RESEARCH ARTICLE

The excipient usefulness of Carbosil® and *Landolphia owariensis* in two oil-based self-emulsifying formulations

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The objective of this work was to improve on the solubility of ibuprofen using two vegetable oil-based self-emulsifying formulations (SEFs) and to evaluate the potential usefulness of Carbosil® (CARB) and *Landolphia owariensis* latex (LOL) in them. Isotropicity, drug solubility, viscosity, emulsification time (EMT), drug release, aqueous dilution, postemulsification drug precipitation and refrigeration tests were carried out on the coconut oil (CO) and shea butter oil (SBO)-based SEFs. Results showed that only four out of nine batches of the SEFs passed the preformulation isotropicity test. A 100-mg quantity proved to be the maximum amount of drug that could be dissolved by the SEFs to form a stable solution. After 72 hrs all the SEFs still retained stability. All of CO SEFs witnessed remarkable phase separation or drug precipitation However, SBO SEFs having oil:surfactant:cosurfactant ratio of 35:45:20 and containing LOL or LOL-CARB blend lost isotropicity or displayed drug precipitation 6 months later. Refrigeration temperature did not introduce any form of instability or phase separation. Similar viscosities were recorded by the two oil-based SEFs. However, little but inconsistent variation in viscosity was observed between SBO SEFS and LOL-containing SEFs. Aqueous dilution and postemulsification drug precipitation test indicated absence of phase separation and drug precipitation, respectively. Drug-release studies showed that the t_{50} of SBO SEFs almost ranked equally with SBO SEFs containing LOL. CO SEFs emulsified at a longer time than those of SBO. SEFs distinctly recorded higher EMTs than those with LOL or CARB-LOL blend. In conclusion, solubility of ibuprofen was improved, CARB gelled the SEFs while LOL reduced their EMTs.

Key words: *Carbosil®, coconut oil, landolphia owariensis latex, self-emulsifying formulation, shea butter oil*

INTRODUCTION

Oil dispersions of drugs have previously constituted the major vehicle for the delivery of lipophilic drugs. But now better alternative vehicles, such as self-emulsifying formulations (SEFs) that could ensure solubilization of these oil-soluble drugs are being rapidly explored. SEF or self-emulsifying drug delivery system (SEDDS) is a strategy that has drawn wide research interest, basically due to its distinct capacity to solubilize and improve the bioavailability of poor water-soluble drugs. This it does by ensuring aqueous solubility of the lipophilic drug. Aqueous solubility is an important molecular property required for a successful drug development. This is because it strongly determines drug accessibility to biological membranes.[1] The essentiality of solubility in drug disposition is underscored by the fact that the optimal rate of passive drug transport across a biological membrane (the major pathway for absorption of drugs), not only depends on permeability but also on solubility of the drug.[1] This is why, drugs that belong to class 11 Biopharmaceutic classification system (BCS), are associated with unpredictable bioavailability in spite of their high membrane permeability status.[2]

The significance and functional uniqueness of SEFs will continue to reveal its industrial applicability in years to come. As a result it has become imperative to evaluate the usability of several excipients as possible ingredients in SEFs formulations. SEF is an isotropic mixture of oil/s, surfactant/s and cosurfactants/

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Access this article online

Quick Response Code:

Website: www.asiapharmaceutics.info

DOI: 10.4103/0973-8398.76746

cosolvents, which on gentle agitation in the presence of aqueous medium undergoes self-emulsification to produce o/w microemulsions.[3] They are referred to as SEDDS if the o/w emulsion is within 100 nm or more, and SMEDDS or SNEDDS for 50 nm or less particle sizes. The oils used can either be synthetic or natural, while nonionic surfactants are preferred because of the less likelihood of incompatibility and interactions. Cosolvents or cosurfactants may also be incorporated chiefly to further achieve enhanced drug solubilization or formulation isotropicity/stability. The presence of oil makes SEOFs unique and distinguishes them from ordinary surfactant dispersions of drugs. An array of synthetic oils has been the major choice of formulators, while natural vegetable oils, though applicable, have been discredited for their low solvent capacity (their capacity to solubilize drugs is low). Nevertheless some workers have begun to emphasize the potential applicability of some of these vegetable oils in this novel drug delivery system. Palm oil and Palm kernel oil have been found to form stable SEDDS;[4] in addition, some unpublished works[5] have also evaluated the functional relevance of melon oil, oil bean oil and blends with goat and cow fat, respectively, in their SEDDS formulations. Similarly Palm kernel oil has equally proven to be a suitable SEDDS component in the delivery of ibuprofen.[6] These natural oils, apart from their physiological biocompatibility status, are nutritionally acceptable, cytologically less or nontoxic, economically affordable and commercially available. Conventional tablet formulations of lipid-soluble drugs especially those of class 11 BCS eventually get solubilized through the help of the emulsification process of bile salts; however, the rate at which this takes place is unpredictable due to inter- and intrasubject variations,[7] hence the bioavailability unpredictability and variability associated with such actives. This among others is the prominent disadvantage SEFs seek to resolve.[8] Peroral coadministration of poorly water-soluble drugs in lipid-based formulations like SEFs improves the bioavailability of such drugs with a predictable profile. Drug release from SEDDS has been reported to take place by interfacial transfer and vehicle degradation.[9,10] Interfacial transfer involves drug diffusion from the formulation into the bulk or directly over the intestinal membrane while vehicle degradation involves, especially the lipase-catalysed lipolytic degradation of the SEDDS and subsequent drug release.[11] Apart from oils other excipients have also been incorporated to either improve the biopharmaceutical performance, physicochemical property or physical stability of SEFs. For instance the incorporation of oleylamine by some workers[12-14] produced cationic SEFs believed to increase mucosal adhesion and absorption of appropriate SEFs. Furthermore the addition of CARB was to act as an intermediate to the solidification of SEFs.[6,15] The objective of this work was to improve the solubility of ibuprofen using two vegetable oil-based SEFs and to evaluate the potential usefulness of CARBand *Landolphia owariensis* latex (LOL) in them. Some physicochemical properties of LOL have been evaluated elsewhere.[6]

MATERIALS AND METHODS

Span 85 (FLUKA AG Chemische Buchs, Engetragene chemical Marke de chemical inc. USA), Tween 80 (Sigma Aldrich, Seelze Germany) and shea butter oil (SBO) was procured from Nsukka main market, Nigeria and appropriately identified before use. Coconut oil (CO) was extracted using Soxhlet method.[16] *Landolphia owariensis* located in the botanical garden of the Department of Botany, University of Nigeria, Nsukka was identified by the garden attendant prior to tapping and collection of latex. All other reagents used were of analytical grade and used as such.

METHODS

Purification of shea butter and COs

A 2% w/w suspension of activated charcoal in oil was heated in a beaker at 80-90°C for an hour.[4] The suspension was later vacuum-filtered using Buchner funnel. The purified oil was stored for further use. This was to remove free fatty acids and unwanted colors and odors.

Preformulation isotropicity test

Nine batches of SEFs consisting of oil, surfactant, cosurfactant ratios as shown in Tables 1-3 below were prepared. The

Table 1: Four grams of SEF for isotropicity studies

	Oil: Surfactant: Cosurfactant	Oil	Surfactant	Cosurfacant
		SBO (g)	Tween 80 (g)	Span 85 (g)
1	20:60:20	0.8	2.4	0.8
2	25:55:20	1.0	2.2	0.8
3	35:45:20	1.4	1.8	0.8
4	40:50:10	1.6	2.0	0.4
5	50:40:10	2.0	1.6	0.4
6	40:45:15	1.6	1.8	0.6
7	35:50:15	1.4	2.0	0.6
8	25:60:15	1.0	2.4	0.6
9	35:55:10	1.4	2.2	0.4

Table 2: Formula for 450 mg (1 capsule) of ibuprofen SEF

Oil: Surfactant: Cosurfactant	SEOF (mg)	Drug (mg)	Total (mg)
20:60:20	350	100	450
35:45:20	350	100	450
25:55:20	350	100	450
25:60:15	350	100	450

Table 3: Formula for one capsule of ibuprofen SEF containing LOL

Oil: Surfactant: Cosurfactant	SEF (mg)	LOL (mg)	Ibuprofen (mg)	Total (mg)
20:60:20	350	13	100	463
35:45:20	350	13	100	463
25:55:20	350	13	100	463
25:60:15	350	13	100	463

appropriate quantities of the three ingredients were introduced into test tubes and stirred over a water bath at 50°C for 10 min. Thereafter, it was stored for 5 hrs at ambient temperature and later evaluated for isotropicity. The SEFs that passed this test were used for further studies while those that witnessed phase separation were discarded.

Drug solubility in the SEF

This experiment was carried out to determine the maximum amount of ibuprofen that could be dissolved in the SEF without precipitation since the drug must preferably be in solution. Increasing quantities of the drug 50, 75, 100 and 200 mg were, respectively, added to a 0.4 ml quantity of SEOF and stirred vigorously at 40°C for 30 min. The maximum drug quantity that dissolved in the SEF was therefore selected and used for further formulation studies.

Formulation of ibuprofen SEFs

Formulation was limited to only the SEOF that passed the isotropicity test. In each case appropriate quantity of ibuprofen was weighed and introduced into a beaker (on a water bath maintained at a temperature of 50°C) containing the appropriate amount of Span 85 and stirred for 10 min. The appropriate quantity of the oil was then added and stirring continued. Finally, tween 80 was introduced and stirred for more 5-10min until drug completely dissolved. Table 2 shows the various quantities of the ingredients used in the formulation of drug-loaded SEOFs of target weight 450 mg.

Formulation of ibuprofen SEFs containing LOL

A 13-mg quantity of LOL was dispersed in the appropriate quantity of oil in a 50-ml beaker and warmed to 50°C in a water bath with stirring. Span 85 was added with continued stirring until all the LOL dissolved. At this point ibuprofen was added and stirring maintained for 10 min. Thereafter tween 80 was introduced and further stirred until a homogenous mixture was obtained. The formula is as shown below in Table 3.

Formulation of ibuprofen SEFs containing a blend of LOL and CARB

A 13-mg quantity of LOL was incorporated into an appropriate quantity of oil in a beaker on a water bath of temperature 50°C). Span 85 was added and the entire system stirred until the LOL dissolved. Ibuprofen was then introduced and stirred until complete drug dissolution was effected. CARB was thereafter added and dissolved with further stirring. Finally tween 80 was incorporated with more stirring for at least 5 min.

Postformulation isotropicity/stability test

The SEFs [Tables 2-7] were stored for 72 hrs at ambient temperature and observed for isotropicity (phase separation and drug precipitation). Those that passed this test were stored for a further 6 months, and thereafter observed for phase separation and/or drug precipitation.

Table 4: Formula for one capsule of ibuprofen SEF containing LOL-Carbosil blend

Oil: Surfactant: Cosurfactant	SEOF (mg)	LOL (mg)	Carbosil (mg)	Ibuprofen (mg)	Total (mg)
20:60:20	350	13	13	100	476
35:45:20	350	13	13	100	476
25:55:20	350	13	13	100	476
25:60:15	350	13	13	100	476

Table 5: Formula for SEF containing LOL or Carbosil for viscosity studies

Oil: Surfactant: Cosurfactant	SEF (mg)	LOL/Carbosil (mg)	Total (mg)
20:60:20	350	20	370
35:45:20	350	20	370
25:55:20	350	20	370
25:60:15	350	20	370

Table 6: Isotropicity test result

	Oil: Surfactant: Cosurfactant	Oil (g)	Surfactant (g)	Cosurfactant (g)
		SBO/CO	Tween 80	Span 85
1	20:60:20	0.8	2.4	0.8
2	25:55:20	1.0	2.2	0.8
3	35:45:20	1.4	1.8	0.8
8	25:60:15	1.0	2.4	0.6

Viscosity studies

Approximately 50 ml of each batch of the SEF was introduced into the lower cup of the Rotovisco viscometer (HAAKE, England) while the upper cylindrical fitting was dipped into the SEOF-filled cup. The equipment was switched on and the meter zeroed. The corresponding Torque was recorded at each shear rates of 162, 81, 54, 27 and 18. The Torque was later appropriately converted to shear stress and plotted against shear rate from where the dynamic viscosity was derived.

Formulation of ibuprofen SEFs containing CARB or LOL for viscosity studies

Twenty milligrams of CARB or LOL was added into an appropriate amount of the oil and dispersed by stirring, at 50°C. More time and effort were required to successfully have LOL dissolved into the SEF. The appropriate amount of Span 85 was introduced and stirring continued. Tween 80 was finally added with further stirring until the dispersion dissolved into solution, thus yielding a weight of 370 mg as shown in Tables 8 and 9. The formula was scaled up to achieve a volume of 60 ml. Any debris of LOL was excluded through filtration. It was then taken to the viscometer as described above.

Emulsification time test

A magnetic stirrer-beaker-hot plate assembly was used for this study. A 250 ml quantity of 0.1 N HCl was introduced into a 500-ml beaker positioned on a hot plate and maintained at

Table 7: Dynamic viscosity (DV) readings

Oil: Surfactant: Cosurfactant		SB-based SEF				CO-based SEF			
		SEF		SEF +LOL		SEF		SEF +LOL	
		DV (poise)	R^2	DV (poise)	R^2	DV (poise)	R^2	DV (poise)	R^2
A	20:60:20	0.008	0.99	0.001	0.99	0.0007	0.99	0.0009	0.99
B	25:55:20	0.0008	0.99	0.0008	0.99	0.0009	0.96	0.0009	0.99
C	25:60:15	0.0008	0.99	0.0011	0.99	0.0008	0.99	0.0008	0.99
D	35:45:20	0.0007	0.98	0.0007	0.99	0.0005	0.99	0.0006	0.99

Table 8: Effect of LOL and CARB on the release of ibuprofen from the SEFs

Oil: Surfactant: Cosurfactant		SBO-based SEF					
		SEFs		SEFs+ LOL		SEFs+LOL+CARB	
		T_{50} (min)	T_{85} (min)	T_{50} (min)	T_{85} (min)	T_{50} (min)	T_{85} (min)
A	20:60:20	3.85	9.35	3.75	20	12.5	22.5
B	25:55:20	3.8	9.35	3.1	5	3.7	10
C	25:60:15	3.85	9.35	7.5	18	8.75	18.75

Table 9: Emulsification time result

SBO-based SEF			CO-based SEF
Oil: Surfactant: Cosurfactant		Mean time (sec)	Mean time (sec)
1	20:60:20	28±1.0	91±8.7
2	25:55:20	28.7±1.5	99.7±13.6
3	25:60:15	28.3±1.5	85.7±13.0
4	35:45:20	28.3±0.6	62.3±1.5
SB SEF+LOL			CO SEF+LOL*
5	20:60:20	8±2.0	–
6	25:55:20	7±2.0	–
7	25:60:15	9±2.0	–
SBO SEF+LOL+CARB			CO SEF+LOL+CARB*
8	20:60:20	9±1.0	–
9	25:55:20	7±1.0	–
10	25:60:15	12.7±2.1	–

*No recorded values because after 6 months isotropicity was lost

37±1°C. SEF (450 mg), SEF containing LOL (463 mg) or SEF containing LOL-CARB blend (476 mg) was syringed into the beaker as the stirrer rotated at approximately 50 revolutions per min. The time taken for the complete emulsification of the SEF was visually observed.

Aqueous dilution test

A 450 mg quantity of SEF was emulsified in 100 ml of 0.1 N HCl. More of 100 ml volumes of the aqueous acid were gradually added and each time observed for phase separation and drug precipitation, until 1000 ml had been added.

Postemulsification drug precipitation test

A 450 mg quantity of SEF was emulsified as above and the emulsion stored at ambient temperature for 4 hrs. Thereafter it was observed for the presence of drug precipitate.

Encapsulation of SEF Formulations

Using a 1-ml syringe each dose of the SEF formulations was introduced into one half of a 500 mg hard gelatine capsule shell, which was covered with the upper half. The drug-loaded capsules were later stored in a polyethylene material for further use.

Refrigeration test

Two capsules of the SEF from each batch were wrapped in a polyethylene material and kept in the refrigerator for 24 hrs at 2°C. It was thereafter observed for drug precipitation.

Characterization of SEOFs by particle size/zeta potential/ polydispersity determination

The particle size of the aqueous dispersion of the SEF was determined by photon correlation spectroscopy using a zeta sizer (Zeta sizer 3000 HS, Malvern Instruments, Worcestershire UK). Thirty milliliter of an aqueous dispersion of the SEF was prepared. Then a ten-fold dilution of the emulsion was made in phosphate buffer solution (PBS, pH 7.4) in order to obtain acceptable light-scattering range measured in kilocounts per second. Measurements were carried out at 25°C at a scattering angle of 90°.The mean particle size was then determined in three runs with each having 10 sub-runs. On the other hand the zeta potential of the formulated SEFs was determined by phase analysis light scattering using the same zeta sizer as in particle size determination. The zeta potential value was a mean from two runs of 10 sub-runs each.

Drug Release Studies

The rotating basket dissolution apparatus (VEEGO, India) was used. Four hundred and fifty milligrams of SEF was syringed into the transparent cylindrical plastic container containing 900 ml of 0.1 N HCl in the dissolution apparatus. A capsule of the SEF, SEF containing LOL or SEF containing LOL-CARB blend was placed inside the basket and the equipment switched on at a rotation speed of 100 rpm. At predetermined time intervals 5 ml samples of the dissolution medium were withdrawn and assayed spectrophotometrically (UV/VIS Unico, USA) after appropriate dilution at 264 nm. Meanwhile, 5 ml of a fresh medium was used to refresh the dissolution medium. The experiment was run in duplicates.

Absolute drug content

A 450 mg quantity of SEF was emulsified in 100 ml of 0.1 N HCl. One milliliter of the emulsion was withdrawn and made up to 100 ml with a fresh aqueous acid. It was later assayed

spectrophotometrically (UV/VIS Unico) for ibuprofen content at 264 nm.

RESULTS

Only four out of nine batches passed the preformulation isotropicity test. One hundred milligrams was the maximum quantity of drug that could be dissolved by the SEF to form a stable solution. After 72 hrs, postformulation isotropicity test showed that all the SEFs retained thermodynamic stability; but after 6 months it was only all CO-based SEFs that showed remarkable phase separation or drug precipitation. Shea butter-based formulation with oil:surfactant:cosurfactant ratio of 35:45:20 containing LOL or LOL-CARB blend also lost isotropicity or displayed drug precipitation. Refrigeration temperature did not introduce any form of instability or phase separation. The values on Table 7 show the dynamic viscosity (ratio of shear stress to shear rate) values of the various batches of shea butter and CO-based SEFs. Similar viscosities were recorded by the two oil-based SEFs. However, little but inconsistent variation in viscosity was observed between SBO SEFS and LOL-containing SEFs. The flow pattern was Newtonian. Aqueous dilution and postemulsification drug precipitation tests indicated absence of phase separation and drug precipitation, respectively. Drug release studies [Figures 1 and 2] showed that the t_{50} of SBO SEFs almost ranked equally with those of LOL-containing SBO SEFs. CO SEFs emulsified at a significantly ($P<0.05$) longer time than those of SBO. Similarly the SEFs distinctly recorded higher EMTs ($P<0.05$) than SEFs containing LOL or CARB-LOL blend. The particle size ranged between 207 and 212 nm with polydispersity index values of 0.176-0.259 and negative zeta potential. Figures 3-5 show the PCS peak analysis graph.

DISCUSSION

Preformulation isotropicity was to determine homogenous miscibility between the surfactants and the oil. Failure of any batch at this stage is tantamount to outright rejection and exclusion. As shown in Table 6, only four out of the nine batches passed the Test. They were, therefore, used for further studies.

The effect of refrigeration was investigated. The formulations did not show any form of organoleptic change or apparent instability of any kind. This is an indication that storage at very low temperatures could be tolerated.

Absence of phase separation upon ten-fold dilution is suggestive of SEFs that have the potential for a ten-fold dilution without introduction of thermodynamic instability. In addition it underscores its thermodynamic stability, which is associated with its nanometer range globule size and high surface area. This *in vitro* test predicts *in vivo* dilutability that SEOFs are subject to upon peroral administration. Dilution and gastrointestinal tract motility-impelled emulsification is not expected to yield microemulsion with phase separation defect, otherwise drug precipitation will be inevitable.

Furthermore the absence of drug precipitation some hours after aqueous dilution precludes the possibility of premature

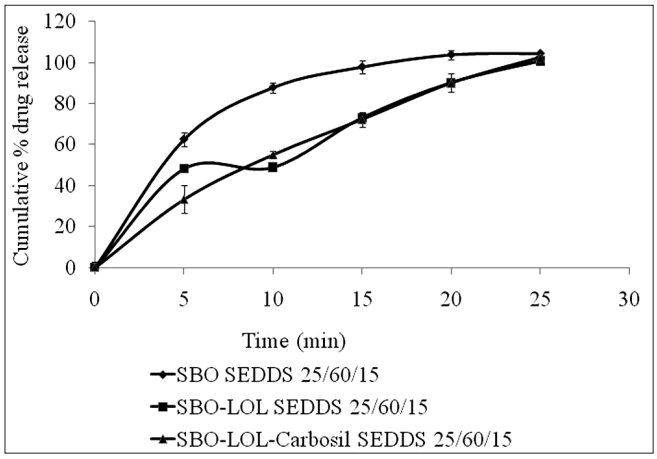

Figure 1: Effect of LOL or LOL-Carbosil® blend on the release of ibuprofen from shea butter oil-based SEOFs containing oil:surfactant:cosurfactant ratio of 25:60:15

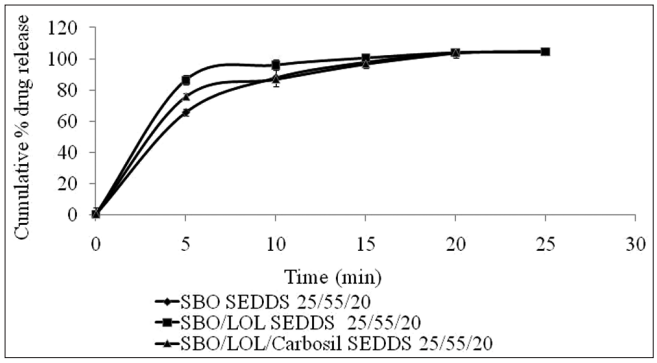

Figure 2: Effect of LOL or LOL-Carbosil® blend on the release of ibuprofen from shea butter oil-based SEOFs containing oil:surfactant:cosurfactant ratio of 25:55:20

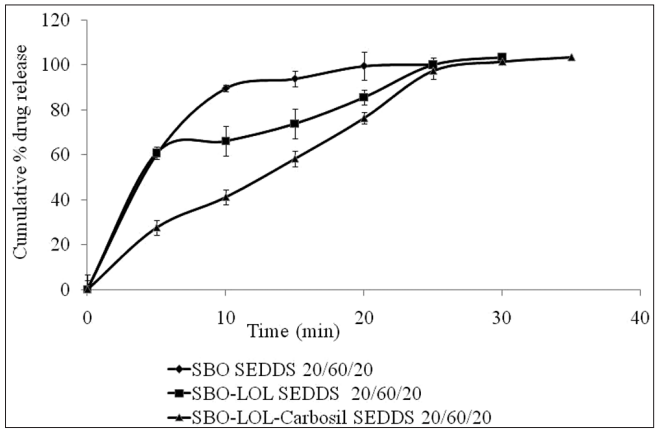

Figure 3: Effect of LOL or LOL-Carbosil® blend on the release of ibuprofen from shea butter oil-based SEOFs containing oil:surfactant:cosurfactant ratio of 20:60:20

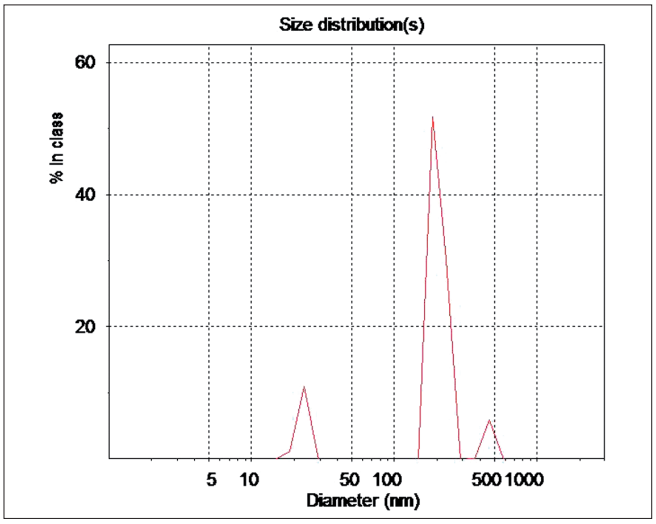

Figure 4: The photon correlation spectroscopic peak analysis result for batch 25:60:15

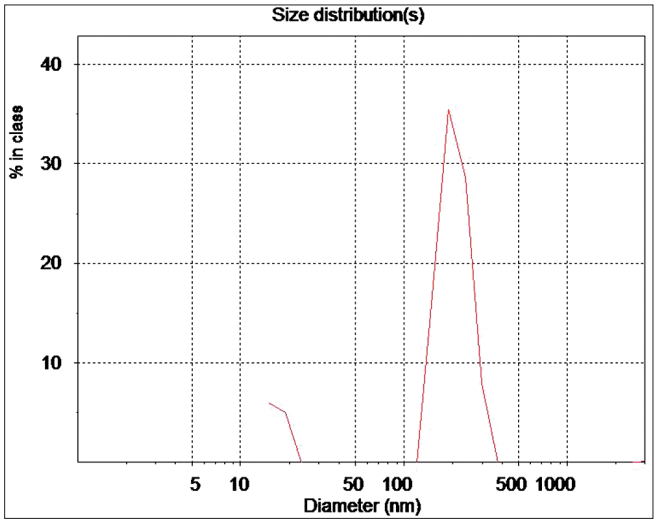

Figure 5: The photon correlation spectroscopic peak analysis result for batch 25:55:20

drug diffusion from droplet matrix or interface after 4 hrs of peroral ingestion and emulsification in the gastrointestinal tract. Oswald ripening which includes increased solubility of smaller droplets and diffusion of drugs into larger droplets may be one of the causes of drug precipitation from conventional emulsions. Its occurrence may jeopardize thermodynamic stability of an SEF formulation and introduce inconsistent bioavailability associated with *in vivo* erratic absorption of lipophilic drugs.[17,18]

The viscosity of SEFs should be relatively high enough to prevent formulation leakage from capsule, which was why some workers incorporated the gelling agent CARB[15] with the purpose of minimizing fluidity and preventing capsule leakage. The flow behavior of the SEFs was generally Newtonian. The 5% w/w concentration of CARB employed in viscosity studies was capable of effectively gelling the SEOFs, however there was no record of dynamic viscosity values, even at increased torque. Gelling of SEOFs with CARB has earlier been carried out by some workers,[15] to prevent leakage and enhance reduction of the quantity of solidifying materials when solidification of SEF is desired. These workers[15] reported that higher CARB concentration produced SEFs with higher viscosities. The constant dynamic viscosity values recorded may be due to the chemical constitution of CARB. It contains silanol (Si-OH) group on its surface which is capable of interacting with nonpolar liquids through H-bond interactions that occur between the OH of the silanol group and other CARB particles; thus forming a three-dimensional gel structure.[15,19] Shearing force provided by the moving cylinder may have broken down this structure, which may be why dynamic viscosity readings were not obtained for CARB-gelled SEFs. As for SEFs containing LOL the cylinder's rotation speed increased with increase in torque. However, it was only in batch A that the dynamic viscosity value of SEF containing LOL was relatively lower than that of SEF. The reverse was the case with batch C, while batches B and D had equal viscosity values. However, there was no significant increase in viscosity due to the incorporation of LOL, meaning that emulsification time and drug release rate may not be elongated.

The release rate of the SEFs (without LOL or LOL-CARB blend) ranked equally in all the batches. The rank of t_{50}/t_{85} duration was approximately in this order SEF<SEF+LOL< SEF+LOL+CARB. Generally the gelling property of CARB may have had a remarkable effect compared to LOL which had a little or no effect on prolonging drug release. On the whole drug release took place in less than 30 min. This agrees with US-FDA guidance for immediate release products, which states that 85% of labeled amount of drug should be released within 30 min of study.[4]

Table 9 shows the EMT result. The higher EMT of CO-based SEFs over SBO SEFs may be due to the existence of high free energy which impeded the rate of emulsification. With respect to SBO formulations the shorter EMT recorded by the LOL and LOL-CARB SEFs, compared to the SEFs, may be because LOL behaved like an emulsifying agent upon contact with the aqueous environment, which lowered the free energy and enhanced the rate of emulsification. Obitte *et al*.[6] had made a similar observation. The presence of CARB, a gelling agent should have elicited longer EMT; however, the apparent emulsifying potential of LOL probably had an overriding effect on this process, hence the similar EMT values [Table 9] of batches 5, 6, 7, 8 and 9. This portends that LOL may be coused with CARB; it functions as an emulsification rate-enhancing agent while CARB still exerts its gelling effect. Viscosity, admixing of oils and free energy of the system have been implicated as some of the factors that affect EMT.[4,20] Generally, the entire formulation batches emulsified in less than 2 min which has been reported to be an evaluation index in the emulsification process.[6,21]

Table 10: Particle size analysis result of SBO SEFs

	Zeta potential	Particle size	Polydispersity index
20:60:20	-6.0	210	0.184
25:60:15	-5.6	207	0.176
25:55:20	-5.8	212	0.259

Table 10 shows the characterization result of some of the stable SBO SEFs. The particles were nanometric and above 100 nm in size, and are therefore referred to as SEDDS according to Bo *et al*.[7] The negative zeta potential is normal with o/w emulsions due to the presence of free fatty acids; although there have been postulations that cationized[13,20] o/w emulsions may adhere better on the mucosal membranes with improved absorption profile and consistent bioavailability.

CONCLUSIONS

The solubility of ibuprofen was improved, CARB was a good gelling agent while LOL increased the emulsification rate of the SEFs. Therefore, LOL may be coemployed as an adjunct with the gelling agent CARB, to reduce the EMT while achieving gellation of SEFs.

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Source of Support: Nil, **Conflict of Interest:** None declared.