SYNTHESIS AND APPLICATION OF FUNCTIONAL MATERIALS BASED ON Na-Alg HYDROPHOBICALLY MODIFIED DERIVATIVES IN COSMETICS

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At present, the flavors produced are volatile and have poor stability. To solve this problem, a functional material of hydrophobic modified derivatives prepared by sodium alginate was proposed. In this study, sodium alginate hydrophobic modified derivative functional material was used as microcapsule wall material to wrap flavor, and it was applied to the preparation of cosmetics. By modifying the preparation conditions, including the microcapsule concentration, oil phase ratio and pH value, an emulsion with excellent cosmetic properties was successfully produced. The results showed that the average instability coefficient of the cosmetics emulsion and cream prepared by microcapsules was 2.76 and 2.03, respectively. During half a month of storage, the average retention sensory scores were 6.56 and 5.94, respectively. In comparison to conventional cosmetics that utilize surfactants, the fragrance retention time is prolonged and more stable. The method proposed in this study can effectively enhance the durability and stability of cosmetic flavors, thereby further advancing technical innovation in the field of cosmetics.

Keywords: Na-Alg; Microcapsules; Essence; Stability; Fragrance retention; Cosmetics

1. Introduction

With the development of social economy, people's requirements for cosmetics are getting higher and higher. In addition to moisturizing, whitening and anti-aging of cosmetics, they also need to have beautiful appearance and aroma [1]. Essence is one of the indispensable ingredients in cosmetics, which can not only enhance the sensory experience of the product but also influence the consumer's overall impression of the product to a certain extent. However, due to the high volatility of essence, cosmetic products are prone to fragrance weakening or even disappearance during storage and use [2-4]. To solve these problems, researchers have been exploring new essence carriers and modification technologies. Zhao H et al. investigated the applicability of microencapsulation in essence material carriers by selecting nine different essence oils as the core material and preparing the corresponding melamine resin shell microcapsule by a homogeneous process.

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The results indicated that the carriers utilizing the microcapsule form had good versatility, with encapsulation efficiencies of up to 88.26% [5]. Zhang S et al. found that plastic microbeads in personal care products could be potentially harmful to the environment and organisms, and proposed a microcapsule particles with maltodextrin and resistant starch as the wall material to realize the encapsulation of essences. The results showed that the encapsulation rate of the flavor was 38%, which could improve the retention rate of the flavor [6]. Yorghanlu R A et al. proposed a new film of sodium caseinate to address the poor mechanical properties and antioxidant properties of carrier materials for grape seed extract. Moreover, they investigated the effect of titanium oxide nanoparticles and the extract itself on the film properties. The results indicated that the antioxidant activity of the film was 86.74% and the permeability of the membrane to water vapor was reduced to 4.89kg/m [7]. Nagler F et al. considered the use of polymers as their encapsulants for controlling and delaying the release of perfumes. Two amphiphilic graft copolymers with polydehydroalanine backbone and different hydrophobic side chains were investigated. The results showed that this polymer carrier could effectively control the release rate of the perfume, extend the duration of the fragrance, and show good stability and compatibility in tests simulating the skin surface [8]. As a result of the above studies, microcapsule technology is one of the most promising ways to avoid rapid volatilization of essence. Microcapsule technology can effectively slow down the volatilization of essence and prolong its fragrance retention time in cosmetics by encapsulating essence in tiny capsules [9].

The advantages of sodium alginate (Na-Alg) as a natural polymer material include wide source, low cost, good biocompatibility, high degradability, etc. Therefore, it has a wide range of applications in the cosmetic industry [10-11]. El-Bana A A et al. proposed a sodium carboxymethyl cellulose/Na-Alg polymer blend film prepared with glycerol, honey and Tween (80) as surfactants in order to improve the surface activity of the film prepared with Na-Alg polymer. Meanwhile, its effect of adding surfactant on the optical properties of the film was explored. The results demonstrated that the addition of surfactant could effectively improve the optical properties of the films and enhance their antimicrobial capacity [12]. Su J et al. proposed an ultra-short-channel and ultra-low-voltage vertical transistor based on Na-Alg/protonaceous filament crosslinked hydrogel electrolyte to simulate pain recognition generated by human sensory nerves under ultra-low-voltage operation. It utilized this vertical transistor to simulate nerve stimulation responses and applied it to simulated human products. The results indicated that the method had significant pain perception ability [13]. To improve the swelling, drug loading and drug release rate of medical drug delivery products, Gorshkova M Y et al. synthesized an adherent two-component drug carrier based on acrylamide/ diethylacrylamide synthetic material and natural Na-Alg hydrogel. The results revealed that the drug release rate of the method reached more than 80%, and the

swelling rate and drug loading capacity were significantly optimized [14]. Taken together, it can be concluded that Na-Alg is often used to prepare gel microspheres. However, such microspheres indicate large pores, which are prone to sudden release during water release, and poor mechanical strength [15]. For this reason, the study considers its modification with coupling agents and the preparation of microcapsules using hydrophobically modified Na-Alg derivatives as wall materials. The aim of the study is to improve the fragrance retention and stability of essences and to prepare higher quality cosmetic products. The novelty of the study lies in the application of microcapsule technology and Na-Alg materials to improve the fragrance retention of essences. This effectively improves the stability and fragrance retention of emulsions in cosmetics. The study also analyzes the performance of the factors affecting the preparation to further determine the appropriate preparation parameters.

The study is divided into three sections. The first section is the methods and materials section, where the materials used for the study are prepared and the methods employed are described in detail. The second section is the results section, where the properties of the prepared materials are analyzed by means of experimental analysis. The third section is the conclusion section, which discusses the methodology proposed for the study as well as the results of the experimental analysis and gives an outlook of the study.

2. Methods and materials

To enhance the fragrance retention time and storage stability of essences in cosmetics, the study considered the preparation of microcapsule using Na-Alg, which was used as an essence carrier in cosmetic emulsions.

2.1 Experimental materials and equipment

The selected materials for the study include nipagin ethyl ester (Minghe Biotechnology Co., Ltd., Shanghai, China), Na Alg (Shanghai Lanrun Chemical Co., Ltd., Shanghai, China), essence (Kleina essence Fragrance Co., Ltd., Shanghai, China), sodium chloride (Jinhai Salt Chemical Co., Ltd., Yueyang, China), n-octylamine (Nanjing Baigel Biotechnology Co., Ltd., Nanjing, China), sodium hydroxide (Sinopharm Chemical Reagent Co., Ltd., Shanghai, China), $(NH_4)_2HPO_4$ (Shanghai Zhanyun Chemical Co., Ltd., Shanghai, China), 1-ethyl – (3-dimethylaminopropyl) diammonium carbide hydrochloride (Hubei Qianmo Biotechnology Co., Ltd., Ezhou, China), calcium chloride (Haizhiyuan Chemical Co., Ltd., Weifang, China), liquid paraffin (Nanjing Chemical Reagent Co., Ltd., Nanjing, China), hydrochloric acid (Huhui Biotechnology Co., Ltd., Shanghai, China), olive oil (Hangzhou Zhanyun Trading Technology Co., Ltd., Hangzhou, China), rhodamine B (Sichuan Weiqi Biotechnology Co., Ltd., Chengdu, China), and Glycerol (Jiangshun Chemical Technology Co., Ltd., Guangzhou, China). The

materials also include white oil, stearic acid, isopropyl palmitate, Brij 30, Carbopol 941, cetyl alcohol, and K12 from the China National Pharmaceutical Group Chemical Reagent Co., Ltd. in Shanghai, China.

The instruments used in the experiments included optical microscope (LEICA, Heilbronn, Germany), electronic balance (Mettler-Torley GmbH, Zurich, Switzerland), ultraviolet absorption spectrometer UV-1800 (Shanghai Meppan Instruments Co., Ltd., Shanghai, China), vacuum drying oven DZF-6020 (Shanghai Jinghong Experimental Equipment Co., Ltd., Shanghai, China), freeze drying oven TF-FD-27S (Shanghai Tuofen Machinery Equipment Co., Ltd., Shanghai, China), electrothermal constant temperature water bath (Shanghai Jinghong Experimental Equipment Co., Ltd., Shanghai, China), electric thermostatic water bath (Shanghai Jinghong Experimental Equipment Co., Ltd., Shanghai, China), high-speed freezing centrifuge GTR16-2 (Beijing Times Beili Centrifuge Co., Ltd., Beijing, China), rotary evaporator RE-3000A (Zhengzhou Kerui Instrument Co., Ltd., Zhengzhou, China), pH meter (Shanghai Lei Magnet Instruments Co. Ltd., Weifang, China), electric mixer (Shandong Longze Machinery Co., Ltd., Weifang, China), Fourier Transform Infrared (FTIR) spectrometer Tensor 27 (Bruker, Shanghai, China), elemental analyzer Element5 820 CHNSO (Prudential Science and Technology Co., Ltd., Beijing, China), laser particle sizer Rise-3000 (Rune Technology Co., Ltd., Jinan, China), counting and measuring instruments (RISE), laser particle sizer (Rise-3000), laser particle sizer (Risen Technology Co. Ltd., Jinan, China), Digital Magnetic Heating Stirrer MS-H280-Pro (Beijing Chuqi Instrument Co., Ltd., Beijing, China), Transmission Electron Microscope (PHILIPS, Amsterdam, The Netherlands), High-Shear Dispersing Emulsifier JS18 (Yangzhou Junrui Electromechanical Equipment Manufacturing Factory, Yangzhou, China), Rotational Rheometer RMOM-75 (Putong Experimental Analysis Instrument Co. Ltd., Guangzhou, China), Stability Analyzer MS20 (Dataphysics, Shanghai, China), Laser Confocal Microscope LEXT OLS5100 (Mingsheng Science & Technology Co., Ltd., Changsha, China), and Impulsive Jet Micromixer (Nohl, Zhangzhou, China).

2.2 Material preparation process

Na-Alg hydrophobically modified derivative functional materials in the preparation process need to be first prepared to obtain 100 mL of deionized water, after which 3 g of Na-Alg was stirred and dissolved in it. After that, the pH value of the solution needs to be adjusted. During the adjustment process, the study used 0.6 mol/L hydrochloric acid solution and pure water for the operation. The concentration of the treated solution was 0.2 wt% and the pH was 3.3. The obtained solution was dissolved in deionized water having 1.22 g of 1-ethyl-(3-dimethylaminopropyl) carbodiimide hydrochloride added to the Na-Alg solution and stirred for 10 minutes. 2.24 g of n-octylamine was added to the solution and the

reaction was stirred for 24 hours. The product was precipitated by adding ethanol and dried under vacuum for 24 hours. Finally, the pure product of Na-Alg hydrophobically modified derivative functional material was obtained by pure water dialysis. The specific fabrication process is shown in Fig. 1.

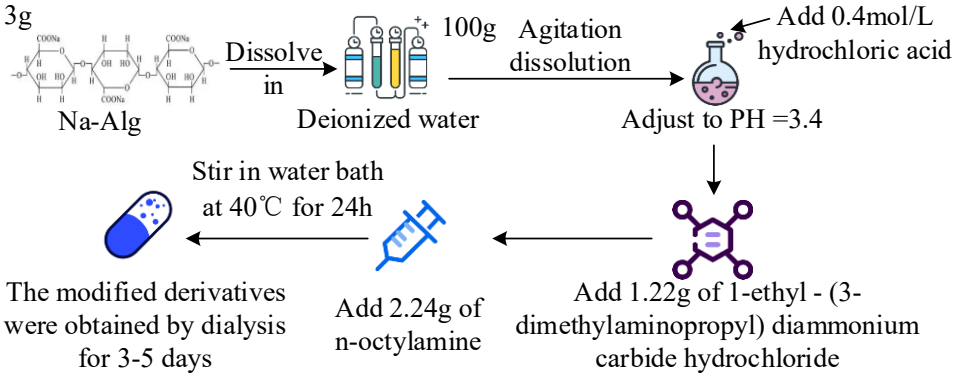


Fig.1 Preparation of functional materials of hydrophobic modified derivatives of Na-Alg

The study used the produced functional materials as wall materials for essence microcapsules and successfully made essence microcapsules using emulsion-gel technique. The study used it as an emulsifier to stabilize the emulsion system. In the study, 1.2 g of sodium monohydrate phosphate and 1 g of calcium chloride were first weighed and added to 100 mL of deionized water simultaneously and stirred until completely dissolved to obtain the desired suspension. Then, the purified Na-Alg hydrophobic modified derivative functional material prepared earlier was dissolved in distilled water. The solution with concentration of 1g/L, 2g/L, 3g/L, and 4g/L was obtained by adjusting the quality of the dissolved derivative. The essence was then added to the solution and emulsified. To compare the effect of the added amount of essence on the microcapsule particle size, 0.1g, 0.2g, 0.3g, and 0.4g of essence were added to 100mL of Na-Alg modified derivative solution at a concentration of 2g/L, and the emulsion was emulsified for 2 minutes at 13000 rpm with a high shear dispersion emulsifier. After that the obtained emulsion was fed into a ramjet micro mixer for 1 minute and then the suspension was added to it for crosslinking reaction. Finally, its pH was adjusted to about 5 utilizing acetic acid. Dialysis was carried out using deionized water to obtain essence microcapsules suspension. Finally the obtained capsule suspension was subjected to centrifugation, washing as well as freezing operations to obtain essence microcapsules. After obtaining essence microcapsules, the study mixed them with liquid paraffin wax and passed through a shear emulsifier to obtain the final emulsion system. To further examine the effectiveness of the essence microcapsules proposed by the study in cosmetic emulsions, the study prepared two types of make-up products using the essence carrier materials prepared by the study and the

conventional method and compared the performance of the two products. The formulations of the four products are shown in Fig. 2.

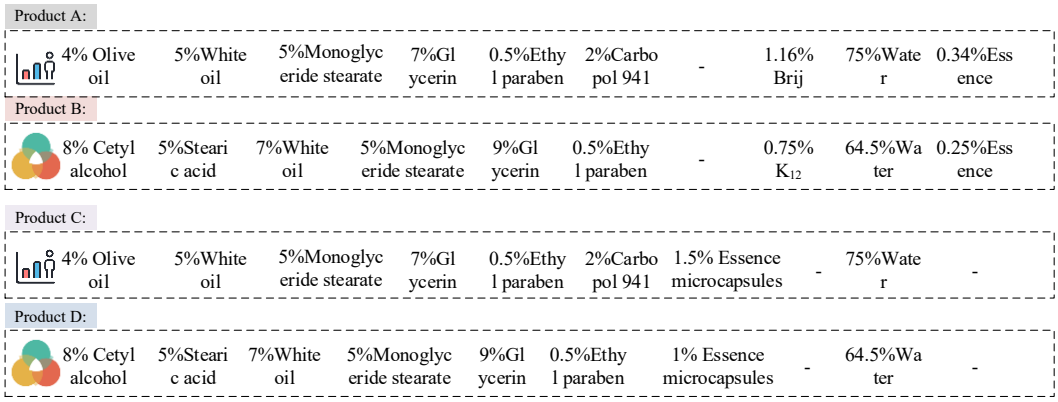


Fig.2 Process of preparing cosmetic emulsions using essence microcapsules and traditional surfactants

In Fig. 2, the study prepared conventional cosmetic lotions (A) and creams (B) by specifying different product formulations, and also cosmetic lotions (C) and creams (D) incorporating essence microcapsules.

2.3 Characterization methods and experimental design

The study was carried out to analyze the distribution of microcapsules obtained from the preparation at 25°C environment. The particle size was measured by particle sizer during the analysis and the average of three determinations was taken. To measure the encapsulation rate and load rate of essence microcapsules, the study was carried out to calculate the encapsulation rate and load rate by determining the essence concentration of ultrasonically treated capsules after crushing by UV spectrophotometer. The calculation method is shown in Equation (1).

$$\begin{cases} EE = \dfrac{W_1}{W_2} \times 100\% \\ LC = \dfrac{W_1}{W_3} \times 100\% \end{cases} \tag{1}$$

In Equation (1), W_3 is the overall weight. W_1 is the weight of the encapsulated essences. EE and LC are the encapsulation rate and load rate of essence microcapsules, respectively. W_2 is the starting weight of essences. The specific procedure of the encapsulation rate and load rate determination method is shown in Fig. 3.

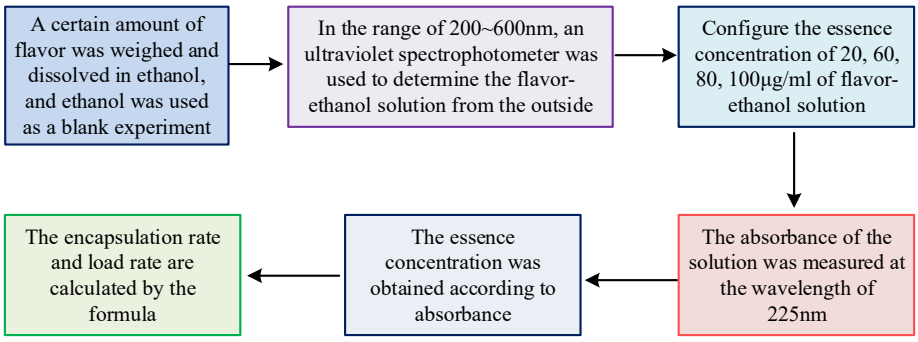


Fig.3 Encapsulation rate and load rate determination process of essence carrier submicrocapsules

In the study, a thermogravimetric analyzer was used to take 5mg~8mg samples into an alumina crucible, which was heated up to 500°C under nitrogen protection to determine the thermogravimetric curve. To investigate the effect of microcapsule functional materials on the slow-release performance of essence, several essence microcapsules and 21 mg of essence were uniformly placed in Petri dishes. In addition, the essence content was determined at different storage times to characterize the slow-release performance of essence microcapsule functional materials under ambient conditions [16-18]. To determine the rheological properties of the emulsion system stabilized by microcapsule particles, the study used two scanning modes, dynamic and steady state, to determine the shear viscosity and viscoelasticity of the emulsion, respectively [19-21]. In addition, the study in order to analyze the stability of the prepared cosmetics. The data of transmitted light and backscattered light were obtained by scanning, and then the instability index of the emulsion product was calculated. The specific process is shown in Fig. 4.

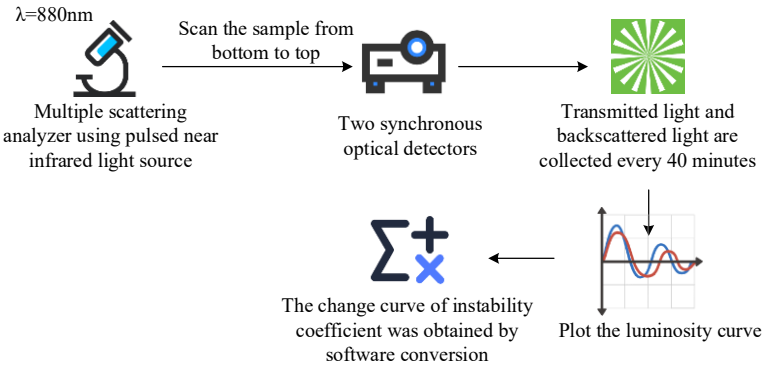


Fig.4 The extraction process of instability index of cosmetic emulsions

In Fig. 4, the study obtains the raw data through multiple scans and then calculates the instability coefficient of the sample [22-23]. The instability

coefficient is calculated as shown in Equation (2).

$$TT = \sqrt{\frac{\sum_{i=1}^{n}\left(x_i - x_b\right)}{n-1}} \tag{2}$$

In Equation (2), TT is the instability coefficient value. n is the number of measurements. x_i and x_b are the value of backlight intensity and the average value of backlight intensity for each measurement, respectively. For the evaluation of the scent retention effect of cosmetic emulsions, five volunteers were selected for the study to rate the scent perception of the emulsion products under different time of placement. These five volunteers were not aware of the real information about the product. A score of 10 was given for a strong fragrance, 0 for no fragrance, and so on for scoring.

3. Results

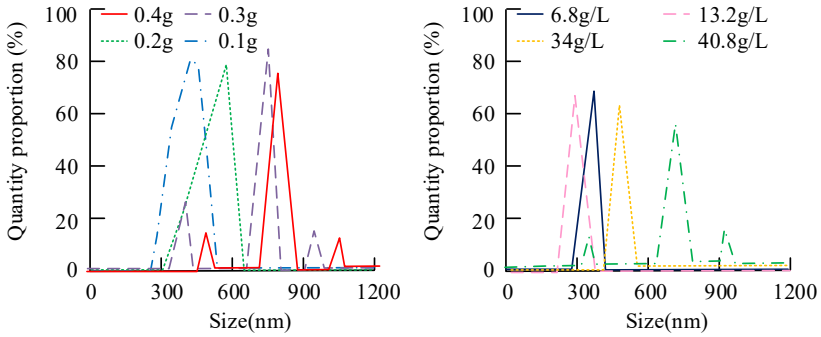
A series of experiments were formulated to analyze the properties of the proposed essence microcapsules prepared based on functional materials derived from Na-Alg hydrophobic modification for their application in the cosmetic industry and their effect on essence stability and fragance retention in order to test the value of the proposed essence microcapsules in the cosmetic industry.

3.1 Factors influencing the particle size of Na-Alg essence microcapsules

To optimize the process parameters of essence microcapsules, it was necessary to study and analyze the effects of different influencing factors on the particle size distribution of the capsules. This was done with the aim of improving the encapsulation of essence and enhancing the stability of the microcapsules in cosmetics. The particle size distribution under different influences is shown in Fig. 5.

In Fig. 5(a), the curves of all four essence dosages show a large peak. Among them, two and more peaks appeared for 0.3g essence and 0.4g essence content. This was because the increase in essence amount also further thinned the capsule wall, but the degree of thinning varied. Considering the practical factors, the essence amount of 0.1g was chosen for the study. In Fig. 5(b), the microcapsule particle size also showed a tendency of decreasing and then increasing as the concentration of the suspension increased. This was due to the fact that an increase in the concentration of the suspension reduced the degree of association between the coupling agent and Na-Alg in the capsule structure, forming a more compact structure with a relatively reduced particle size. However, if the concentration was too high, the excess calcium ions in the cross-linking reaction will be released,

making the multimolecular chain connection, which in turn increased the capsule particle size. Therefore, the concentration of 13.2 g/L suspension to realize the minimum particle size was chosen for the study. In Fig. 5(c), the capsule particle size gradually increased with the increasing concentration of Na-Alg hydrophobically modified derived functional materials. During the transition from 1 g/L concentration to 2 g/L concentration, a slighter decrease in particle size occurred. This was due to the increase in the surface tension of the solution caused by the increase in concentration, which in turn led to the formation of droplets with smaller particle size. However, after increasing to 3g/L, the viscosity of the system increased resulting in an increase in particle size. Therefore, 2g/L of the derived functional material was chosen for the study.



(a) Different essence concentrations

(b) The concentration of suspension

(c) Hydrophobic modified derivative concentration

Fig.5 Particle size distribution of microcapsules under different dosage of essence, concentration of suspension prepared by sodium monohydrogen phosphate and calcium chloride and crosslinking reaction time

For the purpose of determining the cross-linking reaction time, emulsification time, and gel stirring speed during the preparation of microgelatin particles, the study equally analyzed the effect of these three on the capsule diameter particles. The results are shown in Fig. 6.

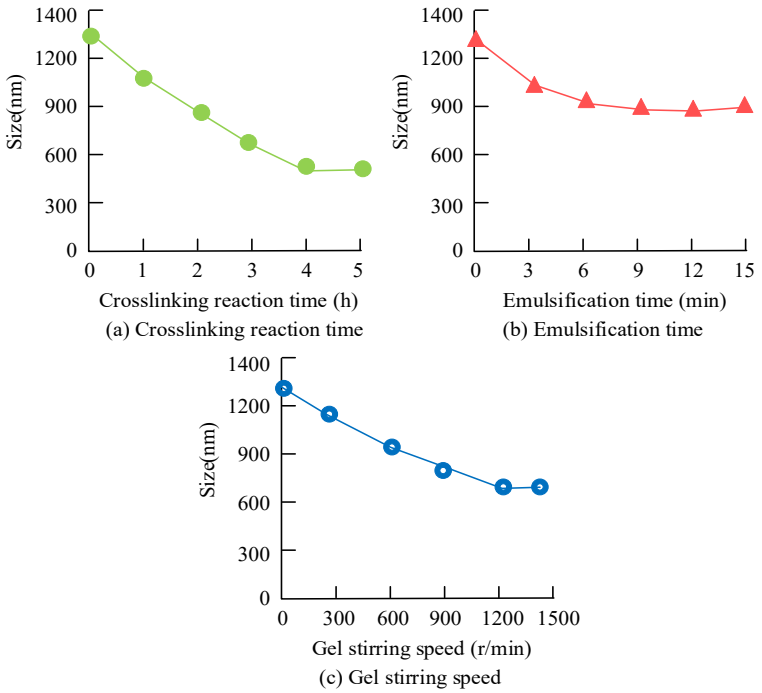
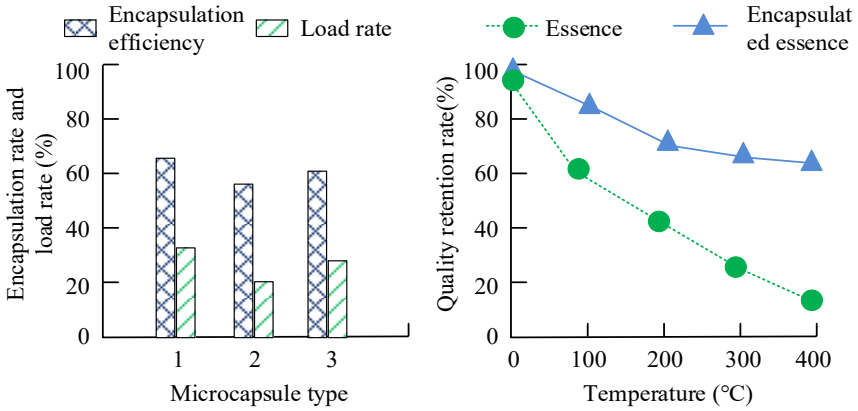


Fig.6 Effects of crosslinking reaction time, emulsification time and gel stirring speed on the size distribution of microcapsules

In Figs. 6(a), 6(b), and 6(c), the capsule size particles were minimized at cross-linking reaction time of 5 h, emulsification time of 6 min and stirring rate of 1200 rpm, respectively. Among them, the distributions of diameter particles were basically the same for emulsification time of 6 min and 12 min, and the crosslinking reaction time of 4 h and 5 h were basically the same. Considering the time cost, the reaction time of 4h, emulsification time of 6 min and stirring rate of 100 rpm were selected for the study.

3.2 Effect of microcapsule materials on essence stability and fragrance retention

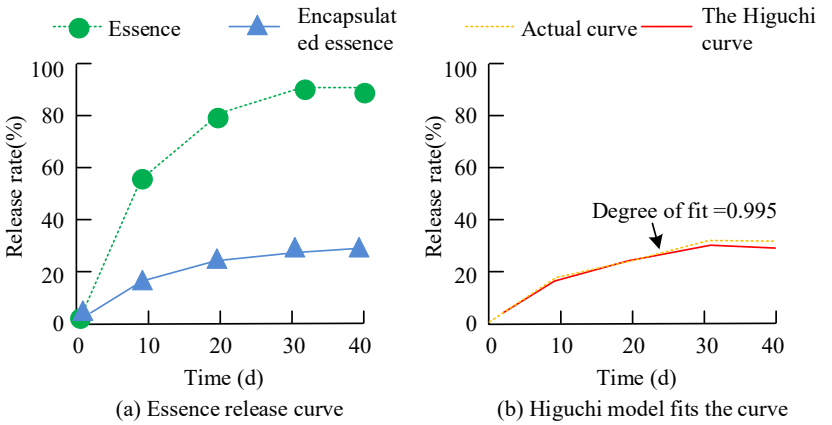
To further test the effect of the prepared aroma microcapsule (microcapsule 1) on the stability of the flavor, the encapsulation rate and load rate were measured in this study, and the encapsulation rate and load rate of the microcapsule structure (microcapsule 2) in reference [24] and microcapsule structure (microcapsule 3) in reference [25] were compared. The thermal stability was also analyzed using thermogravimetry. The results are shown in Fig. 7.



(a) Packet rate and load rate (b) Thermogravimetric curve

Fig.7 Effect of microencapsulated form on the stability of essence

In Fig. 7(a), the essence microcapsules exhibited an encapsulation rate of 69.47% and a load rate of 23.84%. The encapsulation rate and load rate were significantly higher compared to the other two microcapsules. In Fig. 7(b), the thermal decomposition temperature of essence was 60~258°C. When the temperature exceeded this range, more than 99% of the essence was volatilized. Whereas the mass loss of essence microcapsules was 64.87% when the temperature reached 250°C. Compared with the unencapsulated essence, microcapsule could reduce its heat loss rate. To examine the effect of essence microcapsules on essence fragrance retention, the study was carried out by recording the release rate of essence under gastrointestinal conditions and essence encapsulated in capsules. The study used Higuchi model to fit the release profile of essence in essence microcapsules. The results are shown in Fig. 8.



(a) Essence release curve (b) Higuchi model fits the curve

Fig.8 Results of analysis on retention properties of the essence after capsule encapsulation

In Fig. 8(a), the cumulative percentage of essence release gradually

increased with time, and the release rate first accelerated and then slowed down. In contrast, the release rate of essences encapsulated in microcapsule was relatively slow compared to that of essence-only materials. At around 15 days, the retention rate of essences in unencapsulated essences was below 10%, while the retention rate of microcapsule-encapsulated essences remained above 60%. In Fig. 8(b), the release curve of essences detected by the Higuchi model used in the study achieved a goodness-of-fit of 0.995 to the actual curve. It was determined that the release curves developed in the study were practically feasible.

3.3 Performance analysis of liquids prepared by applying microcapsule

After the preparation of endessence microcapsules, the study mixed them with liquid paraffin. The emulsions were obtained after emulsification through high shear emulsifier. In order to examine the rheological properties of the prepared emulsions, the study analyzed their shear viscosity and viscoelasticity. Firstly, the study used steady state scanning mode to record the steady state viscosity for different concentrations and parameters of the prepared materials. The results are shown in Fig. 9.

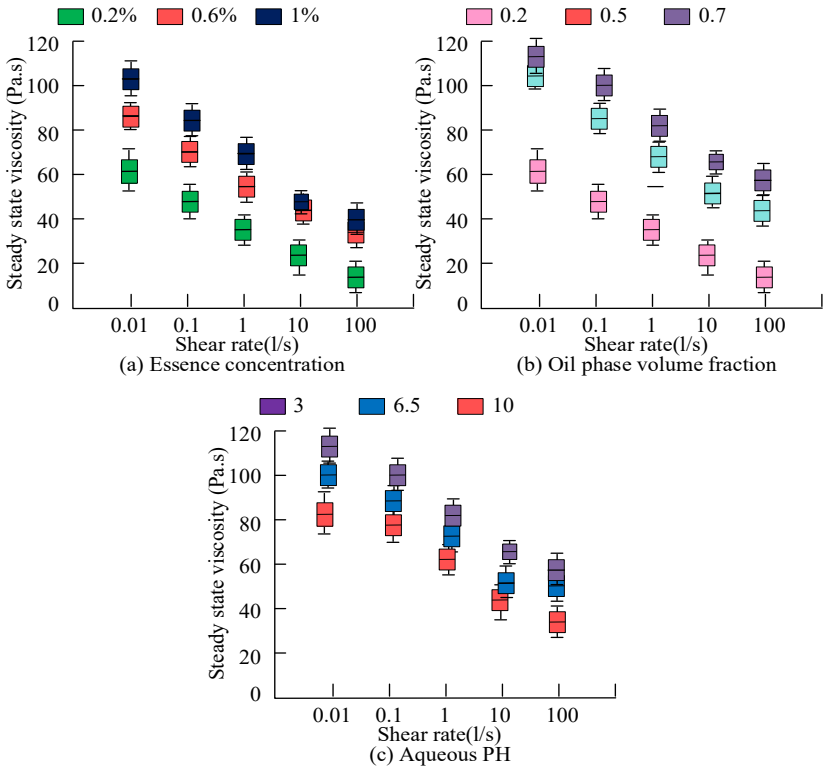


Fig.9 Steady-state viscosity of different concentrations and parameters of prepared materials in emulsion system

In Fig. 9(a), the greater the concentration of essence microcapsules, the higher the steady-state viscosity of the emulsion. This indicated that microcapsule particles could act as a thickener to increase the steady state viscosity of the emulsion system. In Fig. 9(b), the increase of oil toward volume fraction in the emulsion increased the steady state viscosity of the emulsion, which in turn hindered the fluidity of the system. In Fig. 9(c), the lower the pH, the higher the steady-state viscosity of the emulsion. The higher the shear rate, the lower the steady-state viscosity of the emulsion. Combined with the practical application, the study set the oil ratio in the emulsion to 0.5, the pH to 6.5, and the capsule concentration to 0.6 wt%. For the further determination of the rationality of the process parameters selected for the study, the study was carried out to compare and analyze the storage modulus, loss modulus of the three parameters by dynamic scanning mode. The results are shown in Table 1.

Table 1

Changes of energy storage modulus and loss modulus of each parameter in dynamic scanning mode

Contrast parameter		Frequence (Hz)							
		0.01		0.1		1		10	
		Energy storage modulus (Pa)	Loss modulus (Pa)	Energy storage modulus (Pa)	Loss modulus (Pa)	Energy storage modulus (Pa)	Loss modulus (Pa)	Energy storage modulus (Pa)	Loss modulus (Pa)
Microcapsule concentration (%)	0.2	5.22	0.48	6.84	0.50	7.44	0.51	7.92	0.68
	0.6	10.54	1.25	10.82	1.28	10.91	1.32	10.98	1.34
	1.0	13.84	6.88	14.02	6.97	14.32	7.05	14.48	7.11
Oil ratio	0.3	9.45	1.44	9.83	1.50	10.00	1.58	10.68	1.62
	0.5	21.03	7.25	21.12	7.30	21.22	7.33	21.34	7.36
	0.7	98.75	20.74	100.85	20.88	102.38	21.23	106.47	22.19
pH	3	18.94	5.58	20.87	5.00	25.77	6.07	32.45	6.48
	6.5	10.10	1.97	11.55	1.78	11.96	2.25	12.85	2.94
	10	5.44	1.63	8.75	1.51	5.84	2.20	5.00	4.15

In Table 1, the trends of storage modulus and loss modulus for different parameters at different frequencies are basically consistent with those of steady state viscosity. The storage modulus and loss modulus of the parameter combinations chosen in the study were the most centered and relatively stable. Considering the cost and the need for stability of the emulsion system, the proposed parameter combinations were more suitable. To further examine the effect of essence microcapsules on the storage stability of the emulsions, the study was conducted by placing the made emulsions in a 25°C environment for 14 days. Moreover, the changes in the droplet size of the emulsions during these 14 days were recorded. The specific results are shown in Fig. 10.

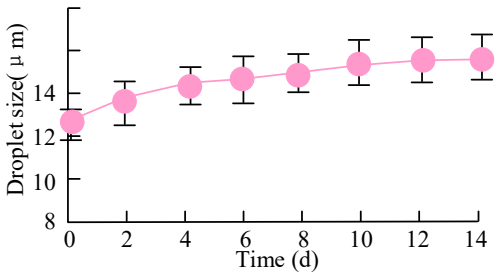


Fig.10 Effect of essence microcapsule on storage stability of emulsion

In Fig. 10, at the beginning of the test, the emulsion droplet diameter particle size was about 13.80 μm. After 14 days, the emulsion droplet diameter particle size was 15.98 μm. The emulsion droplet size increased by only 2.18 μm during the 14 days, which was relatively not a large change and the growth trend was slow.

3.4 Practical application effect of cosmetic emulsions based on Na-Alg hydrophobically modified derivative functional materials

The study applied essence microcapsules to the preparation of cosmetics and compared their performance with that of cosmetic emulsions prepared with conventional surfactants. To examine the practical application of the proposed functional materials in cosmetic emulsions, the study evaluated their stabilization and fragrance retention. The study recorded the instability coefficients of the four products prepared to A, B, C, and D with time. The results are shown in Fig. 11.

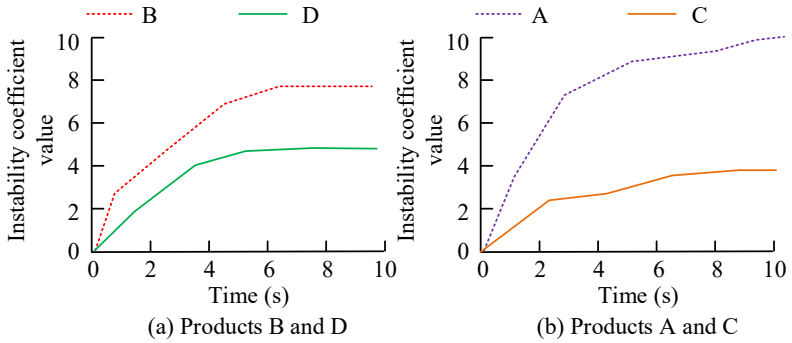
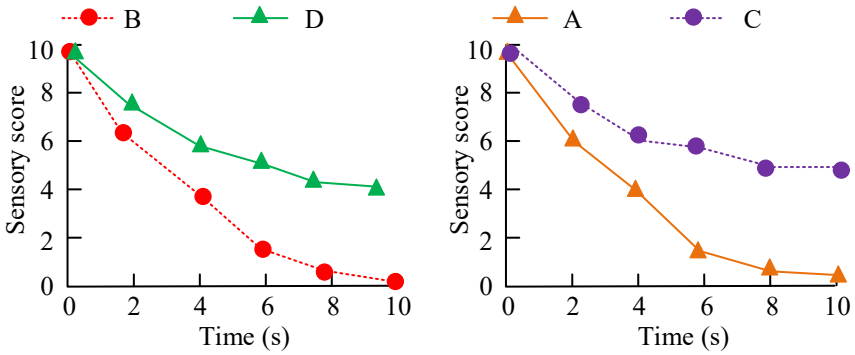


Fig.11 The instability coefficient of four cosmetic emulsions changed with time

In Fig. 11(a), the instability coefficients of both cream products B and D presented an increasing trend with time. Moreover, the instability coefficient value of conventional cream product B was significantly higher than that of product D with the application of essence microcapsules. The average instability coefficient value of product D was 2.76, and the average instability coefficient value of product B was 6.02. In Fig. 11(b), the average instability coefficient values of lotion products A and C were 8.67 and 2.03, respectively. Taken together, it can be

concluded that the the use of essence microcapsules in cosmetic formulations could effectively enhance the stability of the products.

To verify the fragrance retention of prepared cosmetic creams and lotions, the study sought a total of five volunteers to evaluate the fragrance concentration of the products without knowing specific information about the products. To investigate the relationship between fragrance retention and time, the volunteers were asked to evaluate the sensory aspects of the fragrance every two days over a half-month period. The evaluation scores ranged from 0 to 10. The results are shown in Fig. 12.



(a) Products B and D (b) Products A and C

Fig.12 Results of odor retention sensory evaluation of four cosmetic emulsions

In Fig. 12, the sensory scores of all four products for aroma retention decreased over time. Among them, the sensory scores of Products C and D with essence microcapsules applied decreased less. The mean sensory scores of Product C and Product D were 6.56 and 5.94, respectively. The mean sensory scores of Product A and Product B were 4.34 and 3.44, respectively. In summary, it can be concluded that make-up products with essence microcapsules have a better fragrance retention effect than conventional products and are able to prolong the duration of aroma emission.

4. Discussion and conclusion

Essence is widely used in the production of cosmetics, but in practical applications, it has the disadvantages of volatility and non-durability. To solve these problems, the research introduced the essence microcapsules technology, which utilized Na-Alg hydrophobically modified derivative biofunctional materials as microcapsule walls to wrap essences and prepare corresponding cosmetic emulsions. The experimental results indicated that both storage modulus and loss modulus of microcapsule exhibited high stability and moderate levels under specific parameter combinations, which were essential to ensure the stability and

homogeneous distribution of microcapsule in cosmetic products. The emulsion system with essence microcapsules applied showed a good stability with an increase in emulsion droplet size of only 2.18 μm within 14 days. In the practical application of cosmetic preparation, the modified functional materials prepared in the study could effectively enhance the product stability and slow down the essence volatilization compared with the traditional method. The instability coefficients of microcapsule-based Products D and C were significantly different from those of traditional products B and A. The average instability coefficients of emulsion C and cream D were about 1.5 times higher than those of traditional Products B and A, respectively. The average instability coefficients for emulsion C and cream D were 2.76 and 2.03, respectively. Microcapsule-based Products C and D maintained high sensory ratings over a longer period of time. Specifically, their average scent retention sensory ratings were 6.56 and 5.94 during half a month of placement, respectively. This suggests a longer lasting and more enjoyable fragrance experience for the end user. The use of essence microcapsules in cosmetic emulsions can effectively improve product stability and fragrance retention. Future work can further explore the antioxidant, sunscreen and moisturizing properties of cosmetic products to improve product quality and user experience in all aspects.

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