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Review Article

A REVIEW OF SELF-EMULSIFYING DRUG DELIVERY SYSTEM- A NOVEL APPROACH TO DRUG

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A combination of oils, surfactants, and co-surfactants are re-emulsified in aqueous media while being gently stirred and subjected to the same digestive motility that occurs in the gastrointestinal tract in a self-emulsifying drug delivery system. One method for enhancing the oral bioavailability of hydrophobic medications is SEDDS. It is possible to transform the liquid SEDDS into a solid dosage form without compromising the drug release characteristics. The hepatic first-pass effect is circumvented by the micro/nano-emulsified drug's small size, which makes it simple to absorb through lymphatic channels. The primary advantage of this strategy is that it overcomes the first rate-limiting phase of particle dissolution in the GI tract's aqueous environment by pre-dissolving the molecule. When ntropy changes exceed the energy required to expand the surface area, self-emulsification occurs.

Keywords: SEDDS, oil, surfactant, co-surfactant.

INTRODUCTION

For formulation scientists working in the pharmaceutical sector, poorly water-soluble drug formulation has emerged as an intriguing new issue in recent years. Poor oral bioavailability, significant intra- and intersubject variability, and a lack of dosage proportionality might result from the poorly soluble or lipophilic chemicals that make up up to 45% of newly identified chemical entities by the pharmaceutical industry. Many efforts have been undertaken in the oral formulation of these compounds to alter the dissolution profile and consequently increase the absorption rate, including the reduction of particle size, the use of wetting agents, co-precipitation, and the creation of solid dispersions. Lipid-based formulations have recently received more attention as a means of increasing the bioavailability of medications that are poorly soluble in water.

Self-emulsifying drug delivery systems (SEDDSs) are one of the most frequently used delivery methods among many others, which include incorporating pharmaceuticals into oils, surfactant dispersion, emulsions, and liposomes. The rate and extent of medication absorption can be enhanced through a number of methods, including speeding up the absorption process and accelerating the rate or amount of dissolution. These methods are typically applied in the creation of a self-emulsifying formulation. Mixtures of oil, surfactant, cosurfactant, and medication are referred to as SEDDS. In the traditional manufacturing process of SMEDDS, drugs are

dissolved in oils and mixed with the appropriate solubilizing agents. They can be used to improve the oral absorption of highly lipophilic drugs. While SEDDS typically produce emulsions with a droplet size range of 100 to 300 nm, SMEDDS are transparent microemulsions with a droplet size of less than 50 nm. Additionally, SMEDDS have less than 20% oil compared to 40-80% in SEDDS. These are formulations that are easily manufactured, physically stable, and only need a little agitation before being diluted in an aqueous medium such as GI fluids. These tools can produce thin emulsions of oil in water, O/W or emulsions, microemulsions (SMEDDS). They generate fine oil-in-water emulsions when gently agitated into an aqueous phase. Such combinations are expected to self-emulsify quickly in the watery medium of the stomach, with digestive motility providing the required agitation for emulsification. By encouraging the synthesis of lipoproteins and chylomicrons through lipids, blocking CYP450 enzymes to increase intracellular concentration and residence time with surfactants, opening tight junctions to allow paracellular transport, and increasing membrane fluidity to facilitate transcellular absorption, SEDDS has been shown to improve oral absorption of a number of medications. Oral administration of poorly water-soluble medications can be accomplished with the help of SEDDS. This can be achieved by dissolving the medication in a suitable solvent and then adding the formulation to capsules. The oral delivery of hydrophobic drugs can be made possible via SEDDS. By pre-dissolving the molecule, this strategy's is its ability to get past the initial rate-limiting phase of particle dissolution in the GI tract's aqueous environment. However, when the formulation disperses in the GI tract, there is a possibility that the drug will precipitate out of solution if a hydrophilic solvent (such as polyethylene glycol) is utilized. Due to partitioning, drugs that dissolve in lipid carriers are less likely to precipitate after GI tract dilution.Kinetics will favor the drug that remains in the lipid droplets. There are two types of systems for lipid formulations that self-emulsify (SELFs). Self-emulsifying drug delivery systems (SEDDS). Microemulsifying drug delivery systems (SMEDDS). SMEDDSs and SEDDSs differ in ways that are associated with improved drug release properties. SEDDS formulations contain simple binary systems, such as a lipophilic phase and drug or a lipophilic phase, surfactant, and drug. Their dispersion appears turbid, and their droplet sizes fall between 200 and 300 nm. Furthermore, 40–80% of SEDDS contains oil. To create a microemulsion, an SMEDDS formulation has to have a co-surfactant. These dispersions may be identified by their optically clear to translucent appearance and droplet sizes of less than 50 nm. Oil makes up less than 20 percent of SMEDDS. These systems'

(SEDDS) improved oral bioavailability, which permits dosage reduction and is one of their potential benefits. More consistent temporal profiles of drug absorption, selective targeting of drugs towards a particular absorption window in the GIT, protection of drugs from the hostile environment in the gut, control of delivery profiles, decreased variability including dietary effects, and protection of sensitive. medication ingredients, potent medication ingredients, conveniently made liquid or solid dose formulations, and physically stable formulations. However, these systems also have significant drawbacks, such as the inability of the conventional dissolving technique to dissolve these formulations since they may require digestion before the medicine is released. Before assessing its strength, this in vitro model has to be further development and validation. Because it might be challenging to establish connections between in vitro and in vivo data, prototype lipid-based formulations must be created and evaluated in vivo using an appropriate animal model. Moreover, this method's shortcomings include the chemical instability of medications and formulations with high surfactant concentrations (between 30 and 60%), which have the potential to harm the gastrointestinal system."

Composition

The composition of SEDDS is determined by three factors: the type of oil-surfactant combination, the concentration of surfactant, and the temperature at which self-assembly takes place.

Oils

The most crucial ingredients are oils because it has the ability to solubilize lipophilic medications in a precise quantity and enables self-emulsifying formulations, which improve the percentage of lipophilic medications carried by the intestinal lymphatic system, thereby raising the GI tract's absorption. SEDDS have been formulated using oils with varying degrees of saturation, including both medium-chain and long-chain triglycerides. Corn oil, olive oil, oleic acid, and sesame oil, mono-, di-, and triglycerides are a few examples.

Surfactants

In the formulation of SEDDS, nonionic surfactants with high hydrophilic-lipophilic balance (HLB) values—such as Tween, Labrasol, Labrafac CM 10, Cremophor, etc.—are used. To create a stable SEDDS, the surfactant strength range for the formulation is 30±60% w/w. Natural emulsifiers are favored over synthetic ones since they are thought to be safer. Because of their high HLB and hydrophilicity, surfactants help the formulation spread quickly in an aqueous medium and form o/w droplets quickly. Due to their amphiphilic nature, surfactants have the ability to dissolve or solubilize a sizable concentration of hydrophobic pharmaceutical substances. They

can extend the half-life of drug molecules and prevent the drug from precipitating within the GI lumen.

Co-solvents

To create an effective SEDDS, a surfactant concentration that is relatively high—typically greater than 30% w/w—is required. Larger volumes of hydrophilic surfactants or hydrophobic medications may be dissolved in the lipid base with the use of co-solvents such as polyethylene glycol ether (Glycofurol), propylene glycol, polyethylene glycol, polyoxyethylene, and diethylene glycol monoethyl ether (Transcutol). These solvents can occasionally be crucial co-surfactants in systems of microemulsions.

MECHANISM OF SELF-emulsification

Reiss states that self-emulsification occurs when the energy required to expand the surface area is less than the entropy shift that favors dispersion. The energy needed to form a new surface between the oil and water phases determines the free energy of a typical emulsion, which is expressed in the following equation:

$DG=SN_i\ pr_i2S$

Where N is the number of droplets of radius r, s is the interfacial energy, and DG is the process free energy (ignoring the mixing free energy). With time, the emulsion's two phases have a tendency to separate. to decrease the space between surfaces. As a result, monolayer-forming emulsifying agents stabilize the emulsion. They serve as a barrier to prevent coalescence and lower the interfacial energy on the surface of emulsion droplets.

Formulation

The following points should be considered in the formulation of SEDDS

1. Medication solubility in various oils, co-solvents, and surfactants.

2. Choosing oils, surfactants, and co-solvents in accordance with the drug's solubility and creating a phase diagram.

3. oil, surfactants, and co-surfactant are mixed using a magnetic stirrer at 50°C.

4. Next, mix the medication into the blank SEDDS until it dissolves, creating an isotropic mixture. The medication's interference with the self-emulsifying process, which results in modifications to the ideal oil-surfactant ratio, makes its inclusion in SEDDS crucial. Consequently, phase diagram analysis and preformulation solubility research are needed for the creation of the best SEDDS.

5. Before use, let it cool to room temperature and allow it a full day to acclimate.

Preparation of Solid Sedds

The major methods for developing solid SEDDS include solid carrier adsorption, spray drying, melt extrusion, dry emulsion, and solid dispersion. It is possible to make pellets, pills, and capsules out of these solid SEDDS.

1. Solid carriers

As self-emulsifying systems (SES), these solid carriers have the ability to absorb liquid/semisolid compositions. The process of adding SES to a powder that flows freely and has adsorption qualities is straightforward. A blender is used to mix the material until it is evenly adsorbed. Before being compressed into tablets, this solid mixture is either added to additional excipient or put into capsules. The combination mentioned above can subsequently be consolidated into powder forms utilizing a variety of adsorbents, such as silicon dioxide (SylysiaTM 320), magnesium aluminum silicate (NeusilinTM US2), microporous calcium silicate (FloriteTM RE), and eusilinTM US2.

2. Spray drying:

Using a nozzle, the formulated mixture—which may include oil, surfactant, medication, solid carrier, etc.—is sprayed into a drying chamber in this method. Tiny solid particles are left behind as the volatile vehicles evaporate. Subsequently, these particles are compacted into tablets or put into capsules.

3. Melt extrusion:

This formulation method relies on the bulk and ability of the plastic material to be readily extruded and spheronized under pressure. Maintaining a steady temperature and pressure is necessary, but adding a liquid excipient is not necessary.

4. Dry emulsion:

It is primarily an oil-in-water emulsion that is freeze-dried, spray-dried, or transformed into a solid form using a solid carrier.

5. Melt extrusion/extrusion spheronization:

Melt extrusion is a solvent-free process that provides high medicine loading (65%) and uniform composition. Extrusion is a method that produces a product with uniform size, shape, and density by forcing a raw material with plastic properties through a die at a controlled temperature, flow rate, and pressure. The size of the extruder aperture will determine the approximate size of the resulting spheroids. The extrusion-based spheronization method is widely used in the pharmaceutical industry to produce pellets with uniform sizes. extrusion-based spheronization. The active ingredients and excipients are combined dry to produce a homogeneous powder. The mixture is then moistened after a binder is applied. To produce spheroids of consistent size, the mixture is then extruded into an extrudate that resembles spaghetti. Then, these are dry-sifted to achieve the desired size distribution, with coating being optional.

Capsule filling with liquids and semisolids self-emulsifying system.

The simplest and most often used method for encasing liquid or semi-solid SE formulations for oral delivery is capsule filling. If semi-solids are being used, the semisolid excipients must

be heated to a minimum of 20-80°C, which is higher than their melting temperatures. Then, the active ingredients must be stirred into the molten mixture, which is then packed into capsules and allowed to cool to room temperature.

Dosage Forms For Self-Emulsifying System.

1. Self include self-emulsifying capsules.

In order to reach the site of absorption, microemulsion droplets develop and spread in the GIT following the ingestion of capsules containing traditional liquid SE formulations. It is not possible to anticipate an improvement in medication absorption if irreversible phase separation of microemulsions occurs. Sodium dodecyl sulfate can be added to solve this issue and be included in the formulation of the SE. A small amount of HPMC can be used to create extremely saturatable SEDDS, which keep the medication in an in vivo condition and prevent it from precipitating. By adding solid carriers (absorbent polymers), liquid SE components can be put into capsules in a solid or semi-solid condition. One option is to select a solid PEG matrix.

2. Self-emulsifying sustained / controlled release tablets.

Lipids and surfactants have shown a lot of potential for making SE tablets. A gelled SEDDS can be created to minimize the quantity of solidifying excipients needed to turn SEDDSs into a solid dosage form. For the Oil-systems, colloidal silicon dioxide (aerosol 200) can be employed as a gelling agent, which has the dual benefit of reducing the quantity of solidifying excipients needed and helping to reduce the rate of medication release. SE pills are quite helpful in preventing side effects. By adding indomethacin (or other hydrophobic NSAIDs) to SE pills, the medication may be able to pass through the GI mucosal barrier and perhaps lessen GI bleeding. Tyloxapol and glycerol monolaurate often make up the SES.

3. Self-emulsifying microspheres.

Both the spherical crystallization procedure and the quasi-emulsion solvent diffusion approach can be used to manufacture solid SE sustained-release microspheres. The ratio of hydroxypropyl methylcellulose acetate succinate to Aerosil 200 in the formulation can regulate the zedoary turmeric oil. When these microspheres are orally administered to rabbits, plasma concentration time profiles can be obtained, and their bioavailability is 133.6% higher than that of traditional liquid SEDDS.

4. Self emulsifying sustained / controlled release pellets

Compared to traditional solid dosage forms, pellets provide a number of advantages as a multiple dose form, including manufacturing flexibility, a decrease in intra- and inter-subject variability in the plasma profile, and a reduction in GI discomfort without compromising drug absorption. Drugs used in SE-controlled release pellets accelerate their rate of release by coating the pellets. The rate of drug release

might be decreased by using a water-insoluble polymer. Pellets with two water-insoluble model pharmaceuticals (methyl and propyl paraben) can be made by extrusion or spheronization. Polysorbate 80 and monodiglycerides may be present in SES.

5. Self-emulsifying beads.

By using fewer excipients, self-emulsifying systems can be prepared in solid dosage forms. The usual method for creating porous polystyrene beads (PPB) with intricate internal void architectures is to copolymerize styrene and divinyl benzene. PPB is stable and inert across a broad pH, temperature, and humidity range. It has been discovered that characteristics of PPB, such as bead size and ore design, control loading efficiency and in vitro drug release.PPB is loaded with SES.

6. Self-emulsifying nanoparticles (SENs).

Self-emulsifying nanoparticles can be created using nanoparticle technology. An injection serves as one of the solvents. Lipid, surfactant, and medication are present in the created molten lipid mass made using this approach. A non-solvent system is filled dropwise with this molten lipid material. In order to create nanoparticles, this is filtered and dried. This process yields 100 nm-sized particles with a drug loading efficiency of 70–75%. Sonication emulsion diffusion evaporation is the second method. In this approach, biodegradable PLGA/carboxy methyl-chitosan (CMC) nanoparticles were loaded with 5-fluorouracil and antisense epidermal growth factor receptor (EGFR). The combination of PLGA and CMC exhibited a self-emulsifying property without the need for further surfactants.

7. Self emulsifying solid dispersion

Poorly water-soluble medications may dissolve more quickly and have higher bioavailability when dispersed in solid form. It is possible that these excipients will improve the absorption of poorly soluble medications even more. They are filled immediately into hard gelatin capsules in a molten condition, as opposed to previously utilized PEG solid dispersions, which eliminated the need for milling and mixing beforehand. In this sector, SE excipients such as Tocopherol/Polyethylene Glycol 1000 Succinate (TPGS), Labrasol, Transcutol, and Lucire 4414 have been widely employed.

8. Self-emulsifying suppositories

SEDDS may improve the drug's absorption via the GI tract as well as the vaginal or rectal routes. By using either vaginal or rectal self-emulsifying suppositories, glycyrrhizin, which when taken orally, produces therapeutic plasma concentrations, can reach sufficient therapeutic levels for long-term liver problems. Glycyrrhizin and a combination of C6-C18 fatty acid macrogol ester and glycerol ester are included in these formulations.

9. Self emulsifying implants

The utility of SEDDS has been substantially

boosted by research into SE implants. Example 1: A chemotherapy drug called 3-bis(2-chloroethyl)-1é nitrosourea (carmustine) is used to treat malignant brain tumors. However, its short half-life makes it less effective. Copolymers with at least two cross-linkable functional groups per polymer chain, a hydrophilic area, and a bioresorbable region were created by Loomis. These copolymers exhibit SE characteristics without the need for an emulsifier. These copolymers work well as implanted prosthesis sealants.

Characterization Of Seeds

Visual assessment is the primary method used to evaluate self-emulsification. Measurements of turbidity, droplet size distribution, and emulsification duration may all be used to determine the effectiveness of self-emulsification.

Visual assessment

This might offer crucial details on the mixture's microemulsifying and self-emulsifying characteristics, as well as the resulting dispersion.

Droplet size analysis and particle size measurements

Using a Zetasizer that can detect sizes between 10 and 4000 nm, photon correlation spectroscopy is used to estimate the droplet size of the emulsions. Using spherical polystyrene beads for external standardisation, light scattering is observed at a 90° angle and 25°C. The system's compatibility with excessive water is demonstrated by the retention of the particles' nanometric size range even after a 100-fold dilution with water.

Assessment of self-emulsification emulsification:

The USP 24 rotating paddle device is used to evaluate the efficacy of various mixtures' self-emulsification. 200 millilitres of distilled water are combined with one gramme of mixture, and the combination is gently stirred at a temperature of 37°C using a revolving paddle set at 70 rpm. Visual monitoring is used to track the rate of emulsification and the appearance of the resulting emulsions during the self-emulsification process.

Viscosity determination

The rheological characteristics are assessed using a Brookfield viscometer to determine whether it is o/w or w/o kinds, in which case, it is highly viscous.

Droplet size analysis

Using Zeta sizer, a photon correlation spectroscopy tool that measures sizes between 10 and 5000 nm, the droplet size of the emulsion is ascertained.

Thermodynamic stability studies

A lipid-based formulation s crucial to its effectiveness since it may have unfavorable consequences such as the medication precipitating in the excipient matrix solution. Additionally, phase separation may result from the formulation's inadequate physical stability.

The performance of the formulation's performance well as its appearance are both impacted by the excipient's separation. Furthermore, partial release of the medication, delayed disintegration, and brittleness may result from formulation incompatibilities with the gelatin capsule shell. Three primary procedures are carried out for thermodynamic stability analysis.

1. **Heating-cooling cycle:** Six cycles are examined, with storage at each temperature for a minimum of 48 hours, ranging from 5°C in the refrigerator to 45°C. The centrifugation test is used for formulations that remain stable at these temperatures.

1. Centrifugation: Centrifuging at thaw cycles between 20°C and +25°C for a minimum of 48 hours at 3600 rpm for 20 minutes is done on passed formulations. The formulations subjected to the freeze-thaw stress test are those that exhibit no phase separation.

2. Freeze-thaw Formulations that pass this test have good stability, devoid of creaming, cracking, or phase separation.

Dispersibility

An oral emulsion's self-emulsification efficiency is evaluated by conducting a dispersibility test using standard USP XXII dissolving equipment 2. 500 milliliters of water at 37 ± 10C are mixed with one milliliter of each mixture. To provide mild agitation, a standard stainless steel dissolving paddle is employed, moving at a speed of 50 rpm. The following grading scheme is used to visually evaluate the formulations' in vitro performance:

Grade A: Emulsion that forms quickly (in less than a minute) and appears clear or blue.

Grade B: bluish-white, rapidly forming emulsion that is somewhat less transparent.

GradeC In two minutes, a fine, milky emulsion forms.

Grade D: dull, grayish-white emulsion that takes longer than two minutes to emulsify and has a somewhat greasy appearance.

Grade E: A formulation that has large oil globules on the surface and either weak or minimal emulsification. Once distributed in GIT, Grade A and B will continue to exist as an emulsion. However, for SEDDS) formulation, a formulation in Grade C might be suggested.

Refractive index and percent transmittance

The refractive index and percentage transmittance percentages show how transparent a formulation. A drop of the solution on a slide can be compared to water using a refractometer to determine the system's refractive index (1.222). The system's percentage transmittance at a specific wavelength is measured using a UV spectrophotometer, with distilled water serving as a blank. If the refractive index of the system is similar to that of water, If the formulation's % transmittance is greater than 98 percent, it will

be transparent.

In vitro diffusion study

Using the dialysis approach, in vitro diffusion investigations are conducted to examine the drug release behavior of formulations from the liquid crystalline phase surrounding the droplets.

Applications

1. Enhancement in bioavailability and solubility.

2. Defense against biodegradation.

3. Oral delivery of hydrophobic drugs can be made possible by SEDDS.

4. SEDDS solve problems associated with the delivery of poorly soluble drugs.

Examples: Bioavailability enhancement of poorly soluble drugs after administration of SEDDS.

a. Halofantrine shows higher bioavailability with SMEDDS.

b. Vitamin EBA 3-foldhigher from SEDDS27 .

c. Coenzyme Q10 BA is 2-foldhigher from SEDDS.

d. Progesterone BA-fold higher from SEDDS.

e. Nimodipine showed improved *in vitro* and *in vivo* performance compared to SMEDDS3.

Recent Approaches In Self Emulsifying Drug Delivery Systems

1. Surfactant mixtures result in improved reproducibility of the plasma profile in terms of *C*max and *T*max.

2. SEDDS of coenzyme Q10 were prepared, resulting in enhanced bioavailability and reduced toxicity. Lipophilic compound WIN 54954 was formulated as SEDDS in triglyceride oil/nonionic.

3. Self-microemulsifying drug delivery system (SMEDDS) of Simvastatin hashasbeen developed to enhance its oral bioavailability. This study illustrates the potential use of SMEDDS for the delivery of hydrophobic compounds.

4. A novel SEDDS of PTX (used for the treatment of solid tumors) was prepared and it was found that the SEDDS was chemically stable for at least one year when kept as a two-part formulation. Additionally, the drug loading could be increased by approximately fivefold. Compared to marketed I.V. formulation, the excipient presented significantly reduced cytotoxicity and resulted in a stable microemulsion.

5. An antimalarial drug, Halofantrine, was prepared as SEDDS and SMEDDS, resulting in an eight-fold improvement in absolute oral bioavailability relative to previous solid data of the solid.

6. Enhanced bioavailability up to 1.88% of silymarin was achieved by SMEDDS.

7. Using SEDDS, a self-nano emulsified drug delivery system (SNEDDS) of ubiquinone was

prepared, and the study revealed that SNEDDS overcomes the drawbacks of the traditional emulsified system, such as low solubility and irreversible precipitation of the active drug in the vehicle over time.

Future Prospects

Current methods for transforming liquid/semi-solid SEDDS and SMEDDS formulations into powders and granules can be applied to the formulation development of poorly soluble drugs in the future. These materials can subsequently be compressed into tablets or further processed into traditional 'powder-fill' capsules. Using a waxy solubilizing agent as a binding agent, up to 25% solubilizing agent can be added to a formulation by the hot melt granulation method of generating granules or pellets. The use of inert adsorbents, to turn liquids into powders that may be made into powder fill capsules or tablets, such as Fuji Chemicals' Neusilin and Huber's Zeopharm, is also gaining popularity. However, a relatively high ratio of SEDDS to solidifying excipients is required to create solids with appropriate processing qualities, and this seems practically unfeasible for medicines with low solubility in the oil phase. This led to the hypothesis that if SEDDS were gelled, a large reduction in the quantity of solidifying excipients needed to turn SEDDS into solid dosage forms would occur. For the oil-based systems, colloidal silicon dioxide (Aerosil 200) is used as a gelling agent since it may help limit drug release while also lowering the quantity of solidifying excipients needed.

To optimize in vivo absorption of drug molecules encapsulated in solid SEDDS and reveal their full therapeutic potential, a comprehensive and systematic investigation of the molecular relationships among drug molecules, solid carriers, and lipid excipients is needed. Firstly, compare and contrast the in vivo pharmacokinetics and solubilization behavior of several medications encapsulated in liquid and solid SEDDS. Secondly, it is suggested that a range of influential physicochemical and biophysical analysis techniques, and surface-sensitive methods, be used for the clarification of the optimal parameters that ultimately lead to the improvement of biopharmaceutical performance for specific treatments in order to explore and test the relationships within solid SEDDS on the nanoscale (Joyce et al., 2019).

CONCLUSION

SEDDS is a feasible formulation method for medications with low water solubility. Oral administration of hydrophobic medicines has demonstrated a considerable improvement in oral bioavailability when done with SEDDS. Given that SEDDS efficacy is often situation-specific, a thorough analysis of the formulation's constituent parts is required. It is crucial to take into account the toxicity of surfactants because they are commonly utilized in SEDDS formulations at very high

concentrations. In actuality, the toxicity and propensity to self-emulsify need to be balanced before use.

The size and charge of the oil droplets in the final emulsion are two other significant variables that influence the effectiveness of GI absorption. Instead of conventional SEDDS, a number of preparations have been created to provide modified emulsified formulations. Examples include solid SESs, surfactant dispersions, self-emulsifiable pellets, pre-formulated freeze-dried emulsions, microencapsulated emulsions, self-microemulsion formulations, and lipid/crosslinked polymeric matrix (Tsuji et al., 1996).

When diluted with water, any of these formulations will result in micelle dispersions or fine oil droplets. Currently on the market, medications developed as SEDDS, including ritonavir, saquinavir, and CsA, are freely accessible. Since over 40% of novel therapeutic chemicals are hydrophobic, it is expected that additional pharmaceutical items will become SEDDS in the years to come.

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