying drug delivery system: A novel alternative dosage form for pulmonary arterial hypertension treatment. European Journal of Pharmaceutical Sciences. 2022 Jul 1;174:106159.
17. Arshad R, Tabish TA, Kiani MH, Ibrahim IM, Shahnaz G, Rahdar A, Kang M, Pandey S. A hyaluronic acid functionalized self-nano-emulsifying drug delivery system (SNEDDS) for enhancement in ciprofloxacin targeted delivery against intracellular infection. Nanomaterials. 2021 May;11(5):1086.
18. Anwer MK, Iqbal M, Aldawsari MF, Alalaiwe A, Ahmed MM, Muharram MM, Ezzeldin E, Mahmoud MA, Imam F, Ali R. Improved antimicrobial activity and oral bioavailability of delafloxacin by self-nanoemulsifying drug delivery system (SNEDDS). Journal of Drug Delivery Science and Technology. 2021 Aug 1;64:102572.
19. Khumpirapang N, von Gersdorff Jørgensen L, Müllertz A, Rades T, Okonogi S. Formulation optimization, anesthetic activity, skin permeation, and transportation pathway of Alpinia galanga oil SNEDDS in zebrafish (Danio rerio). European Journal of Pharmaceutics and Biopharmaceutics. 2021 Aug 1;165:193-202.
20. Kanwal T, Saifullah S, ur Rehman J, Kawish M, Razzak A, Maharjan R, Imran M, Ali I, Roome T, Simjee SU, Shah MR. Design of absorption enhancer containing self-nanoemulsifying drug delivery system (SNEDDS) for curcumin improved anti-cancer activity and oral bioavailability. Journal of Molecular Liquids. 2021 Feb 15;324:114774.
21. Bhagwat DA, Swami PA, Nadaf SJ, Choudhari PB, Kumbar VM, More HN, Killedar SG, Kawtikwar PS. Capsaicin loaded solid SNEDDS for enhanced bioavailability and anticancer activity: *in-vitro*, in-silico, and *in-vivo* characterization. Journal of Pharmaceutical Sciences. 2021 Jan 1;110(1):280-91.
22. Nazlı H, Mesut B, Özsoy Y. *In-vitro* Evaluation of a Solid Supersaturated Self Nanoemulsifying Drug Delivery System (Super-SNEDDS) of Aprepitant for Enhanced Solubility. Pharmaceuticals. 2021 Oct 27;14(11):1089.
23. Md S, Alhakamy NA, Aldawsari HM, Ahmad J, Alharbi WS, Asfour HZ. Resveratrol loaded self-nanoemulsifying drug delivery system (SNEDDS) for pancreatic cancer: Formulation design, optimization and *in-vitro* evaluation. Journal of Drug Delivery Science and Technology. 2021 Aug 1;64:102555.
24. Kazi M, Shahba AA, Alrashoud S, Alwadei M, Sherif AY, Alanazi FK. Bioactive self-nanoemulsifying drug delivery systems (Bio-SNEDDS) for combined oral delivery of curcumin and piperine. Molecules. 2020 Apr 8;25(7):1703.
25. Batool A, Arshad R, Razzaq S, Nousheen K, Kiani MH, Shahnaz G. Formulation and evaluation of hyaluronic acid-based mucoadhesive self nanoemulsifying drug delivery system (SNEDDS) of tamoxifen for targeting breast cancer. International journal of biological macromolecules. 2020 Jun 1;152:503-15.
26. Rasoanirina BN, Lassoued MA, Kamoun A, Bahloul B, Miladi K, Sfar S. Voriconazole-loaded self-nanoemulsifying drug delivery system (SNEDDS) to improve transcorneal permeability. Pharmaceutical Development and Technology. 2020 Jul 2;25(6):694-703.
27. Subramanian P, Rajnikanth PS, Kumar M, Chidambram K. *In-vitro* and *In-vivo* Evaluation of Supersaturable Self-Nanoemulsifying Drug Delivery System (SNEDDS) of Dutasteride. Current drug delivery. 2020 Jan 1;17(1):74-86.
28. Suhery Wn, Sumirtapura Yc, Pamudji Js, Mudhakir D. Development and characterization of self-nanoemulsifying drug delivery system (SNEDDS) formulation for enhancing dissolution of fenofibric acid. J Res Pharm. 2020;24(5):738-47.
29. Kazi M, Al-Swairi M, Ahmad A, Raish M, Alanazi FK, Badran MM, Khan AA, Alanazi AM, Hussain MD. Evaluation of self-nanoemulsifying drug delivery systems (SNEDDS) for poorly water-soluble talinolol: Preparation, *in-vitro* and *in-vivo* assessment. Frontiers in pharmacology. 2019 May 2;10:459.
30. Baloch J, Sohail MF, Sarwar HS, Kiani MH, Khan GM, Jahan S, Rafay M, Chaudhry MT, Yasinzai M, Shahnaz G. Self-nanoemulsifying drug delivery system (SNEDDS) for improved oral bioavailability of chlorpromazine: *in-vitro* and *in-vivo* evaluation. Medicina. 2019 May 24;55(5):210.
31. Kanwal T, Kawish M, Maharjan R, Ghaffar I, Ali HS, Imran M, Perveen S, Saifullah S, Simjee SU, Shah MR. Design and development of permeation enhancer containing self-nanoemulsifying drug delivery system (SNEDDS) for ceftriaxone sodium improved oral pharmacokinetics. Journal of Molecular liquids. 2019 Sep 1;289:111098.
32. Abd-Elhakeem E, Teaima MH, Abdelbary GA, El Mahrouk GM. Bioavailability enhanced clopidogrel-loaded solid SNEDDS: development and *in-vitro*/*in-vivo* characterization. Journal of Drug Delivery Science and Technology. 2019 Feb 1;49:603-14.
33. Altamimi MA, Kazi M, Hadi Albgomi M, Ahad A, Raish M. Development and optimization of self-nanoemulsifying drug delivery systems (SNEDDS) for curcumin transdermal delivery: An anti-inflammatory exposure. Drug development and industrial pharmacy. 2019 Jul 3;45(7):1073-8.
34. Syukri Y, Fitriani H, Pandapotan H, Nugroho BH. Formulation, characterization and stability of ibuprofen-loaded self-nano emulsifying drug delivery system (SNEDDS). Indonesian Journal of Pharmacy. 2019 May 27;30(2):105-13.
35. Singh H, Nathani S, Singh N, Roy P, Paul S, Sohal HS, Jain SK. Development and characterization of solid-SNEDDS formulation of DHA using hydrophilic carrier with improved shelf life, oxidative stability and therapeutic activity. Journal of drug delivery science and technology. 2019 Dec 1;54:101326.
36. Syukri Y, Martien R, Lukitaningsih E, Nugroho AE. Novel Self-Nano Emulsifying Drug Delivery System (SNEDDS) of andrographolide isolated from Andrographis paniculata Nees: characterization, *in-vitro* and *in-vivo* assessment. Journal of Drug Delivery Science and Technology. 2018 Oct 1;47:514-20.
37. Ujilestari T, Martien R, Ariyadi B, Dono ND. Self-nanoemulsifying drug delivery system (SNEDDS) of Amomum compactum essential oil: design, formulation, and characterization. Journal of Applied Pharmaceutical Science. 2018 Jun 29;8(6):014-21.
38. Mustapha O, Kim KS, Shafique S, Kim DS, Jin SG, Seo YG, Youn YS, Oh KT, Lee BJ, Park YJ, Yong CS. Development of novel cilostazol–loaded solid SNEDDS using a SPG membrane emulsification technique: Physicochemical characterization and *in-vivo* evaluation. Colloids and Surfaces B: Biointerfaces. 2017 Feb 1;150:216-22.
39. Siqueira SD, Müllertz A, Gräeser K, Kasten G, Mu H, Rades T. Influence of drug load and physical form of cinnarizine in new SNEDDS dosing regimens: *in-vivo* and *in-vitro* evaluations. The AAPS journal. 2017 Mar;19(2):587-94.
40. Pratiwi L, Fudholi A, Martien R, Pramono S. Self-nanoemulsifying Drug Delivery System (Snedds) for topical delivery of mangosteen peels (Garcinia mangostana L.,): Formulation design and *in-vitro* studies. Journal of Young Pharmacists. 2017;9(3):341.
41. Mahmood A, Prüfert F, Efiana NA, Ashraf MI, Hermann M, Hussain S, Bernkop-Schnürch A. Cell-penetrating self-nanoemulsifying drug delivery systems (SNEDDS) for oral gene delivery. Expert opinion on drug delivery. 2016 Nov 1;13(11):1503-12.
42. Nasr A, Gardouh A, Ghorab M. Novel solid self-nanoemulsifying drug delivery system (S-SNEDDS) for oral delivery of olmesartanmedoxomil: design, formulation, pharmacokinetic and bioavailability evaluation. Pharmaceutics. 2016 Jun 27;8(3):20.
43. Balakumar K, Raghavan CV, Abdu S. Self nanoemulsifying drug delivery system (SNEDDS) of rosuvastatin calcium: design, formulation, bioavailability and pharmacokinetic evaluation. Colloids and Surfaces B: Biointerfaces. 2013 Dec 1;112:337-43.
44. Kaur G, Chandel P, Harikumar SL. Formulation development of self-nanoemulsifying drug delivery system (SNEDDS) of celecoxib for improvement of oral bioavailability. Pharmacophore. 2013 Jul 1;4(4):120-33.
45. Patel J, Patel A, Raval M, Sheth N. Formulation and development of a self-nanoemulsifying drug delivery system of irbesartan. Journal of advanced pharmaceutical technology & research. 2011 Jan;2(1):9.

46. Zhao Y, Wang C, Chow AH, Ren K, Gong T, Zhang Z, Zheng Y. Self-nanoemulsifying drug delivery system (SNEDDS) for oral delivery of Zedoary essential oil: formulation and bioavailability studies. International Journal of Pharmaceutics. 2010 Jan 4;383(1-2):170-7.

47. Singh SK, Prasad Verma PR, Razdan B. Glibenclamide-loaded self-nanoemulsifying drug delivery system: development and characterization. Drug development and industrial pharmacy. 2010 Aug 1;36(8):933-45.

48. Wang L, Dong J, Chen J, Eastoe J, Li X. Design and optimization of a new self-nanoemulsifying drug delivery system. Journal of colloid and interface science. 2009 Feb 15;330(2):443-8.

49. Rao SV, Shao J. Self-nanoemulsifying drug delivery systems (SNEDDS) for oral delivery of protein drugs: I. Formulation development. International journal of pharmaceutics. 2008 Oct 1;362(1-2):2-9.

50. Shafiq S, Shakeel F, Talegaonkar S, Ahmad FJ, Khar RK, Ali M. Development and bioavailability assessment of ramipril nanoemulsion formulation. European journal of pharmaceutics and biopharmaceutics. 2007 May 1;66(2):227-43.

51. Taha EI, Samy AM, Kassem AA, Khan MA. Response surface methodology for the development of self-nanoemulsified drug delivery system (SNEDDS) of all-trans-retinol acetate. Pharmaceutical development and technology. 2005 Jan 1;10(3):363-70.

52. Nazzal S, Smalyukh II, Lavrentovich OD, Khan MA. Preparation and *in-vitro* characterization of a eutectic based semisolid self-nanoemulsified drug delivery system (SNEDDS) of ubiquinone: mechanism and progress of emulsion formation. International journal of pharmaceutics. 2002 Mar 20;235(1-2):247-65.