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RESEARCH ARTICLE

Immediate release of ibuprofen from Fujicalin®-based fast-dissolving self-emulsifying tablets

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Abstract

Background: Drug release from a solid form of self-emulsifying drug delivery system (SEDDS) has greatly been limited due to strong adsorption and physical interaction with carriers. To facilitate drug release process in the stomach, an acid-soluble powderizing carrier, Fujicalin® was evaluated together with different disintegrants and hydrophilic lubricants.

Method: Immediate-release self-emulsifying tablets (IR-SETs) of ibuprofen (IBU) was prepared with solidified SEDDS of IBU, various disintegrants, and lubricants, and drug release was evaluated to develop IR-SET that can release IBU with a similar IBU release rate to that obtained with liquid SEDDS.

Results: The liquid SEDDS consisted of Capryol 90, Cremophor EL, Labrasol, and IBU at a ratio of 3:4:3:3, and was solidified with various adsorbents. The powderized SEDDS was tabletted by a direct compression. Fujicalin®-based SEDDS tablets demonstrated remarkably higher dissolution rate of IBU compared with Neusilin® and Neosyl®-based SEDDS tablets. The IR-SET formula of IBU prepared with Fujicalin® as an adsorbent, Polyplasdone® as a disintegrant, and sodium bicarbonate as a co-disintegrant showed over 90% of initially loaded dose of IBU released within 5 min in a stimulated gastric juice (pH 1.2), exhibiting almost equivalent rate of IBU release to that shown by liquid SEDDS. The particle size analysis revealed no significant differences in droplet sizes of the microemulsions formed from liquid (116 nm) and IR-SET (110 nm).

Conclusion: The novel IR-SET can be promising as a fast-releasing SEDDS tablet of IBU for fast onset of action.

Keywords: Self-emulsifying drug delivery system, Fujicalin®, ibuprofen, adsorbent, fast emulsifying tablet

Introduction

A number of pharmaceutical approaches have been made to improve the oral bioavailability of hydrophobic drugs via solubilization technologies including self-emulsifying drug delivery system (SEDDS)[1–5]. SEDDS is an isotropic mixture of oil, surfactant, and drug, which could be spontaneously dispersed to produce fine oil-in-water (o/w) emulsion upon mild agitation in the gastrointestinal tract[6]. The drugs can be maintained in a solubilized state by being *incorporated* in an internal phase of the *o/w emulsion*[7,8]. SEDDS formulations are viscous liquids and thus marketed usually in the form of soft gelatin capsules, which have some drawbacks in the manufacturing process such as difficulty in process control, leakage of the encapsulated components, high production cost, and lower stability[9–11].

To address these problems, several attempts have been made to transform liquid SEDDS into solid dosage forms using solid carriers or adsorbents such as silicon dioxide (Sylysia™), calcium silicate (Florite™), and magnesium aluminum silicate (Neusilin®), having large surface area[12–19]. The solid forms of SEDDS are able to offer the advantages of SEDDS in combination with those of solid dosage forms such as production reproducibility and improved stability[20] when they would lead to the formation of fine or microemulsion at a similar rate exhibited by liquid SEDDS.

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Considering the fact that the drug is rapidly dispersed from liquid SEDDS formulations encapsulated in soft gelatin capsules, the solidified SMEDDS should also liberate the drug as fast as possible to obtain a similar rate of onset of drug effects. However, drug release from the solid forms of SEDDS has significantly been retarded and even incomplete due to strong physical interactions with solidifying carriers or adsorbents[14,15,21,22]. For instance, the release of lansoprazole from the silicate-based solid SEDDS was very slow, that is, the time required for *50% drug release* ($T_{50\%}$) was more than 1 h under the paddle speed of 150 rpm[15]. Thus, the ideal adsorbent used to produce solid SEDDS may possess the ability to hold considerable amount of liquid formulation and quickly release the SEDDS to form fine or microemulsions predominantly in the stomach. In this regard, Fujicalin® (Fuji Chemical Industry Co. Ltd., Osaka, Japan) is highly desirable.

Fujicalin® is a granulated dibasic calcium phosphate that possesses fairly large inter- and intravoid volumes (27 m^2/g as measured by BET method) for liquid adsorption[23]. In addition to this, due to its property of being soluble in acidic media such as gastric juice, fast collapse (or disintegration) of Fujicalin®-based SEDDS tablets can be expected, possibly causing the immediate dispersion of SEDDS formulations and thereby prompt release of the incorporated drug, which can be seen from liquid SEDDS[24].

It is the purpose of present study to design the immediate-release tablet dosage form with powdered SEDDS (i.e. immediate-release self-emulsifying tablet, IR-SET) for ibuprofen (IBU) that can replace viscous and liquid SEDDS. IBU was selected as a model drug because it is a poorly water-soluble analgesic agent and requires a fast onset of action for the relief of acute pain[25]. In this work, Fujicalin® was adopted as an adsorbent carrier and compared with other inorganic materials such as Neusilin® and Neosyl® for the ability of SEDDS adsorption and IBU release in a simulated gastric juice (pH 1.2). To facilitate drug release from the SEDDS tablet formulations, the efficient disintegrants were screened. Since hydrophilic lubricants such as sodium lauryl sulfate[26] may be advantageous to initiate a rapid drug release, the influence of hydrophilic and hydrophobic lubricants upon drug release was also investigated.

Materials and methods

Chemicals and reagents

IBU was supplied by Samil Pharm. Co., Ltd. (Seoul, Korea). Labrasol, Labrafac Lipophile WL1349, Labrafil M1944CS, Lauroglycol 90, and Capryol 90 were purchased from Gattefosse (Lyon, France). Cremophor EL and Pluronic L-64 were obtained from BASF Corporation (Ludwigshafen, Germany). Tween 80, Tween 40, triacetin, polyethylene glycol 400 (PEG 400), and sodium bicarbonate ($NaHCO_3$) were supplied by Duksan Chemicals (Cheongju, Korea). Fujicalin® (Fuji Chemical Industry Co. Ltd., Toyama, Japan), Neusilin® UFL2 (Fuji Chemical Industry Co. Ltd.), Neosyl® GP (Akrochem Corp., Akron, OH), Amberlite™ IRP-88 (Rohm & Haas, Philadelphia, PA), Polyplasdone® XL-10 (ISP Corp., Wayne, NJ), Primellose® (Generichem Corp., Totowa, NJ), and Vivastar® (JRS Pharma, Rosenberg, Germany), magnesium stearate (Mg-S), sodium stearylfumarate (Na-SF), and sodium lauryl sulfate (SLS) were kindly supplied by Masung Co., Ltd. (Seoul, Korea). All other chemicals were of reagent or HPLC grade.

Solubility test

An excess amount of IBU (~1 g) was added to a glass vial containing 1 mL of vehicles tested (Table 1). The mixture was vortexed and then kept for 3 days at ambient temperature in a shaking water bath to reach equilibrium. The samples were centrifuged at 12,000 rpm for 10 min to separate undissolved IBU. The supernatant was diluted with methanol to quantify IBU by HPLC.

Pseudo-ternary phase diagram and SEDDS formulation

The pseudo-ternary phase diagram of oil, surfactant/co-surfactant (S/CoS), and water was constructed using water titration method in the presence of drug[27]. A mixture of oil (Capryol 90) and a blend of surfactant (Cremophor EL) and co-surfactant (Labrasol) (fixed S/CoS ratio of 4:3, v/v) were placed in glass vials at ratios of 10:0, 9:1, 8:2, 7:3, 6:4, 5:5, 4:6, 3:7, 2:8, 1:9, and 0:10. Water was added to the mixture by stepwise increment of 5% and the mixture was gently stirred and maintained for 2 h. The resultant mixture was evaluated visually for phase appearance. The transparent phase and milky dispersion were considered as microemulsion and emulsion, respectively[28]. From the pseudo-ternary phase diagram, a self-emulsifying composition consisted of Capryol 90, Cremophor EL, and Labrasol at the ratio of 3:4:3 was developed. Three hundred milligrams of IBU could be dissolved in 1 mL of the self-emulsifying system at 25°C.

Table 1. Solubility of ibuprofen (IBU) in various oils and (co) surfactants.

	Solubility (mg/mL)
Oils	
Lauroglycol 90	239.7 ± 9.1
Triacetin	198.2 ± 15.2
Capryol 90	296.5 ± 18.4
Labrafil M1944CS	169.3 ± 16.2
(Co)Surfactants	
Tween 80	267.6 ± 25.2
Cremophor EL	304.1 ± 10.4
Labrasol	360.3 ± 17.2
Labrafac Lipophile WL1349	230.5 ± 23.5
Pluronic L-64	290.8 ± 18.4
PEG 400	80.5 ± 8.4
Tween 40	50.1 ± 6.6

Data are expressed as mean ± SD ($n = 3$).

Formulation of SETs

The SETs were prepared by three steps including (i) powderization of liquid SMEDDS by adsorbing it to porous solid carriers, (ii) blending of powdered SEDDS with pharmaceutical excipients, and (iii) compression of the tablet mixture. The liquid SEDDS containing 100 mg of IBU (~0.43 mL) was mixed with the solid carriers (Fujicalin®, Neusilin®, or Neosyl®) using mortar and pestle for 10 min. The microscopic structure of the SEDDS-retaining solid carriers was observed by scanning electron microscope (SEM; Hitachi, Tokyo, Japan) to examine whether the liquid SEDDS was effectively held by the carriers tested. The powders were then blended with disintegrants (Amberlite™, Polyplasdone®, Primellose®, or Vivastar®) for 2 min. Sodium bicarbonate was also added to each formulation to aid faster tablet disintegration. Various lubricants (Mg-S, Na-SF, or SLS) were added to the tablet mixtures before direct compression. All compositions of the SETs tested are summarized in Table 2. SETs were prepared by compressing the tablet mixture between flat-faced 13-mm platens under 100 kgf/cm^2 of compaction force. The mechanical strength of the tablets was measured using a manual hardness tester (Yita Seisakusho Ltd., Japan).

In vitro drug release

In vitro dissolution test was performed using USP-24 Type 2 dissolution test apparatus (DST-600A; Fine Scientific Instruments, Korea). Liquid SEDDS and SETs containing 100 mg of IBU were placed in the dissolution vessel filled with 900 mL of simulated gastric juice (pH 1.2), maintained at 37.0 ± 0.5°C and stirred at 50 rpm. For the formulation of F11, the impact of paddle speeds on the drug release was assessed at 25, 50, and 100 rpm, respectively. Aliquots were collected periodically and replaced with fresh and pre-warmed dissolution medium. The samples were centrifuged at 12,000 rpm for 10 min and the supernatants were diluted with methanol for HPLC analysis.

HPLC assay of drug

Levels of IBU were measured by HPLC using a mobile phase composed of acidic aqueous solution (pH 3, adjusted with acetic acid)–acetonitrile (40:60, v/v) set at a flow rate of 1.0 mL/min. The HPLC system consisted of a pump (L-2130), a UV detector (L-2400), and a data station (LaChrom Elite; Hitachi). The column eluant was monitored at 223 nm, and IBU peak was separated on a Capcell Pak C_{18} column (Shiseido, Japan).

Droplet size of microemulsion

After *in vitro* dissolution test of liquid SEDDS or SETs, the medium was withdrawn and were centrifuged at 12,000 rpm for 10 min to remove undissolved components. The particle size of the microemulsion formed from self-emulsifying systems was determined by Zetasizer Nano ZS (Malvern Instruments, UK) at a wavelength of 635 nm and scattering angle of 90° at 25°C.

Results and discussion

Development of SEDDS of IBU

The self-emulsifying formulations should be a monophasic viscous liquid at room temperature and have good solvent properties to load high amounts of poorly water-soluble drugs[29,30]. The solubility values of IBU in various oils and surfactants are presented in Table 1. Among various oils and surfactants, Capryol 90 and Cremophor EL showed fairly good solubilities such as 297 and 304 mg/mL, respectively, and thus, were selected as oil and surfactant, respectively. Labrasol, a medium-chain triglyceride derived from coconut oil, led to the highest solubility (360 mg/mL) and was selected as a co-surfactant. From these results, Capryol 90, Cremophor EL, and Labrasol were finally selected for preparing the SEDDS of IBU.

Pseudo-ternary phase diagram was subsequently constructed to determine their macroscopic phase behaviors and to find out appropriate ratios of oil, surfactant, and co-surfactant in the microemulsion area. As shown in

Table 2. Percent compositions of immediate-release self-emulsifying tablets (IR-SETs).

Codes	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12
SEDDS	52.0	52.0	36.1	36.1	36.1	36.1	34.2	30.4	36.1	36.1	34.2	32.3
Neusilin®	42.5											
Neosyl®		42.5										
Fujicalin®			58.4	58.4	58.4	58.4	55.3	49.1	58.4	58.4	55.3	52.2
Polyplasdone®	5.0	5.0	5.0				10.0	20.0	5.0	5.0	5.0	5.0
Amberlite™				5.0								
Primellose®					5.0							
Vivastar®						5.0						
$NaHCO_3$											5.0	10.0
Mg-S	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5			0.5	0.5
Na-SF									0.5			
SLS										0.5		
Hardness (kp)	5.1 ± 1.6	5.8 ± 0.8	3.2 ± 0.4	3.4 ± 0.3	3.0 ± 0.5	3.3 ± 0.6	3.7 ± 0.3	3.6 ± 0.2	3.0 ± 0.5	3.4 ± 0.4	3.6 ± 0.6	3.4 ± 0.5

Abbreviations: Mg-S, magnesium stearate; Na-SF, sodium stearyl fumarate; SLS, sodium lauryl sulfate; SEDDS, self-emulsifying drug delivery system. Hardness data are expressed as the mean ± SD (n = 3).

Figure 1, the combination of Labrasol, Cremophor EL, and Capryol 90 yielded the broad microemulsion region. In particular, efficiency of the formation of SEDDS was superior when S/CoS concentration was >60% of SEDDS formulation. From this result, the ratio of oil to S/CoS was set to be as 3:7 (Capryol 90/Cremophor EL/Labrasol = 3/4/3) as an optimal SEDDS composition. It was a visually isotropic system after dilution with aqueous media, yielding a transparent dispersion with a mean droplet size of 116 nm (Table 3).

Characteristics of powdered SEDDS and SETs

The alteration of viscous SEDDS of IBU into free-flowing powder form was initially required to ultimately prepare the tablet dosage form. Inert solid carriers such as Neusilin®, Neosyl®, and Fujicalin® were tested for SEDDS adsorption since porous structures could provide large surface area for SEDDS loading. The specific surface areas of these adsorbents were reported as 110 m^2/g for Neusilin® UFL2, 200 m^2/g for Neosyl® GP, and 27 m^2/g for Fujicalin®, respectively[13,14,23]. Relatively greater amount of Fujicalin® was required to powderize liquid SEDDS compared with Neusilin® or Neosyl® due to its lower porosity (Table 2).

The SEM images of intact Fujicalin® and Neusilin® showed that the particle size of both excipients were approximately 30–100 μm and rather rough and smooth textures were observed for Fujicalin® and Neusilin®, respectively (Figure 2A and 2B). After the adsorption of liquid SEDDS, the obvious changes in the appearance of two solid carriers could be identified (Figure 2C and 2D). The surface of both solid carriers being seen as white were covered with liquid SEDDS and similar texture was previously reported elsewhere[31]. From the SEM observation, we could confirm that liquid SEDDS was effectively retained in the micropores as well as surface of the porous carriers.

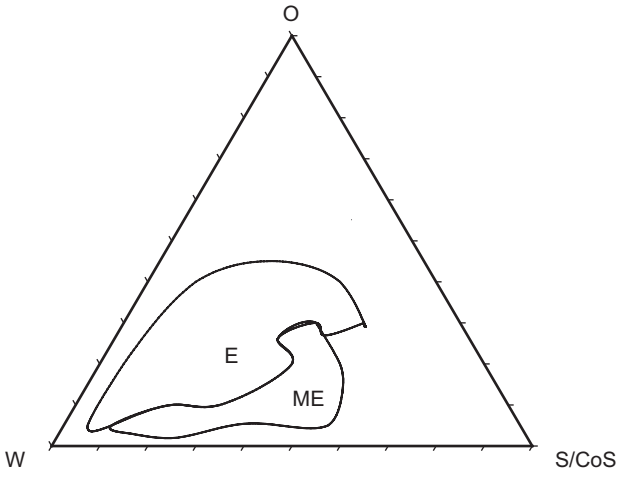

Figure 1. Pseudo-ternary phase diagram composed of oil (O), Capryol 90; surfactant (S), Cremophor EL; and co-surfactant (CoS), Labrasol. S/CoS ratio is 4:3. ME and E indicate microemulsion and emulsion area, respectively.

The powdered SEDDS was then tablettized with various disintegrants and lubricants as listed in Table 2. The sizes of the SETs were 13 mm in diameter and 5 ± 0.2 mm in height. The hardness of the tablets was measured in the range of 3–7 kp (Table 2).

In vitro drug release

In vitro drug release profiles of SETs were examined to investigate the effect of solid carriers, disintegrants, and lubricants on the release behaviors of IBU from SETs. Since the purpose of this work was to design SETs with powdered SEDDS that can release IBU at rates similar to that of liquid SEDDS, the drug release study was focused on the identification of efficient adsorbent, disintegrant, and lubricant.

Influence of adsorbents

The release profiles of IBU from Neusilin®-, Neosyl®-, and Fujicalin®-based SETs (F1, F2, and F3) were compared with that obtained with liquid SEDDS (Figure 3). IBU was completely released from liquid SEDDS for 3 min in simulated gastric juice (pH 1.2). The energy required to form an o/w emulsion from SEDDS is known to be very low[7,8] and thus, the rotational force of a paddle could lead to spontaneous formation of fine oil droplets in the release medium. On the contrary, the IBU release from F1 (Neusilin®) and F2 (Neosyl®) was noticeably retarded and only about 40% of IBU was released for 1 h. The retarded release observed may be attributed to strong adsorption of SEDDS components. In fact, the hinderance of the release of a drug adsorbed onto silicone dioxide such as Neosyl® has already been reported[32]. For instance, the release of heparin loaded onto the silicone dioxide-based solid SEDDS was greatly retarded to the degree that >1.5 h was taken for complete drug release under the paddle speed of 150 rpm. Similarly, due to the strong adsorption ability of Neusilin®[13], Neusilin®-based solid SEDDS demonstrated the delayed release of cyclosporin being ~25% after 6 h under a rotation speed of 100 rpm[22]. However, F3 formulation employing Fujicalin® as a solid

Table 3. Droplet sizes of microemulsions formed from liquid and solid self-emulsifying drug delivery system (SEDDS).

Codes	Size (nm)	Polydispersity index
Liquid SEDDS	115.8 ± 6.2	0.103
F1	105.6 ± 3.2	0.160
F2	98.5 ± 7.2	0.157
F3	100.2 ± 9.5	0.079
F4	95.9 ± 6.3	0.205
F5	102.4 ± 4.1	0.227
F6	97.0 ± 4.6	0.151
F7	104.4 ± 3.9	0.212
F8	110.0 ± 9.2	0.225
F9	126.2 ± 6.6	0.209
F10	107.5 ± 4.7	0.179
F11	109.6 ± 6.4	0.165
F12	113.9 ± 8.5	0.120

Data are expressed as mean ± SD ($n = 3$).

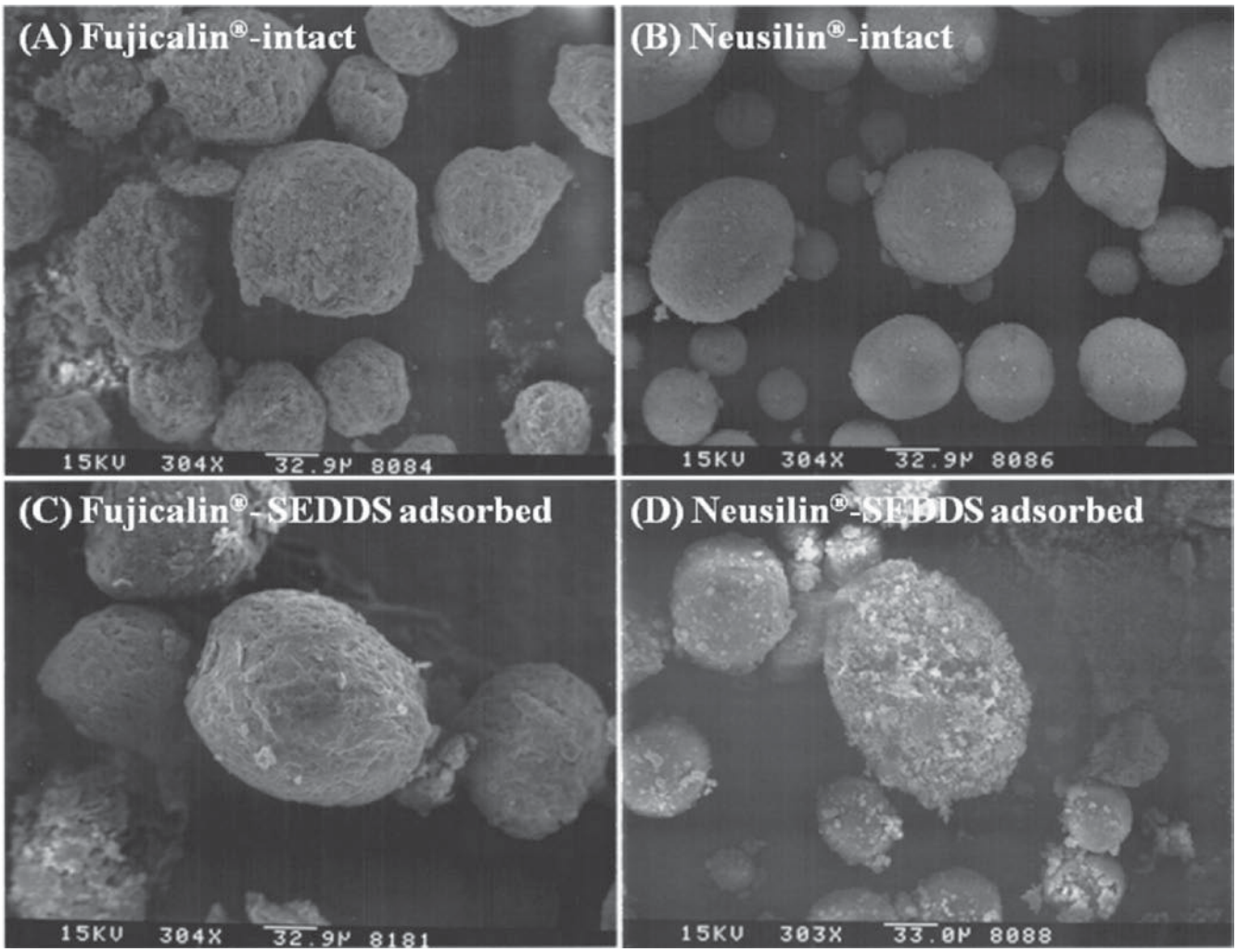

Figure 2. Scanning electron micrographs (300×) of Fujicalin® and Neusilin® before and after self-emulsifying drug delivery system (SEDDS) adsorption.

carrier demonstrated remarkably higher dissolution rate of IBU compared with F1 and F2 probably due to a soluble characteristics of Fujicalin® in acidic dissolution medium, leading to efficient escape of SEDDS components from the adsorbent[33]. Indeed, the F3 tablets were rapidly disintegrated within 5 min in the release medium (pH 1.2) and over 90% of IBU was released for 15 min. A fast-dissolving solid carrier in gastric juice, Fujicalin®, was therefore adopted as a primary solid carrier to formulate IR-SET for further studies.

Further enhancement of the dissolution of the drug was required and an investigation into the effect of super-disintegrants and lubricants on the drug release was performed as the IBU release from F3 formulation was still slower than that obtained with liquid SEDDS (Figure 3).

Influence of disintegrants

The release profiles of IBU from Fujicalin®-based SETs containing different kinds of disintegrants were shown in Figure 4. The IBU release from the SETs containing super-disintegrants such as Polyplasdone® (F3), Primellose® (F4), and Vivastar® (F5) caused a faster initial release compared with that containing Amberlite™ (F6). In particular, among the super-disintegrants tested, Polyplasdone® (F3) demonstrated the fastest IBU release, resulting in 5–10% more IBU dissolution compared with F4 and F5 during the initial 10 min. The reason for this might partly be in line with earlier report that the rate and extent of water uptake and swelling of Polyplasdone® can be maintained in an acidic medium (0.1 N HCl) but those of croscarmellose sodium (Primellose®) and sodium starch glycolate (Vivastar®) were significantly reduced[33]. Moreover, the disintegrating ability of Primellose® and Vivastar® was found to even be decreased in acidic condition[34]. The increasing Polyplasdone® levels from 5% to 20% in the SETs (F3, F7, and F8) did not further accelerate the drug release (Figure 5). Although it was confirmed that Polyplasdone® was fairly effective in increasing IBU release from Fujicalin®-based SETs in an acidic condition, the drug release should be further improved up to the degree that was achieved by liquid SSEDDS.

Influence of lubricants

Na-SF (F9) and SLS (F10) are known as hydrophilic lubricants compared with Mg-S generally used in the tablet formulation[35,36]. Thus, it was expected that the use of these lubricants can further increase the drug release from the SETs by decreasing the time required for tablet wetting. However, no considerable differences in the release of IBU were found between the formulations. One explanation for this effect may be the low amount of the lubricants at 0.5%, w/w of total formulation, observed to be appropriate for tabletting (Figure 5).

Influence of sodium bicarbonate

Sodium bicarbonate was additionally included to F3 formulation to facilitate tablet disintegration by effervescent effect (Figure 6), which may lead to the enhancement of IBU dissolution. Both F11 and F12 SETs were more rapidly disintegrated, compared with F3, possibly by carbon dioxide produced from interaction of sodium bicarbonate with an acidic media[37]. Due to the synergistic disintegration effect of sodium bicarbonate and Polyplasdone®, >90% of initially loaded dose of IBU was released from the SETs of F11 and F12 for 5 min, exhibiting almost equivalent rate of IBU release to that shown by liquid SEDDS.

Influence of paddle speed

Drug release profiles from the optimized IR-SET (F11) were examined under various paddle speeds and are depicted in Figure 7. The release rate of IBU increased with increasing stirring rate and over 95% of IBU was released from F11 for 3 min at 100 rpm and this rate of IBU release was nearly equivalent to that shown by liquid SEDDS. Even, at the lowest paddle speed (25 rpm) tested, around 80% of the drug incorporated in IR-SETs was released in the medium for 10 min, indicating that F11 could effectively liberate the drug even in mild agitation conditions.

With the drug release results obtained above, it was considered that the IR-the F11 formulation can be a solid dosage form of self-emulsifying system of IBU with the ability to release the drug at a similar rate to that obtained from liquid SEDDS.

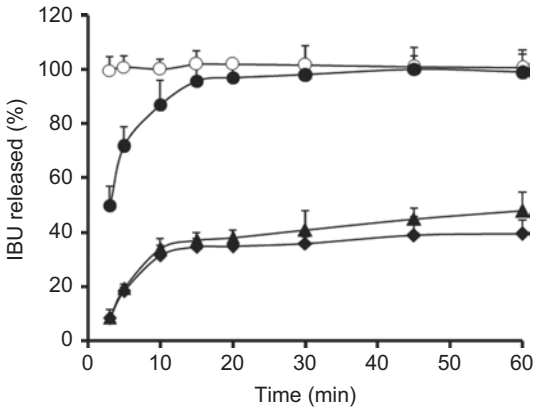

Figure 3. Release profiles of ibuprofen (IBU) from liquid self-emulsifying drug delivery system (SEDDS) (○), Neusilin®-based self-emulsifying tablet (SET) (F1, ▲), Neosyl®-based SET (F2, ◆), and Fujicalin®-based SET (F3, ●) in simulated gastric juice. Data are expressed as mean ± SD (n = 3).

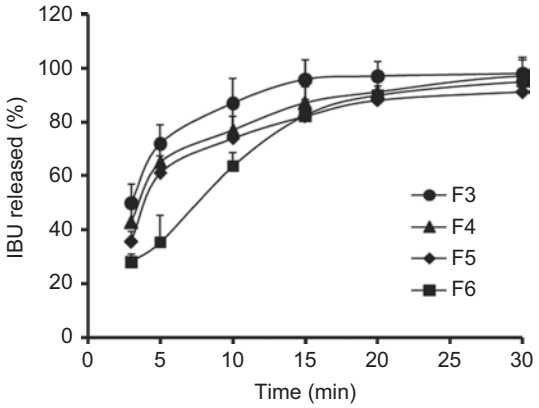

Figure 4. Effect of various super-disintegrants on the release characteristics of ibuprofen (IBU) from Fujicalin®-based self-emulsifying tablet (SET) in simulated gastric juice. Data are expressed as mean ± SD (n = 3).

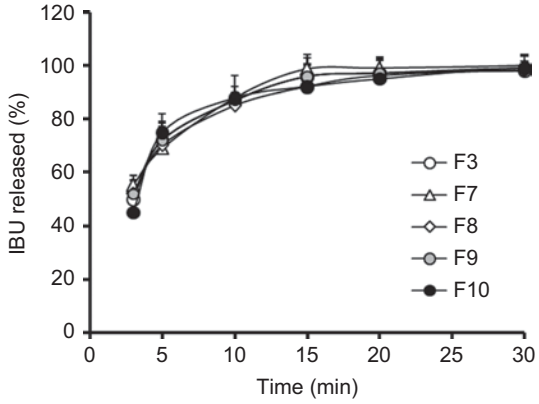

Figure 5. Effect of Polyplasdon® levels and lubricants on the release characteristics of ibuprofen (IBU) from Fujicalin®-based self-emulsifying tablets (SETs) in simulated gastric juice. Data are expressed as mean ± SD (n = 3).

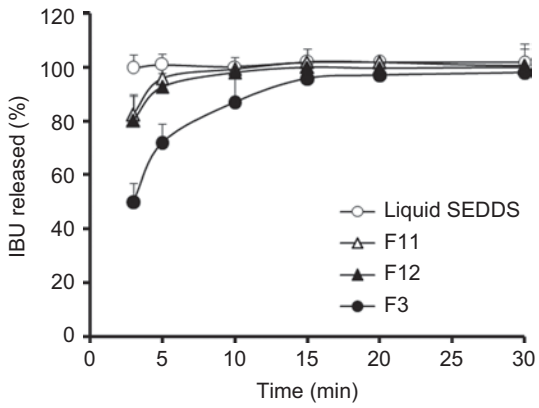

Figure 6. Effect of sodium bicarbonate as a co-disintegrant on the release characteristics of ibuprofen (IBU) from Fujicalin®-based self-emulsifying tablets (SETs) in simulated gastric juice. Data are expressed as mean ± SD (n = 3).

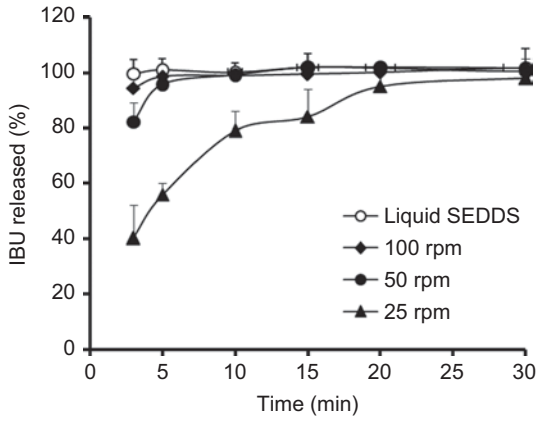

Figure 7. Effect of stirring rate on the release characteristics of ibuprofen (IBU) from self-emulsifying tablet (SET) formulation of F11 in simulated gastric juice. Data are expressed as mean ± SD (n=3).

Droplet size of microemulsion

The average diameters and polydispersity indices of the microemulsion droplets formed from liquid SEDDS and SETs are presented in Table 3. The droplet sizes of the microemulsions formed from liquid SEDDS and IR-SET (F11) were 115.8 and 109.6 nm, respectively, with narrow size distributions. The droplet sizes of both formulations were not significantly different and this may result in a comparable rate and extent of drug absorption, which will be examined in future studies[8].

Conclusion

In our study, novel IR-SET of IBU were successfully prepared based on the powderization of liquid SEDDS with Fujicalin®, soluble in a gastric juice. The optimized IR-SET (F11) demonstrated a similar rate of IBU release to that observed with liquid SEDDS and was consisted of liquid SEDDS of IBU, Fujicalin®, Polyplasdone®, sodium bicarbonate, and Mg-S at the weight ratio of 34.2:55.3:5:5:0.5. The Fujicalin®-based IR-SET showed the remarkably higher dissolution rate of IBU in an acidic media (pH 1.2) and over 90% of initially loaded IBU was released for 5 min. Such rapid release may be attributed to a combined effect of acid-soluble Fujicalin® and enhanced tablet disintegration exhibited by Polyplasdone® and sodium bicarbonate. The average droplet size of the microemulsion formed from IR-SET (F11) was measured to be 109.6 nm. On the basis of these results, it was suggested that IR-SET formulation of F11 can be promising as a fast-releasing SEDDS tablet of IBU with practical expectation for rapid pharmacological actions.

Declaration of interest

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