Preparation of Water-in-oil Microemulsion-based Lacquer Wax Isopropyl Ester and its UVA and UVB Protection Characteristics

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Lacquer wax represents a significant resource derived from the berries of *Toxicodendron vernicifluum* in China. The main chemical component of lacquer wax is fatty acid. The fatty acid isopropyl ester prepared from this acid has played a role in enhancing skin penetration and spreading properties, which makes it suitable for use as an important material in washing, cosmetics, and pharmaceuticals. In this study, the isopropyl ester of lacquer wax was synthesized by lipase-catalyzed transesterification for the first time ever. In addition, microemulsion of lacquer wax-based isopropyl ester (LW-IPE) was prepared by adding surfactant, co-surfactant, and water to solve the flocculation phenomenon of LW-IPE. The microemulsion was characterized by its stability, conductivity, viscosity, and particle size, which confirmed the formula of water-in-oil (W/O) microemulsion. The W/O microemulsion demonstrated an excellent thermodynamic stability in the temperature range between 20 °C and 40 °C and was stabilized with the addition of NaCl. *In vitro* evaluation of protection against ultraviolet light (UVA and UVB) demonstrated that arbutin in W/O microemulsion is capable to protect against UVA. This study is believed as providing valuable information on the performance of microemulsion systems suitable for use in the cosmetics and pharmaceuticals industries.

Keywords: Isopropyl ester; Lacquer wax; Microemulsion; Stability; UVA protection

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INTRODUCTION

Lacquer wax is known as a significant resource derived from the berries of mesocarp of *Toxicodendron vernicifluum* (Chen *et al.* 2014), containing hexadecanoic acid, oleinic acid, and octadecanoic acid. Lacquer wax is elastic in nature and flexible in performance, and it has a wide range of applications in food and chemical sciences as well as pharmaceutical and medical industries (Lamberton 1961). Due to the desirable moisture retention capability, lacquer wax has been applied in the making of high-end cosmetics as well (Lamberton 1961). In Southwest China, lacquer wax has been viewed as a source of food in local Lisu people's edible oil for thousands of years and has shown its unique medicinal value (Long *et al.* 2003).

Some studies have been performed to improve the utilization rate of lacquer wax. Chen *et al.* (2015) used lacquer wax to prepare high content solid lacquer wax emulsions

modified by polyacrylic acid, which can be used for coatings, textiles, and agricultural water retention. Li *et al.* (2017) treated lotus pods with 0.5 µL/L of 1-methylcyclopropene (1-MCP) and 3% lacquer wax to reduce browning and delay the post-harvest senescence of fresh lotus pods and seeds. Hu *et al.* (2019) demonstrated that 2% lacquer wax could produce the same effect as 3% chitosan in delaying kiwifruit senescence and suggested that a lacquer wax coating is effective in extending the post-harvest life of kiwifruit. However, there remains little information so far about the preparation of microemulsions using lacquer wax-based isopropyl ester (LW-IPE).

The LW-IPE contains various fatty acid isopropyl esters, such as isopropyl palmitate and isopropyl oleate. The fatty acid isopropyl esters form a low-viscosity lipophilic non-ionic surfactant with a large dispersion coefficient, antistatic property, stability; it is also odorless and non-toxic. In this study, the lipase-catalyzed esterification was performed to synthesize LW-IPE and this green chemistry procedure avoided the drawbacks of chemical methods (Bu *et al.* 2010). With skin penetration enhancement function and excellent spreading properties, the isopropyl fatty acid is taken as a microemulsion on a frequent basis to deliver drugs (Liu *et al.* 2015).

Microemulsion is a system consisting of water, oil, and an amphiphile, which forms a single optically isotropic, thermodynamically stable liquid solution with a droplet diameter of 100 nm (Kreuter 1994; McClements 2012). There are three types of microemulsions: oil in water (O/W), water in oil (W/O), and bicontinuous (BC) (Mehta and Bala 2000), and these structural changes can be conducive to the preferential release of the drug (Lawrence and Rees 2000). As the formation of nanoemulsions requires input energy (Meleson *et al.* 2004), microemulsion can be prepared without high mechanical stresses (Nakabayashi *et al.* 2011). Microemulsions have been proposed as the carrier of pharmaceuticals to achieve a controlled release of a particular drug, due to its long-term stability, excellent biocompatibility, spontaneous formation, and remarkable capability of solubilization. The microemulsion method is capable to address the problem of flocculation in LW-IPE by enhancing its stability.

Studies show that long wavelength UVA (ultraviolet type A; 320 to 400 nm) and medium-wave UVB (ultraviolet type B; 280 to 320 nm) can impinge on our body, which can induce erythema of the skin, blackening, wrinkles, and aging of skin, and even carcinogenesis (Gęgotek *et al*. 2018). Most of the UV absorbers have chromophoric groups that can strongly and selectively absorb ultraviolet light and convert ultraviolet energy into other forms of energy, thus playing an anti-ultraviolet role. Unsaturated fatty acid is a kind of natural UV absorbers, and the conjugated double bonds involved in unsaturated fatty acids play main role in uvioresistant action (Liu *et al*. 2008). Lacquer wax consists mainly of fatty acids, mainly including oleic acid, linoleic acid, and palmitic acid, also including small amounts of arachidonic acid, hexadecanedioic acid, docosanedioic acid, and eicosanebioic acid. Studies have shown lacquer wax to have good anti-ultraviolet effects, which probably can be attributed to the unsaturated fatty acids and a small amount of binary fatty acids in lacquer wax that are responsible for the UV light absorbance (Dong 2011). Liu *et al*. (2017) studied the anti-UV activity of fatty acids in tea oil. After 200 to 400 nm ultraviolet irradiation of 30 to 60 min, the absorbance value of fatty acids in tea oil was at a high level, which showed that the double bond or conjugated double bond had good effects on UV radiation prevention (Liu *et al.* 2017). Chen *et al.* (2002) prepared fatty acid based nanowires which showed good UV absorption ability and could be used in cosmetics to resist ultraviolet radiation (Chen *et al.* 2002).

As indicated by the recent cosmetics market, people are quite conscious of the

accompanying dangers like actinic changes, development of premalignancy (solar keratosis), and skin cancer due to excessive exposure to ultraviolet (UV) radiation (Gaspar and Campos 2003). Therefore, the microemulsion of LW-IPE is necessary to produce a sunscreen effect, thus satisfying the demand of the cosmetics market. The objective of this study is to develop a new W/O microemulsion of LW-IPE for use in the cosmetics industry as a delivery system for UV radiation protection.

EXPERIMENTAL

Material and Methods

Materials

The lacquer wax was sourced from the institute of Chemical Industry of Forest Products (CFA, Nanjing, China). Novozymes 435 lipase was purchased from Novozymes Biotechnology Co. Ltd. (Tianjin, China). Ethanol, sorbitan monooleate (Span80), polyoxyethylene sorbitan monooleate (Tween80), and isopropanol were purchased from Sinopharm Chemical Reagent Co. Ltd. (Shanghai, China).

Synthesis of LW-IPE

The lipase (10 g/L), isopropanol (400 mL), and the lacquer wax (100 g) were mixed in a conical flask with a cover. The mixture was stirred in a water bath shaker at the temperature of 55 ℃ for 36 h. The catalyst was removed by filtration, and the product was washed with hot deionized water until it reached the specified pH levels ranging from 6.0 to 7.0. The solvent in the crude product was removed at 65 ℃ using a rotary evaporator.

Phase behavior of microemulsions

The pseudoternary phase diagram of water, LW-IPE, and surfactant (S)/cosurfactant (CS) three-component system was drawn by titrating of water into a mixture of S, CS, and LW-IPE. In the phase diagram, the microemulsion region was defined as the transparent area as observed. The S used in this study was a mixture of the Span80 and Tween80, and the CS was ethanol. The ratios of S/CS were 2:1, 3:1, and 4:1, respectively. The ratios of S/CS to LW-IPE were: 9:1, 8:2, 7:3, 6:4, 5:5, 4:6, 3:7, 2:8, and 1:9, respectively. After vigorous stirring and complete equilibration, the aqueous phase was dropwise added in the mixture of S, CS, and IPE until the transparent and homogeneous phases became turbid. The points at which turbidity firstly appeared between regions of transparent and translucent phases were considered to be the boundary points. Phase diagrams were obtained at 25 ℃.

Conductivity of microemulsions

Conductivity was measured at 25 ℃ using a DDSJ-318 conductivity meter (INESA and Scientific Instrument Co. Ltd., Shanghai, China). The conductivity measurements were performed at the time of titrating water into the isopropyl ester and S/CS mixtures. The electrical conductivity of the microemulsion system was expressed as a function of water content. The ratio of oil (IPM) in the mixture of oil and S/CS were 3:7, 4:6, 5:5, 6:4, and 7:3, respectively.

Viscosity of W/O microemulsions

The viscosities of microemulsions were measured with the assistance of a

rheometer (Thermo Fisher Scientific with HAAKE RheoWin 4.30.0004, Karlsruhe, Germany) at 25 ℃ using a 4 cm cone and plate. The viscosities of the microemulsion samples with water content ranging from 0% to 16% were performed with an increasing rate from 0 s^{-1} to 400 s^{-1}.

Particle size distributions of W/O microemulsion

The particle diameter and polydispersity index (PDI) of the W/O microemulsion samples were measured using a dynamic light scattering analyzer (Nano-ZS90, Malvern Instruments Ltd., Malvern, UK) at 25 ℃.

Stability of microemulsions

The centrifugation method at 3500 rpm for 20 minutes and 10000 rpm for 10 min was employed to evaluate the studied microemulsions for stability.

Effects of temperature and NaCl concentration on the area and formation of microemulsions

The effects of environmental factors (temperature and concentration of NaCl) on the phase diagrams were determined. The effect of temperature on microemulsion area was assessed at 20, 30, and 40 ℃, respectively. The effect of NaCl with the concentrations of 0.1, 0.2, or 0.3 mol/L on the formation of microemulsions was determined at 25 ℃.

UV protection characteristics by Ultraviolet spectrometry

The microemulsions were diluted 10 times, 50 times, and 100 times, respectively. Then the absorbance of the sample at a certain ultraviolet wavelength was measured with the assistance of an ultraviolet spectrophotometer (Mapada, Shanghai, China).

The calculation of in vitro sun protection factor (SPF)

The most common *in vitro* technique involves the measurement of the spectral transmittance at UV wavelengths from 280 to 400 nm (Springsteen *et al.* 1999). The *in vitro* SPF is calculated using Eq. 1 as follows (Diffey and Robson 1989),

$$\mathrm{SPF} \frac{\int_{280nm}^{400\mathrm{nm}} E_\lambda S_\lambda d\lambda}{\int_{280\mathrm{nm}}^{400\mathrm{nm}} E_\lambda S_\lambda \mathrm{T}_\lambda d\lambda} \quad (1)$$

where E_λ indicates the CIE (International Commission on Illumination) erythema spectral effectiveness, S_λ denotes the solar spectral irradiance, and T_λ represents the spectral transmittance of the sample. The two standardized functions, E_λ and S_λ are illustrated in Table 1.

The Boot's star system

The Boot's Chemist has developed a label system that uses a four star rating based on spectrophotometric analysis (Diffey and Robson 1989). The spectral transmittance values, T_I, are converted to spectral absorbance values using $A_\mathrm{I} = -\log(T_\mathrm{I})$. A term known as the "UVA ratio" was calculated, which is the ratio of the total absorption in the UVA to that in the UVB, as shown in Eq. 2. The method specifically requires the A_I data to be measured in 5 nm increments and the integrals to be solved applying Simpson's rule for area approximation.

Table 1. Solar Spectral Irradiance and Action Spectrum for Erythema in Human Skin Used to Calculate Sun Protection Factors (Springsteen *et al.* 1999)

Wavelength (nm)	Solar Spectral Irradiance (S_λ)	CIE Erythema Spectral Effectiveness (E_λ)
290	3.68×10^{-6}	1.0
295	7.97×10^{-4}	1.0
300	1.28×10^{-2}	0.65
305	6.51×10^{-2}	0.22
310	0.171	7.4×10^{-2}
315	0.295	2.5×10^{-2}
320	0.398	8.6×10^{-3}
325	0.536	2.9×10^{-3}
330	0.63	1.4×10^{-3}
335	0.65	1.2×10^{-3}
340	0.68	9.7×10^{-4}
345	0.69	8.1×10^{-4}
350	0.7	6.8×10^{-4}
355	0.71	5.7×10^{-4}
360	0.73	4.8×10^{-4}
365	0.75	4.0×10^{-4}
370	0.78	3.4×10^{-4}
375	0.8	2.9×10^{-4}
380	0.83	2.4×10^{-4}
385	0.86	2.0×10^{-4}
390	0.9	1.7×10^{-4}
395	0.93	1.4×10^{-4}
400	0.97	1.2×10^{-4}

The star rating, and its associated claim for UVA protection, are determined on the basis of the measured UVA ratio.

$$\frac{\alpha\mathrm{UVA}}{\alpha\mathrm{UVB}} = \frac{\int_{320nm}^{400nm} A_\lambda d\lambda}{\int_{290nm}^{320nm} A_\lambda d\lambda} \quad (2)$$

Table 2. Boot's Star Rating System

UVA Ratio	Star Category	Category Descriptor
0.0 to <0.2	—	Too low for UVA claim
0.2 to <0.4	*	Moderate
0.4 to <0.6	**	Good
0.6 to <0.8	***	Superior
0.8 to ≥0.8	****	Maximum

Critical wavelength method

The method proposed here is to determine that the wavelength λ_C, where the area under the absorption spectrum from 290 nm (the approximate lower wavelength limit of terrestrial sunlight) to λ_C is 90% of the integral of the absorption spectrum from 290 nm to 400 nm, that is, $\int_{290}^{\lambda_c} A_\lambda d\lambda = \int_{290}^{400} A_\lambda d\lambda$ where A_λ indicates the absorbance of the product at wavelength λ nm. If the value of λ_C ranges between 340 nm to 370 nm, the sample is

considered to have a certain UVA and UVB protection effect. If the value of λ_C exceeds 370 nm, the sample is considered to have a broad spectrum sunscreen effect.

RESULTS AND DISCUSSION

The Physicochemical Properties and the Composition of LW-IPE

The composition and physicochemical properties of LW-IPE are indicated in Table 3. The LW-IPE is a mixture of various fatty acid isopropyl esters, of which the content of isopropyl palmitate is the highest, followed by isopropyl oleate, isopropyl stearate, and isopropyl linoleate. The physicochemical properties such as acid value, viscosity, and refractive index are significant to the potential application in cosmetics (Chen *et al.* 2015). The acid value can reflect the yield of LW-IPE obtained from the lipase-catalyst esterification reaction. In this study, the LW-IPE yield reached 86.7%. The refractive index of water was 1.0, and the refractive index of LW-IPE was 1.441 (at 25 °C) (Qiu 1997). Using this difference opens up the possibility to improve the brightness and the permeability appearance based on the emulsion system. Viscosity is the direct factor affecting the ductility of the emulsion, which makes the LW-IPE with low viscosity (13.2 MPa·s) effective in moisturizing the skin and keeping it smooth. In conclusion, the LW-IPE is a prospective exclusive cosmetic additive.

Table 3. Physicochemical Properties and Composition of LW-IPE

Physical and Chemical Property	Acid Value (mg/g)	Refractive Index	Viscosity (MPa·s)	Isopropyl Palmitate (%)	Isopropyl Linoleate (%)	Isopropyl Oleate (%)	Isopropyl Stearate (%)
LW-IPE	3.25	1.441	13.2	73.64	0.82	19.39	6.15

Formation of Microemulsions

Effects of surfactant and cosurfactant on the phase diagram

Normally, the CS used is an alcohol of medium carbon-chain length, such as ethanol, isopropanol, or 1,2-propanediol. The 1,2-propanediol has been commonly used for producing food, cosmetics, and medical care products due to its lower toxicity. However, 1,2- propanediol is susceptible to the formation of hydrogen bonds with Tween and aqueous solution, resulting in a microemulsion system with large viscosity. Therefore, 1,2-propanediol as the CS was less than satisfactory for microemulsion system, but it can be used to form the gel.

Comparing the area of pseudoternary phase diagrams (Fig. 1a), the area of isopropanol was discovered to be larger that of ethanol. Nevertheless, ethanol was selected as the CS due to its lower toxicity relative to isopropanol and is food approved. The ratio of surfactant (Kim *et al.* 2009) to co-surfactant could have a significant impact on the formation of microemulsion.

The area formed by different ratio of S:CS is illustrated in Fig. 1b. The ratio of the surfactant to cosurfactant (S:CS) can exert a substantial effect on the formation of microemulsion. The microemulsion area at S:CS of 2:1 was found larger than others. Therefore, the ratio of 2:1 was taken as one of the optimum conditions.

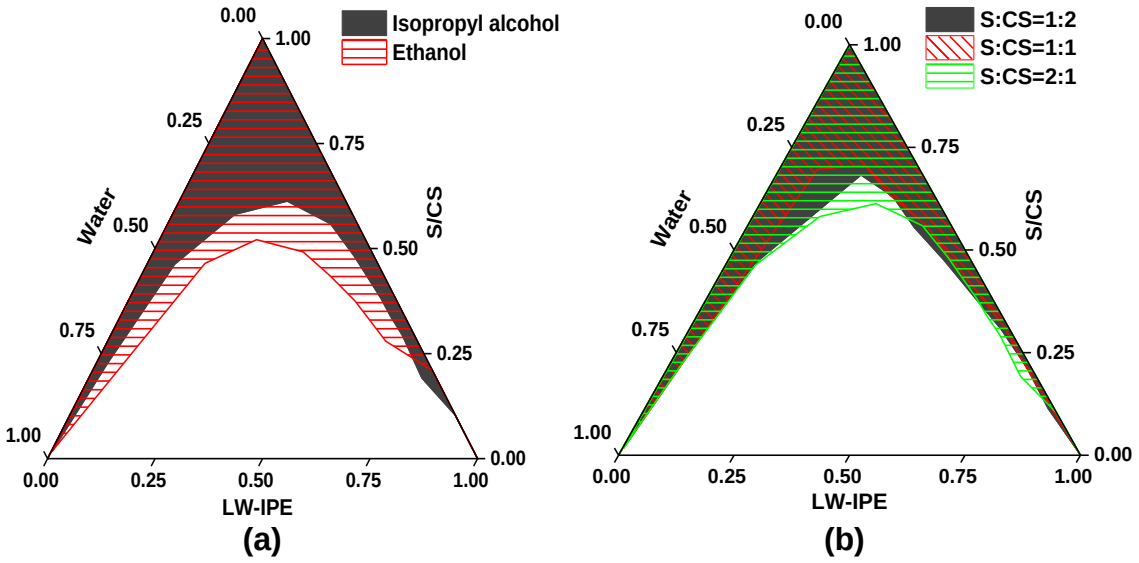

Fig. 1. Pseudoternary phase diagrams of LW-IPE microemulsion system: (a) Isopropyl alcohol and ethyl alcohol as CS of microemulsion system, respectively; and (b) Effect of the ratio of S to CS on the microemulsion system

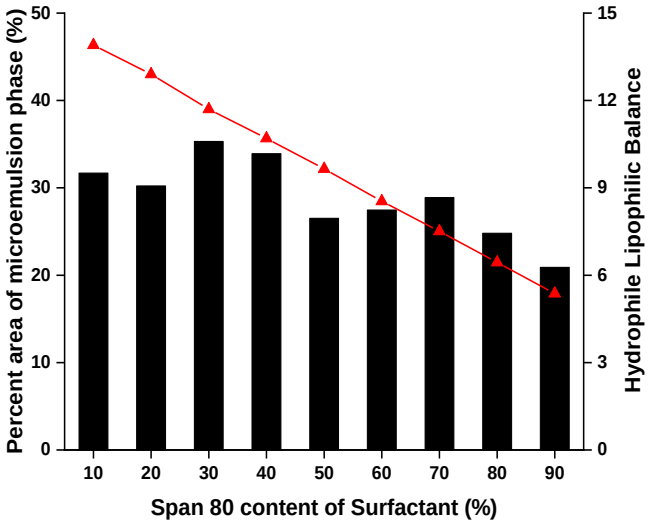

Fig. 2. Effect of Span80 content to the microemulsion area (%)

The optimum microemulsion formulations were determined by conducting evaluation of the microemulsion areas in the pseudoternary phase diagrams. Surfactants could play the role as permeability enhancer because of the tight junction caused by the interaction between surfactant head groups and lipid bilayers. In some cases, they may even have the capability to modify the hydrogen bonding and cause change to ionic forces. Tween80 and Span80 are nonionic surfactants used in many pharmaceutical formulations (Gurpreet and Mehta 2017), and they could be mixed to derive different value surfactants. In general, they are regarded as non-toxic and non-irritant materials. The percent microemulsion area reached the maximum when 30% Span80 was present in the surfactant. The hydrophile lipophilic balance (HLB) of Span80 is lower as compared to Tween80, and the lower HLB values tend to form W/O microemulsions. Thus, 70% Span80 was taken as

the mixture surfactant, which possessed the larger percent area, when percentage of Span80 ranged from 60% to 90%. The Span80:Tween80 = 3:7 and Span80:Tween80 = 7:3 combinations were selected as mixed surfactants for this study.

Conductivity Analysis of Microemulsions

Conductance is considered as a common method to identify and differentiate between the W/O, BC, and O/W regions during the formation of microemulsions. Figure 3 indicates that the conductivities of the LW-IPE microemulsion system for LW-IPE to S/CS ratios of 3:7 to 7:3 were on the increase with the rise of water mass fraction. The increasing level of conductivity is speculated to result from the formation of positively and negatively charged micelles from inter-micellar collisions. As indicated by the low conductance for the ratio of 3:7 to 7:3 systems at low water content, the water was in the dispersed phase of non-conducting oil. In Fig. 3a, conductivities of the microemulsions with ratio of LW-IPE to S/CS increased rapidly when the water mass fraction was in excess of 10%, suggesting the formation of water and oil in a bicontinuous phase. In Fig. 3b, the conductivities were lower than that in Fig. 3a, as the water content was on the rise. When LW-IPE to S/CS ratio was increased from 5:5 to 7:3, the conductivity changes appeared to peak, indicating that only W/O microemulsions were formed with the increase of water content from 0% to 10%. In Fig. 3b systems, no significant difference in conductance was found, and the water mass fraction was discovered to be higher than others at the ratio for LW-IPE to S/CS of 5:5. Therefore the ratio of LW-IPE to S/CS 5:5 was selected for further study. In Fig. 3a, the ratio of LW-IPE to S/CS 5:5 of Span80:Tween80 - 3:7 system was compared with the Span80:Tween80 - 7:3 system (Fig. 3b).

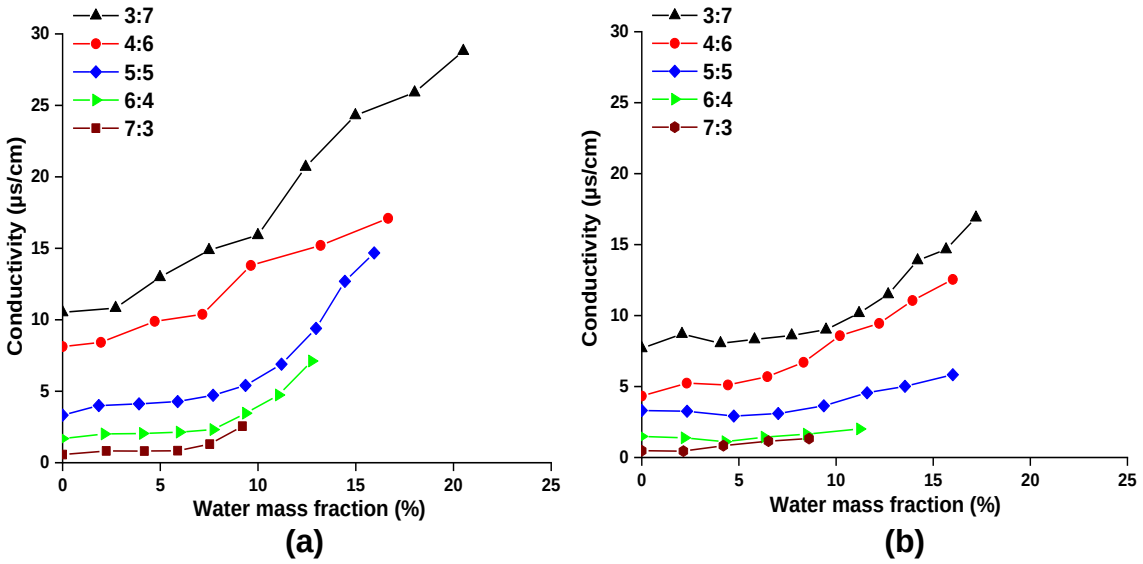

Fig. 3. Variations in electrical conductivity as a function of water mass fraction (%): The weight ratio of LW-IPE to S/CS from 3:7 to 7:3 of Span80:Tween80 (3:7) (a); and S80:T80 (7:3) system (b).

Rheological Behavior Analysis of Microemulsions

Viscosity analysis accounts for the structure and interactions between emulsion particles and the continuous phase (Warr 1995). Viscosity is a physical characteristic of emulsions that exerts influence on consumer preference, and it is significant to

understanding the effect of water content on viscosity. In Fig. 4, the viscosity of W/O systems was on the rise with the increase of water content at the same shear rate. However, in Fig. 4a, the viscosity of the system with water content of 12% was higher than the 16% system, indicating that the viscosity reached the phase inversion point. The system becomes another type of emulsion followed by a decline in viscosity (Kreuter 1994).

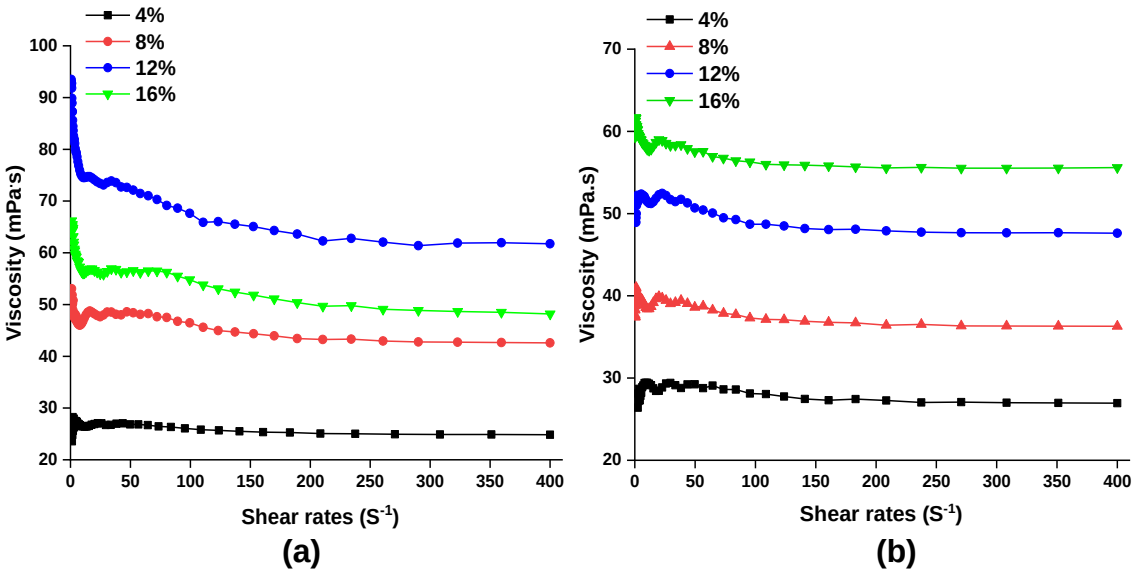

Fig. 4. Viscosity curves at 25 °C for the microemulsion system with the ratio of LW-IPE to S/CS at 5:5 (a) Span80:Tween80 - 3:7 system, (b) Span80:Tween80 - 7:3 system.

All samples tested in this study behaved in a similar way to Newtonian fluids. When the Span80:Tween80 = 7:3, the viscosity gradually increased as the water content rose from 4% to 16%. Comparing the conductivity results, a discovery was made that there was a rise when the water content increased from 12% to 16%. The rheological property confirmed that only the W/O region was formed when the water content was below 16% for Span80:Tween80 = 7:3 system, and below 12% for Span80:Tween80 = 3:7 system. These results further support the conductivity results.

Particle Size Determination of Microemulsions

A small particle size is the characteristic of stable emulsions and it facilitates uptake by the intestine (Sharma *et al.* 2010). In Fig. 5, the particle size of microemulsions ranged from 20 nm to 30 nm, satisfying the requirements of particle size (below 50 nm). Besides, the PDI of microemulsions was below 0.6 when the water content increased from 4% to 12%. Low PDI was also an indicator of stability against coalescence, just like small particle size.

The diameter and PDI increased with the rise of water content. Insufficient surfactant adsorption at the interface occurred at high water content, thus resulting in the instability of microemulsion systems and an increase in particle size and PDI. These results were consistent with the increasing viscosity as the water content was on the rise. However, enough water was required for the W/O delivery system to deliver more drugs. Thus, a 12% water concentration was selected.

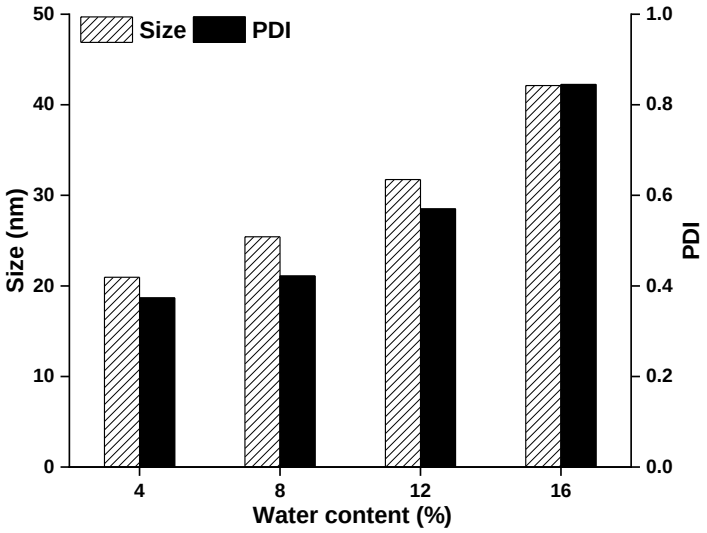

Fig. 5. Effect of water content on diameter and PDI of W/O microemulsions droplets at 25 °C

Temperature and NaCl Concentration Effect on the Formation of Microemulsion

The microemulsion area may be affected by extrinsic factors *i.e.*, salt or temperature. In Fig. 6a, there was an increase in microemulsion area with the rise of temperature from 20 ℃ to 40 ℃. The microemulsion formed by the nonionic surfactant became more lipophilic as the temperature was on the increase. The solubility of lipophilic component in surfactants showed a tendency to increase as the temperature was on the rise. The reduced inter-facial tension promoted the incorporation of the polar component in the inter-facial layer, which was conducive to the formation of microemulsion. Through this study, the variation of microemulsion area was identified as insignificant under different temperatures, suggesting that microemulsions of LW-IPE had excellent thermodynamic stability.

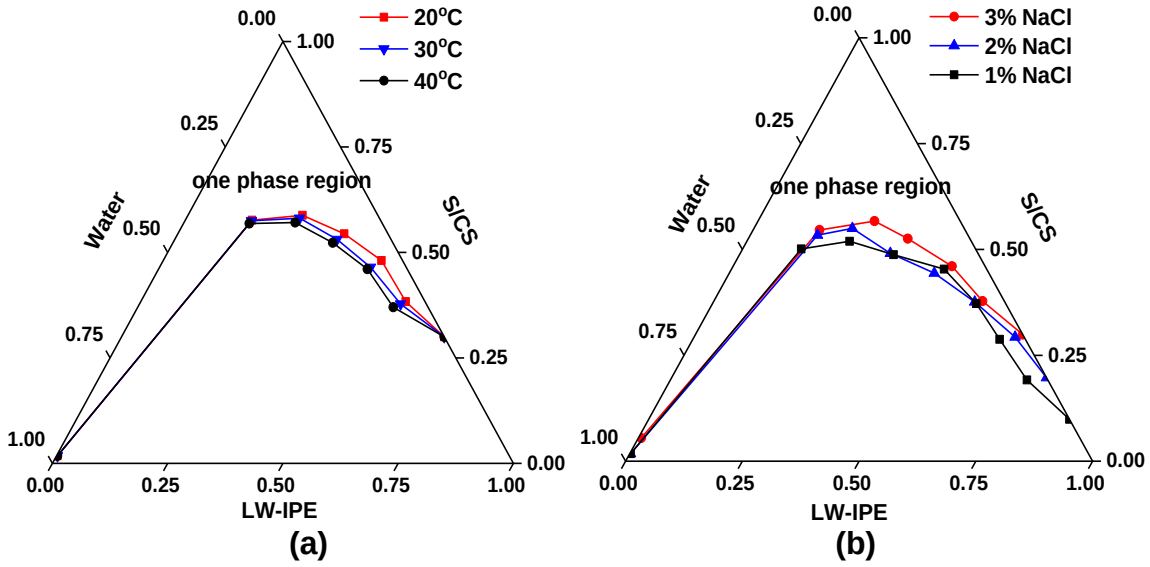

Fig. 6. Effect of (a) temperature and (b) concentration of NaCl on the area of microemulsion region.

In order for application in medicine and cosmetics, microemulsions are required to have tolerance to salt to some extent. The influence of NaCl concentration from 1% to 3% on microemulsion area is shown in Fig. 6b, which indicates that the LW-IPE had excellent stability in the concentration of NaCl solution below 3%, because the Span80 and Tween80 was a binary surfactant and appeared to be more adaptive to salinity than a single surfactant.

Preliminary evaluation on sun protection effects of microemulsion of LW-IPE by Ultraviolet spectrometry

UVA and UVB radiation can cause erythema and vascular damage, thus leading to photoaging. Excessive and incorrect exposure to harmful sunlight radiations could have a negative consequences for human skin (Cvetkovska *et al.* 2017). The demand for sun protection in cosmetics is growing with the increase of ultraviolet radiation. Therefore, the UV protection effects of W/O microemulsion and arbutin in W/O microemulsion were evaluated using an ultraviolet spectrometric method (Xu and Zhang 2006). In Fig. 7, the values of SPF decreased with the rise of dilution ratio, indicating that the microemulsion is capable of producing a desirable UVB protection effect at the concentration of 0.1 mol/L. Compared with three samples of UVA ratio, the UVA ratios of blank W/O microemulsion ranged between 0.4 and 0.6. These results demonstrate that the category descriptor was beneficial to Boot's star rating system. The values of UVA ratio of arbutin in W/O microemulsion improved when compared with arbutin in aqueous solution. With Boot's star rating system, the category descriptor of arbutin in W/O microemulsion was moderate, and the arbutin in aqueous solution was overly low for UVA claim. According to the critical wavelength method, if the value of λ_C ranges between 340 nm to 370 nm, the sample is considered to have a certain UVA and UVB protection effect. In Table 4, the λ_C of W/O microemulsion and arbutin in W/O microemulsion were both in excess of 340 nm, indicating that they have a certain UVA and UVB protection effects. In contrast, the arbutin in aqueous solution led to no UV protection effect. Therefore, the blank W/O microemulsion and the arbutin in W/O microemulsion have UV protection effect to some extent.

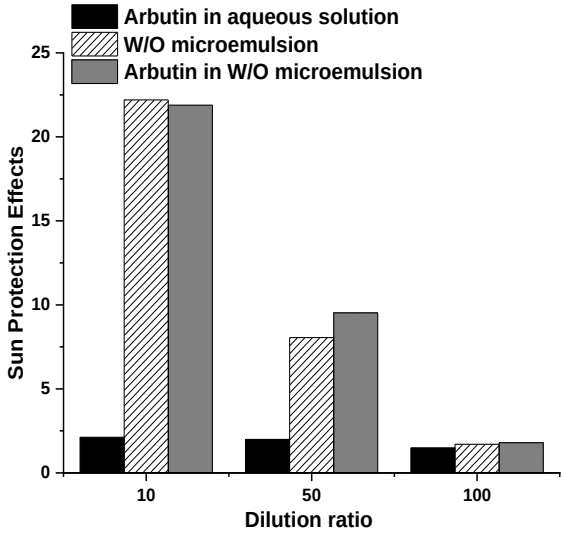

Fig. 7. Sun protection effects

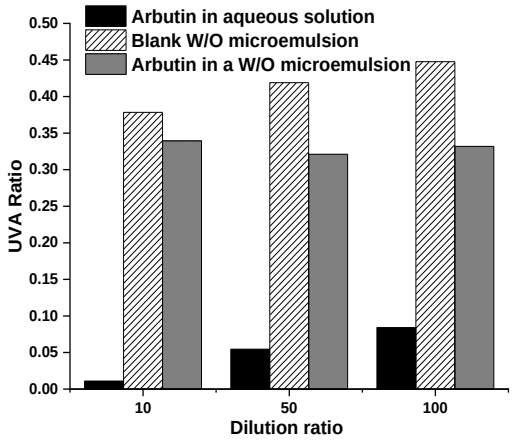

Fig. 8. UVA ratio by Boot's star system

Table 4. Critical Wavelength

Dilution Ratio	λ_C (nm)		
	Arbutin in Aqueous Solution	W/O Microemulsion	Arbutin in W/O Microemulsion
10	310	345	345
50	310	350	345
100	310	350	345

CONCLUSIONS

1. The lacquer wax-based isopropyl ester (LW-IPE) was synthesized by means of lipase-catalyzed transesterification. The LW-IPE yield reached as high as 86.7%. It showed an acid value of 3.25 mg/g, a refractive index of 1.441, and a viscosity of 13.2 mPa·s. These findings indicate that LW-IPE can be a prospective exclusive cosmetic additive.

2. A microemulsion of LW-IPE was prepared by the addition of surfactant, co-surfactant, and water to overcome the flocculation phenomenon. Arbutin microemulsion can be formulated in nano-sized W/O microemulsions that can be formed under mild processing condition with Span80:Tween80 = 7:3 as mixed surfactants, ethanol as cosurfactant, and LW-IPE as the oil phase. The microemulsions exhibited excellent thermodynamic stability and was stable to the addition of NaCl.

3. By ultraviolet spectrometric method, UVA and UVB protection effects created by the microemulsion were evaluated. As revealed by the results, the microemulsion had a certain UV protection effect, which provides a new material for the application in cosmetics and pharmaceutical industries.

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