

Sustained-release properties of cotton fabrics impregnated with nanotuberoses fragrance

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ABSTRACT: Tuberoses-fragrance (TF) loaded polybutylcyanoacrylate nanoparticles were successfully prepared via emulsion polymerization. The nanotuberoses fragrance (Nano-TF) was directly impregnated into the cotton fabrics as an aromatic reagent. Dynamic light scattering and transmission electron microscopy showed that the average size of the spherical Nano-TF was 202.4 nm. Fourier transform infrared spectroscopy demonstrated that TF was encapsulated into the BCA nanoparticles and that the Nano-TF was in existence in the cotton fabrics. Thermogravimetric analysis showed that the loading TF content of the Nano-TF was 50.9% and that 10.02% Nano-TF had been impregnated into the fabrics. A lot of Nano-TF was adhered onto the surface of the cotton fabrics after 50 washings, as shown by scanning electron microscopy and gas chromatography/hydrogen flame ionization detection (GC-FID). In addition, GC-FID demonstrated that most aroma compounds of the cotton fabrics impregnated with Nano-TF only lost less than 20% of their aroma after 60 days of deposition and around 75% of their aroma after 6 h of deposition at 120°C, so they showed better sustained-release properties than those with TF. © 2014 Wiley Periodicals, Inc. *J. Appl. Polym. Sci.* **2015**, *132*, 41678.

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Fragrances and flavors as small molecular compounds have been applied in many fields, including perfumes,¹ textiles,^{2,3} food additives,⁴ medicines,^{5,6} cosmetics, tobacco, leather,⁷ and carbonless copying paper. However, the easy volatilization, oxidation, and distortion of flavors and fragrances during their manufacturing, storage, and use inhibits their utilization.⁸ Recently, many researchers have paid more attention to the enhancement of the stability and sustained-release properties of fragrances and flavors. The encapsulation of fragrances can effectively control the flavor-release rate, extend the aroma-reserving time, and protect active substances from the environment.^{9–14} Li *et al.*¹⁵ prepared orange oil microcapsules coated with chitosan via a spray-drying method; the microcapsules had a mean diameter of less than 20 μm, and the encapsulation efficiency of the orange oil was greater than 90%. In particular, the application of capsules containing fragrances and essential oils in textiles has been focused recent years.^{16–25} Yang *et al.*²⁶ reported that patchouli oil microcapsules prepared via a complex coacervation method were grafted onto cotton fabrics with 1,2,3,4-butanetetracarboxylic acid as the crosslinking agent. After 30 days, the patchouli oil in the microcapsules still remained on the fabric, and the release amount was close to 50%.

Early on, aromatic cotton fabrics were generally obtained with several chemical crosslinkers, including 1,2,3,4-butanetetracarboxylic acid, glutaraldehyde,²⁷ glyoxal,²⁸ formaldehyde,²⁹ and formaldehyde derivatives.³⁰ However, these crosslinking agents produced health and environmental problems for people.^{31,32} With the enhancement of environmental safety consciousness, the addition of physical crosslinking agents or physical functions to textiles has exhibited superiority over the addition of chemical crosslinkers for aromatic cotton fabrics. Specos *et al.*³³ prepared citronella essential oil microcapsules (25–100 μm) by complex coacervation and then applied them to the cotton textiles via a conventional pad-dry method. The treated textiles presented better and longer lasting protection from insects compared to fabrics sprayed with an ethanol solution of the essential oil; this ensured a repellency effect higher than 90% for 3 weeks. Yang *et al.*³⁴ prepared vanillin/chitosan microcapsules with a mean size of 8 μm via spray-drying and then applied them to cotton textiles with citric acid as a safety crosslinking agent. These microcapsules could not effectively penetrate into the fibers because of the limitation of their big size. Our team prepared 130 nm chitosan–sodium tripolyphosphate loaded with a sweet-smelling osmanthus fragrance via the complex coacervation method and applied them onto the cotton fabrics directly

Table I. Properties of the Components in TF

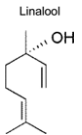
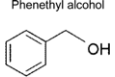
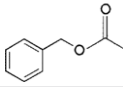
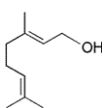
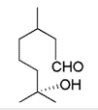
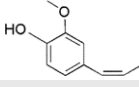
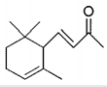
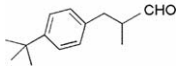
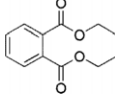
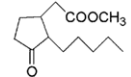
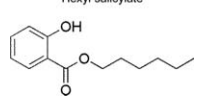
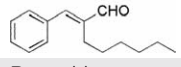
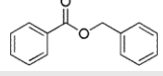
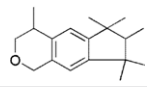
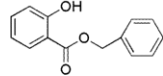
Number	Name	Mass quality (%)	Boiling point (°C)
1	Linalool 	5	198
2	Phenethyl alcohol 	6.8	222
3	Benzyl acetate 	12	216
4	Geraniol 	6	230
5	Hydroxycitronellal 	4	241
6	Isoeugenol 	2	268
7	Methyl ionone 	3.2	125-126
8	Lilial 	5.5	279 (0.8kPa)
9	Diethyl phthalate 	12	298
10	Methyl dihydrojasmonate 	7.5	>300

Table I. Continued

Number	Name	Mass quality (%)	Boiling point (°C)
11	Hexyl salicylate 	3	278
12	α -Hexylcinnamaldehyde 	5	174-176/15 mmHg
13	Benzyl benzoate 	6	324
14	Galaxolide 	7	129
15	Benzyl salicylate 	5	168-170/5 mmHg

without any crosslinking agents. Most components of osmanthus fragrances in the cotton fabrics treated with osmanthus fragrances were lost completely after 20 washing cycles, compared with those with the nanocapsules.³⁵ Similarly, 67.3-nm polybutylcyanoacrylate (PBCA) nanocapsules encapsulated with a rose fragrance were obtained via ionic polymerization under an emulsion system and were then applied to the cotton fabrics directly.³⁶ However, the loading capacity (LC) of the previous fragrance nanocapsules were low, and this obviously influenced the sustained-release properties of the aromatic cotton fabrics.

In this study, PBCA nanocapsules containing a tuberose fragrance (TF) with the high LC were prepared via emulsion polymerization. After that, these nanocapsules were applied onto the cotton fabrics in a manner depending on the adhesive properties of PBCA. The morphology and structure of the nanotuberose fragrance (Nano-TF) and the aromatic cotton fabrics were characterized by transmission electron microscopy (TEM), Fourier transform infrared (FTIR) spectroscopy, thermogravimetric analysis (TGA), and scanning electron microscopy (SEM). The aroma sustained-release properties of the cotton fabrics after different treatments, including water washing, long-term placement, and high temperatures, were investigated in detail by gas chromatography/hydrogen flame ionization detection (GC-FID). The relationship between the structure of Nano-TF and the properties of the aromatic cotton fabrics was built up.

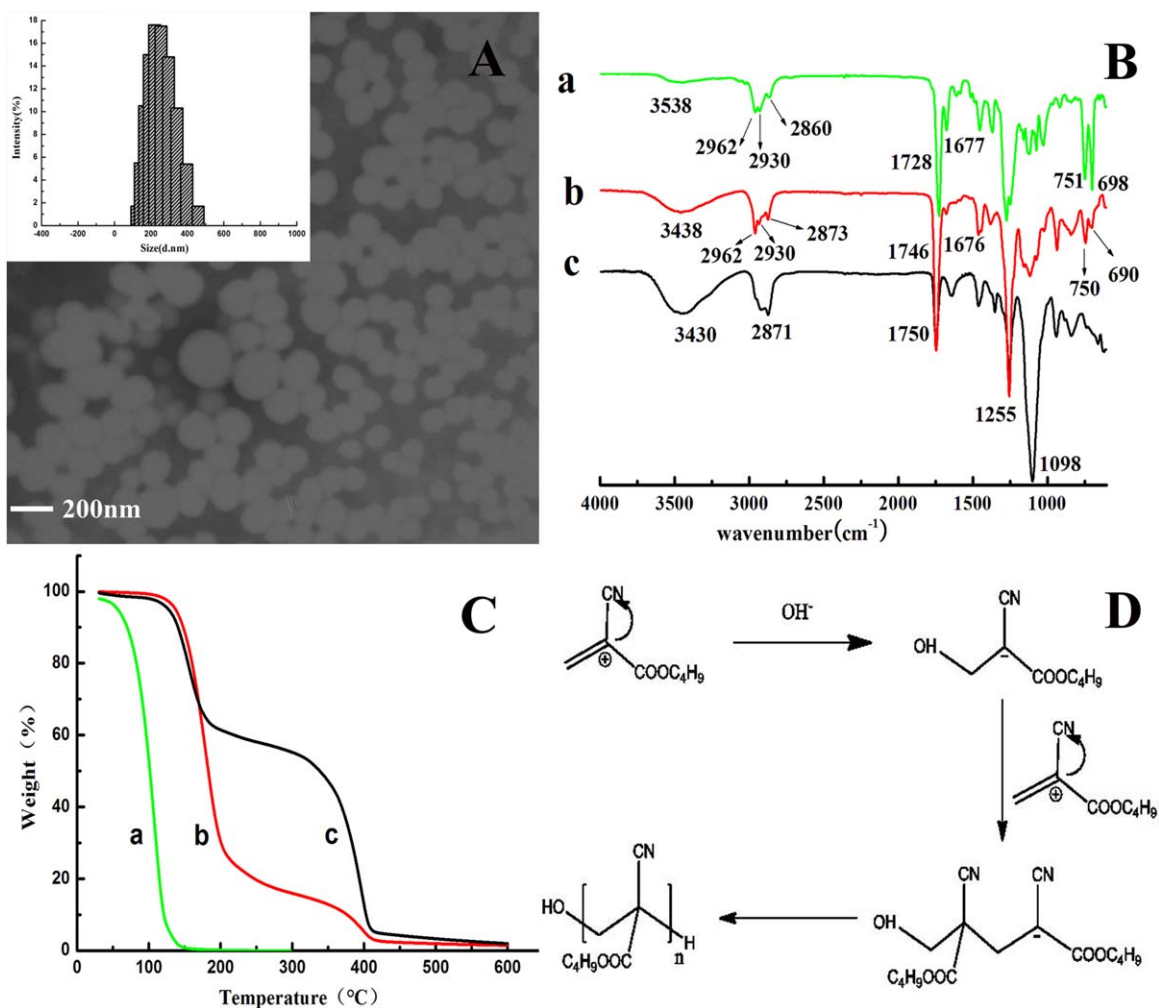


Figure 1. TEM and DLS (inset) of (A) Nano-TF, (B) FTIR spectra result, (C) TGA result, and (D) polymerization mechanism of PBCA [(a) TF, (b) Nano-TF, and (c) BCA nanoparticles]. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

EXPERIMENTAL

Materials

Hydrochloric acid (HCl), sodium hydroxide (NaOH), butylcyanoacrylate (BCA), polyoxyethylene sorbitan monolaurate (Tween-20), and the surfactant polyoxyethylene ether (JFC) were all purchased from Sinopharm Chemical Reagent Co., Ltd. Benzyl propionate (2 mg/mL) was obtained from Shanghai Anpu Scientific Instrument Co., Ltd. (Shanghai, China) as the internal standard. TF was compounded by ourselves. The properties of the components in TF are shown in Table I. All of the reagents were used without further purification.

Preparation of Nano-TF

In a typical experiment, 0.36 g of TF and 1.5 g of Tween-20 were mixed in a 50 mL round flask and stirred at 500 rpm for 5 min. An amount of 27.78 g of H₂O was added to the flask and emulsified for 20 min at 500 rpm. Then, the pH of the system was controlled to 5.0 with an aqueous solution of HCl (0.1 mol/L). With the addition of BCA (0.36 g), the polymerization reaction was carried out at 25°C for 3 h. At last, the pH of

the system was adjusted with an aqueous solution of NaOH (1 mol/L) to 7.0.

Impregnation of Nano-TF on Cotton Fabrics

The cotton fabrics was purified in an NaCO₃ aqueous solution (2 g/L) for 60 min at 100°C, then washed with H₂O, and dried naturally. Next, the purified cotton fabrics (2 g) were immersed in the Nano-TF (2 g) and surfactant JFC (0.2 g) at a liquid ratio [Volume of finishing liquid/Quality of cotton fabric (kg)] of 40:1 for 8 h at 800 rpm and 35°C. Then, the finished cotton fabrics were washed and dried naturally. The washing conditions (ISO 105 C01) were as follows: 50 g of aromatic cotton fabrics, 3 g of nonperfumed commercial washing agent purchased from Nice Group Co., and 1500 g of 40°C water were added to a commercial washing machine (XQB42-777B washing machine, Haier, China). This included a permanent press cycle, a 10-min warm water wash, a 5-min cold rinse, and 3 min of spinning. After 50 washing cycles, the aromatic cotton fabrics were dried naturally.¹⁹ The conditions of their placement time were as follows: the temperature was controlled as 25 ± 2°C, and the relative humidity was about 50%. During this period, the aromatic cotton fabrics

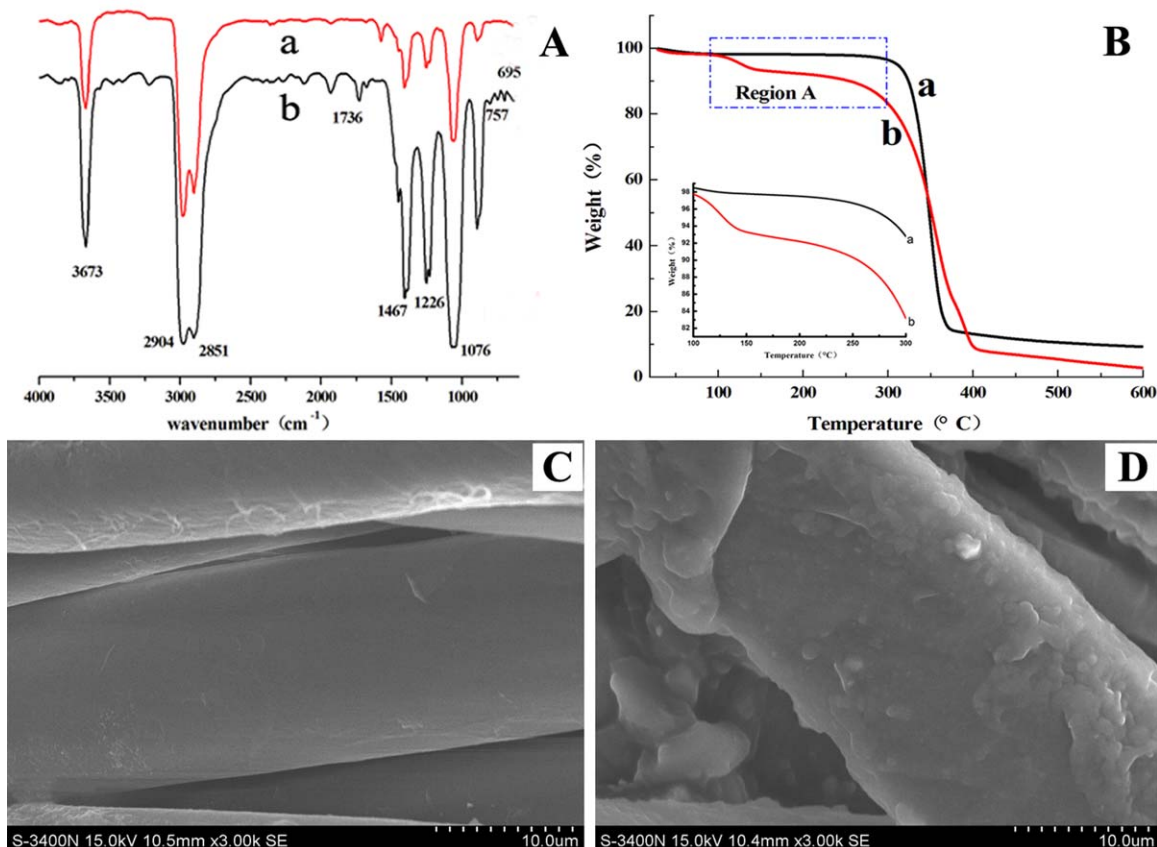


Figure 2. (A) FTIR spectra result, (B) TGA result, and (C) SEM of the cotton fabrics and (D) aroma cotton fabrics with Nano-TF [(a) cotton fabrics and (b) aromatic cotton fabrics]. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

were determined after 5, 20, and 60 days of placement. The conditions of the placing temperature were as follows: the temperature was $120 \pm 2^\circ\text{C}$ with an air current rate of 0.4 m/s in the ovens (moisture content = $0.01 \times 10^3 \text{ kg/m}^3$, Y802 Eight Baskets Oven, Huizhou Electricity Factory). In this process, the aromatic cotton fabrics were analyzed after 1, 3, and 5 h.

Dynamic Light Scattering (DLS)

The mean diameter and the polydispersity index (PDI) of Nano-TF were determined by a Zetasizer Nano ZS (Malvern Instruments, Ltd., United Kingdom). PDI was a pointer of the nanocapsule size distribution, which ranged from 0 to 1.

Particle Micromorphology

The morphology and size distribution of Nano-TF were investigated through TEM. TEM analysis of Nano-TF was performed with an H-600 electron microscope (Hitachi Co., Japan).

Chemical Structural Analysis

We used FTIR spectroscopy to obtain the structural changes of the materials after they were reacted through checking the alteration of the peak shape, position, and intensity. The chemical structures of the PBCA, TF, Nano-TF, cotton fabrics, and aromatic cotton fabrics were characterized by a VETOR-7 FTIR instrument (Bruker Co., German).

TGA

A TGA-Q5000IR instrument (TA Instruments) was used to determine the heat stability and loading TF content of the

Nano-TF. In addition, the adsorption capacity of the Nano-TF onto the cotton fabrics was measured. We performed this measurement by heating the fabrics to 600°C at a rate of $10^\circ\text{C}/\text{min}$ under a constant N_2 flow (20 mL/min). The same process was used for the cotton fabrics and aromatic cotton fabrics.

SEM

SEM analysis was performed to determine the appearance of the cotton fabrics and aromatic cotton fabrics. The samples were placed on a carbon-coated stub and coated with a thin layer of sputtered gold by a Cressington 208HR sputter coater. The morphology of the samples was observed via a scanning electron microscope (FEI Quanta 200FEG, Phillips FEI Co., The Netherlands).

Release Experiments

Each volatile component in the TF mixture released from the aromatic cotton fabrics was measured by GC-FID. The effects of the 50 washing cycles, the placement time at room temperature, and the 120°C treatment on the aromatic sustained-release properties of the cotton fabrics were investigated in this study. The initial content of each component in the aromatic cotton fabrics without any treatment was abbreviated as W_1 . The content of those with different treatments was abbreviated as W_2 . The loss ratio (LR) of each component was calculated according to the following equation:

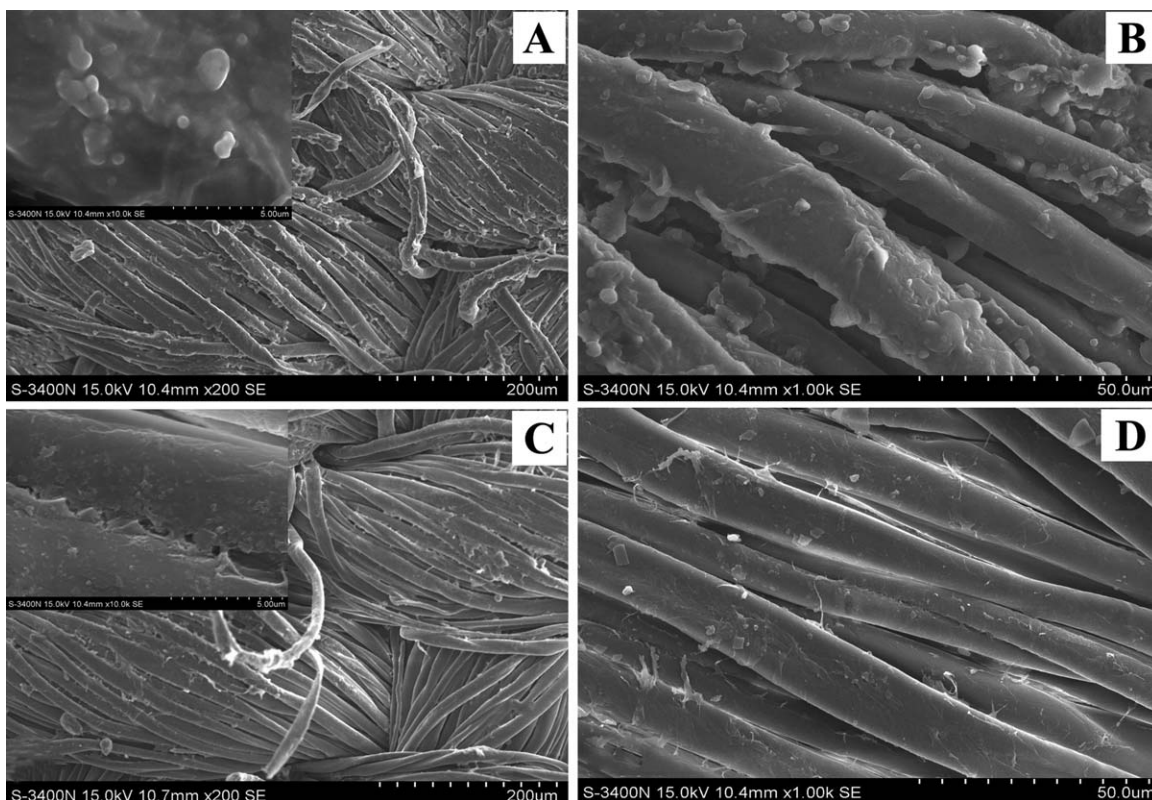


Figure 3. Influence of water washing on the aromatic cotton fabrics impregnated with Nano-TF: (A,B) without washing and (C,D) after washing 50 times.

$$LR(\%) = \frac{W_2 W_1}{W_1} \times 100 \quad (1)$$

When the fabrics were introduced in a bottle that was closed and placed into a water bath at 80°C for 50 min, the volatile components spread out in the gas phase until the head space reached a balance. Then, the solid-phase microextraction fiber was exposed to the head space 1 cm above the finished fabrics to absorb the analytes. After 50 min, the fiber was withdrawn into the needle and then introduced into a heated chromatograph injector for desorption and analysis.

An Agilent HP6890N gas chromatograph with hydrogen flame ionization detection (Agilent Technologies, Inc., New York) was used with a DB-5MS polar column (60 m × 0.25 mm × 0.25 mm film, Supelco). The carrier gas was ultrapurified helium at a flow rate of 1.0 mL/min. The injection was conducted in splitless mode for 20 min at 250°C. The temperature program was isothermal for 2 min at 60°C with an increase to 150°C at a rate of 5°C/min. Finally, the sample was heated up to 250°C and held for 5 min.

RESULTS AND DISCUSSION

Morphology and Structure of the Nano-TF

Figure 1(A) show the morphology and size distribution of the Nano-TF. The spherical Nano-TF dispersed evenly, and its size ranged from 150 to 250 nm, as shown in the TEM images. DLS indicated that the average diameter of the Nano-TF was 202.4 nm and the PDI was 0.107. Figure 1(B) shows the FTIR spectra of the

TF, Nano-TF, and PBCA. The TF was a mixture, including alcohol, phenol, ester, aldehyde, ketone, and terpenes. The main absorption peaks appearing in the FTIR spectra of the TF

Table II. Influence of 50 Water Washings on the Aromatic Sustained-Release Properties of the Cotton Fabrics Impregnated with the Nano-TF (A) and TF emulsion (B)

Component	LR (%)		Change ratio (%)
	A	B	
Linalool	57.38	100	42.62
Phenethyl alcohol	85.58	100	14.42
Benzyl acetate	100	100	0
Geraniol	77.63	100	22.37
Hydroxycitronellal	33.33	100	66.67
Isoeugenol	15.54	92.25	76.71
Methyl ionone	82.58	98.94	16.36
Lilial	32.14	87.19	55.05
Diethyl phthalate	6.67	100	93.33
Methyl dihydrojasmonate	6.56	100	93.44
Hexyl salicylate	12.37	96.99	84.62
α-Hexylcinnamaldehyde	22.94	90.01	67.07
Benzyl benzoate	14.46	86.08	71.62
Galaxolide	22.68	78.93	56.25
Benzyl salicylate	13.93	94.1	80.17

Table III. Influence of the Placement Time at Room Temperature on the Aromatic Sustained-Release Properties of the Cotton Fabrics Impregnated with Nano-TF (A) and TF Emulsion (B)

Component	LR (%)					
	5 days		20 days		60 days	
	A	B	A	B	A	B
Linalool	53.57	88.09	79.11	100	83.51	100
Phenethyl alcohol	2.36	100	57.64	100	72.01	100
Benzyl acetate	71.68	100	84.62	100	100	100
Geraniol	10.34	88.6	46.28	100	70.76	100
Hydroxycitronellal	6.82	100	16.09	100	100	100
Isoeugenol	12.53	70.98	24.1	89.93	28.15	92.57
Methyl ionone	2.91	95.88	71.13	96.85	73.75	97.78
Lilial	44.72	17.87	56.35	64.46	62.69	74.36
Diethyl phthalate	5.87	7.22	11.58	78.95	13.35	87.83
Methyl dihydrojasmonate	4.26	86.22	7.39	94.68	11.16	97.12
Hexyl salicylate	30.93	82.71	29.41	94.19	36.56	96.05
α -Hexylcinnamaldehyde	3.84	60.58	8.75	86.05	12.11	88.32
Benzyl benzoate	1.89	17.17	9.02	67.17	11.62	70.39
Galaxolide	14.81	32.92	17.96	73.12	19.27	80.76
Benzyl salicylate	2.05	63.94	7.02	87.04	10.29	88.33

corresponded to the absorption peak of $-\text{OH}$ (3538 cm^{-1}), the three absorption peaks of $(\text{O}=\text{C})-\text{H}$ (2860 , 2930 , and 2962 cm^{-1}), the absorption peak of $-\text{C}=\text{O}$ (1728 cm^{-1}), and the two absorption peaks of benzene ring (monosubstituted or disubstituted) in the fingerprint region (751 and 698 cm^{-1}). For PBCA, the characteristic absorption bands at 3430 cm^{-1} were attributed to the stretching vibrations of $-\text{OH}$ groups, which belonged to OH^- as an initiator during the polymerization of PBCA [Figure 1(D)]. All of these peaks appeared in the spectrum of Nano-TF, however, the stretching vibrations peak of $-\text{OH}$ shifted to 3482 cm^{-1} because of the function of the hydrogen bonds between TF and PBCA. In addition, the absence of the $-\text{C}=\text{C}-$ absorption peaks (1640 cm^{-1}) in the PBCA FTIR spectra showed that PBCA was polymerized effectively. These results show that the TF was encapsulated by PBCA.

Figure 1(C) shows the TGA results of the TF, Nano-TF, and PBCA. The TF was completely decomposed from 50 to 115°C . For PBCA, there were two weight loss stages. The first weight loss (36.53%) from 125 to 200°C corresponded to the decomposition of PBCA in the amorphous region. The second weight loss (56.77%), ranging from 200 to 425°C , could be ascribed to the decomposition of PBCA in the crystalline region. Compared with the PBCA and TF, the Nano-TF had two weight loss stages. The first weight loss from 125 to 200°C increased to 68.84% with the existence of the TF. In addition, the initial thermal decomposition temperature of the Nano-TF was improved to 125°C because of the encapsulation of the TF with PBCA. According to eq. (2), the LC of TF in Nano-TF was 50.9% :

$$\frac{52.99 - \text{LC}}{100\% - 4.313\% - \text{LC}} = \frac{44.64\%}{100\% - 2.145\%} \quad (2)$$

Structure of the Cotton Fabrics Impregnated with Nano-TF

Figure 2(A) illustrates that the difference between the structure of the cotton fabrics and the cotton fabrics impregnated with the Nano-TF. For the cotton fabrics, the strong absorption band at 3673 cm^{-1} was attributed to the stretching vibrations of the $-\text{OH}$ groups. The peaks at 2904 and 2851 cm^{-1} corresponded to the asymmetrical and symmetrical stretching vibrations of the $-\text{CH}_2$ groups, respectively. The absorption peak at 1467 cm^{-1} was assigned to the deformation vibrations of $\text{C}-\text{H}$, and the characteristic bonds at 1226 and 1076 cm^{-1} were attributed to the $-\text{C}-\text{O}$ groups of esters and anhydrides. All of these peaks appeared in the spectrum of the aromatic cotton fabrics. Compared with the cotton fabrics, the absorption band of the aromatic cotton fabrics at 1736 cm^{-1} was assigned to the $-\text{C}=\text{O}-$ group of the compounds in TF. In addition, the two absorption peaks at 751 and 698 cm^{-1} were ascribed to the benzene ring (monosubstituted or disubstituted) in the fingerprint region, as shown in Figure 1(B). This result demonstrated that the Nano-TF was impregnated into the cotton fabrics.

The TGA results of the cotton fabrics and the aromatic cotton fabrics are shown in Figure 2(B). The cotton fabrics only had one thermal decomposition from 300 to 375°C , and the weight loss was 82.12% . The initial decomposition temperature of the aromatic cotton fabrics decreased to 125°C for the existence of Nano-TF. The whole weight loss increased to 92.14% , and this belonged to the decomposition of the cotton fiber and Nano-TF. We concluded that 10.02% Nano-TF was impregnated into the cotton fabrics.

Figure 2(C,D) shows the morphology difference between the cotton fabrics and the aromatic cotton fabrics. The cotton fibers

Table IV. Influence of the Placement Time at 120°C on the Aromatic Sustained-Release Properties of the Cotton Fabrics Impregnated with the Nano-TF (A) and TF Emulsion (B)

Component	LR (%)					
	1 h		3 h		5 h	
	A	B	A	B	A	B
Linalool	47.05	97.54	51.54	98.46	59.87	100
Phenethyl alcohol	27.93	88.00	57.14	100	63.56	100
Benzyl acetate	23.21	100	23.50	100	45.00	100
Geraniol	4.77	78.42	8.04	88.83	71.32	92.60
Hydroxycitronellal	10.23	87.22	100	100	100	100
Isoeugenol	23.04	77.85	69.68	87.73	72.72	88.72
Methyl ionone	10.90	92.03	70.12	95.62	70.26	96.11
Lilial	26.40	66.18	77.06	46.79	79.65	79.78
Diethyl phthalate	10.98	69.05	67.59	48.31	76.50	80.20
methyl dihydrojasmonate	8.12	84.10	64.99	93.82	76.79	96.03
Hexyl salicylate	12.98	84.82	74.08	90.75	79.39	93.38
α -Hexylcinnamaldehyde	4.21	79.63	62.25	86.61	78.48	89.38
Benzyl benzoate	0.79	77.56	19.28	64.52	54.44	70.69
Galaxolide	4.60	67.84	65.23	76.44	73.14	80.85
Benzyl salicylate	3.60	48.95	14.97	88.15	23.50	88.89

were smooth and arranged in a line. After the addition of Nano-TF, the surface of the cotton fabrics became rough. Some irregular spherical Nano-TF particles with sizes ranging from 1 to 10 μm were adhered onto the surface of the cotton fibers. At first, some Nano-TF, with sizes of 150–200 nm, could penetrate into the cotton fibers. In addition, PBCA, as a shell of Nano-TF particles, was a sticky resin, which could become coalescence during the drying process of the emulsions. Therefore, Nano-TF particles with big sizes were aggregated on the cotton fibers.

Release Properties of the Aromatic Fabrics

Influence of 50 Water Washings. Table II shows a comparison of the aroma losses between the cotton fabrics impregnated with Nano-TF and the TF emulsion. After 50 washing cycles, the aroma compounds in the cotton fabrics impregnated with the Nano-TF and TF emulsion were obviously lost. For the cotton fabrics impregnated with the TF emulsion, almost every component of the TF was lost completely. However, only four compounds, including phenethyl alcohol, benzyl acetate, geraniol, and methyl ionone in the cotton fabrics impregnated with the Nano-TF were reduced by over 75%; other compounds retained their high contents. This result demonstrates that the sustained-release properties of the cotton fabrics impregnated with Nano-TF were better than those of the fabrics impregnated with the TF emulsion.

Figure 3 illustrates the influence of water washing on the aromatic cotton fabrics impregnated with Nano-TF. A large amount of Nano-TF dispersed on the surface of the cotton fibers without washing, as shown in Figure 3(A,B). The size of

the Nano-TF increased to 5–10 μm for their aggregations, which was attributed to the adhesive properties of PBCA during the drying process. After 50 washing cycles, there was still some Nano-TF on the cotton fibers. During this experiment, Nano-TF was added to the cotton fabrics directly without any adhesives. The adhesive properties of PBCA provided advantages for the interactions between the Nano-TF and the cotton fibers.

Influence of the Placement Time at Room Temperature. Table III shows the influence of the placement time at room temperature on the aroma sustained-release properties of the cotton fabrics impregnated with the Nano-TF and TF emulsion. With prolonged time, both of the aroma compounds in the cotton fabrics impregnated with Nano-TF and TF emulsion were reduced. During this period, the loss of fragrant components released from the cotton fabrics impregnated with Nano-TF was still much lower than that with TF emulsion. At day 5, three compounds, including phenethyl alcohol, benzyl acetate, and hydroxycitronellal, in the cotton fabrics impregnated with the TF emulsion had not been detected completely. However, for the cotton fabrics impregnated with the Nano-TF, phenethyl alcohol and hydroxycitronellal decreased by 2.36 and 6.82%, respectively. After 60 days, most of the fragrance in the aromatic cotton fabrics with the TF emulsion were lost completely, whereas only two compounds, benzyl acetate and hydroxycitronellal, released from the fabrics with Nano-TF were reduced by 100%. The whole aroma of the aromatic cotton fabrics with Nano-TF was retained. This was attributed to the encapsulation of the fragrance with PBCA and a high LC.

Influence of the Placement Time at 120°C. The influence of the display time at 120°C on the aroma sustained-release properties of the cotton fabrics impregnated with Nano-TF and TF emulsion is shown in Table IV. Generally, aroma compounds evaporate easily at high temperatures because of the quickened movement of the small, fragrant molecules. When both of the aromatic cotton fabrics were deposited at 120°C, the aromatic compounds decreased with time prolonged. The aroma-reserving effect of the cotton fabrics impregnated with the Nano-TF was better than that with the TF emulsion. Almost each component in the cotton fabrics impregnated with the TF emulsion was reduced in excess of 60% after 1 h of placement at 120°C. However, most components in the cotton fabrics impregnated with Nano-TF lost less than 20%. After 5 h of display, the linalool in the cotton fabrics impregnated with the TF emulsion was also totally lost; other compounds were reduced by over 80%. For the cotton fabrics impregnated with the Nano-TF, the main components, phenethyl alcohol, benzyl acetate, diethyl phthalate, methyl dihydrojasmonate, and galaxolide, within the TF mixture were reduced by 63.56, 45.00, 76.50, 76.79, and 73.14%, respectively. The results revealed that the cotton fabrics impregnated with the Nano-TF had excellent sustained-release properties.

CONCLUSIONS

PBCA nanoparticles loaded with TF (Nano-TF) were successfully prepared via emulsion polymerization. Nano-TF was applied in the cotton fabrics as an aromatic reagent by impregnation without adhesives. DLS and TEM showed that the average size of the spherical Nano-TF was 202.4 nm. FTIR spectroscopy demonstrated that the TF was incorporated into PBCA via hydrogen bonding, and Nano-TF was in existence in the cotton fabrics. TGA illustrated that the LC values of the TF in the Nano-TF were 50.9 and 10.02%. Nano-TF was impregnated into the cotton fabrics. GC-FID showed that the aromatic sustained-release properties of the aromatic cotton fabrics impregnated with Nano-TF after 50 washing cycles, 60 day of placement, and 5 h of display at 120°C was better than those of the fabrics impregnated with the TF. The whole aroma of the cotton fabrics impregnated with Nano-TF remained intact. PBCA nanocapsules with a high LC of fragrance exhibited excellent sustained-release properties and could be applied in many fields.

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