

# Fragrance-release Property of $\beta$ -Cyclodextrin Inclusion Compounds and their Application in Aromatherapy

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**ABSTRACT:** Fragrance compounds and essential oils are chosen carefully taking advantage of research works in aromatherapy. Considering their volatile nature, the fragrance molecules have to be formed as inclusion compounds with cyclodextrin molecules in order to retain fragrances for a long time. To prepare aromatherapeutic textiles,  $\beta$ -cyclodextrin is the first choice as the host molecule, because  $\beta$ -cyclodextrin molecules are capable of forming inclusion compounds with organic compounds that fit into their own cone-shaped hydrophobic cavities. As a result of the inclusion, the physicochemical properties of the compounds are changed; for example, the vapor pressure of the volatile substance is reduced and the stabilities against light and air are enhanced. The functional textile with the “guest–host” effect may be achieved by anchoring the inclusion compound. The sedative effects for emotion and the pharmaceutical effects of essential oils are shown in detail. X-ray powder diffraction spectrum shows that lavender oils can form inclusion compounds with  $\beta$ -cyclodextrin. The effects of the nature of essential oils, such as detection threshold and tenacity on the fragrance-release property are discussed. The inclusion compounds are fixed onto fabric by the traditional pad method to obtain the

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medical textile with aromatherapy effect. The results of sensorial evaluations shows that the perfume of the fabrics can last for more than 30 days.

**KEY WORDS:** aromatherapy, medical textile, inclusion compound,  $\beta$ -cyclodextrin, fragrance-release.

## INTRODUCTION

**P**URE FRAGRANCE COMPOUNDS and essential oils have been traditionally used in folk medicine for a long time. They are much discussed these days because of their viable holistic and pharmaceutical effects and the trend in medicine to go back to natural drugs and therapies. The term aromatherapy was coined in the late 1920s by a French cosmetic chemist R.M. Gattefosse, who noticed the excellent antiseptic properties and skin permeability of essential oils [1]. The term Aroma-chology [2] (a Service Mark of the Olfactory Research Fund) was coined in 1982 to denote the science dedicated to the study of the interrelationship between psychology and fragrance technology to elicit a variety of specific feelings and emotions – relaxation, exhilaration, sensuality, happiness, and well-being – through odors, via stimulation of the olfactory pathways in the brain, especially the limbic system. Regrettably, aromatherapy is yet to be defined in Science.

The developments in the field of aromatherapy after 1980 can be diversified into four basic areas: medical and holistic-medical aromatherapy, as practiced in France; popular and esoteric aromatherapy, as found in publications in all western societies; aromatherapy applied during massage, as practiced mainly in Great Britain; and the scientific study of fragrance, as encouraged by the Fragrance Research Fund [3].

Lavender is the most used and the most versatile of all the essential oils. It is distilled from *Lavandulvern*, which is native to the Alpine slopes of the Mediterranean. It is a very useful oil, especially when used against symptoms due to a nervous problem. Its main effects are presented in Table 1 [4]. The sedative and other pharmaceutical effects of essential oils are listed in Table 2.

*Table 1. Main effects of lavender oil.*

System	Symptoms
Nervous	Anxiety, depression, general debility, irritability, palpitations
Skin	Alopecia, bites, boils, burns, psoriasis, inflammation, eczema dermatitis
Muscular	Aches and pains, rheumatism, sprains
Menstrual	Irregularity, leukorrhea, scanty
Respiratory	Flu, all catarrhal complaints

Table 2. The pharmaceutical effects of essential oils [5–7].

Essential Oil	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18
	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#
Effects																		
Sedation																		
Coalescence																		
Diuresis																		
Facilitating menses																		
Good for stomach																		
Diaphoresis																		
Expelling wind																		
Losing weight																		
Relieving pain																		
Curing diabetes																		
Stopping diarrhea																		
Curing flu																		
Curing rheumatism																		
Urging sexual																		
passion																		
Relieving spasm																		

Note: 1#–18# refer to pine, vanilla, ginger, clove, lavender, mint, onion, oregano, citrus, rosemary, thyme, fennel, basil, chamomile, cinnamon, lemon, metasequoia, and ylangylang respectively in order.

Cosmetic companies are now beginning to incorporate aroma-ology or aromatherapy into their product development. In the US, retail sales of all home fragrance products, which were divided into environmental fragrances and fresheners, climbed nearly 11% to \$1.96 billion in 1999 over 1998 sales of \$1.77 billion, according to Kalorama Information, a New York City-based market research firm. The investigation of the US retail sales of home fragrances showed that sales increased 9.7% from \$1.35 billion in 1995 to \$1.96 billion in 1999, and are projected to increase by 7.9% to reach \$2.87 billion in 2004 (Table 3). The strongest performing sector is environmental fragrances, which comprises incenses, aromatherapy products, and specialty products such as pomanders and scented drawer liners. This study showed that the sales of environmental fragrances were driven by the ‘cocooning’ trend to create pleasant home environments as well as having a functional use as odor neutralizers, insect repellants, or smoke reducers.

A new development in the field of textiles is selling for active wear, leisurewear, and intimate apparel. This approach will combine innovative fiber and textile technologies designed to appeal beyond physiological and functional benefits.

Fragrance compounds and essential oils are volatile substances. The most difficult task in textile aromatherapy is how to prolong the lifetime of

*Table 3. US retail sales of home fragrances [8] by category, 1995–2004 in millions of dollars.*

Year	1995	1999	CAGR 1995–1999	2004	CAGR 1999–2004	CAGR 1995–2004
Products						
Environmental fragrances	727	1270	15.00%	2150	11.01%	12.80%
Air fresheners	624	690	2.50%	720	0.90%	1.60%
Total	1351	1960	9.70%	2,870	7.90%	8.70%

CAGR = Compound annual growth rate.

aromas. Microencapsulation is an effective solution [9,10]. Microcapsules are minute containers that are normally spherical if they enclose a liquid or gas, and roughly of the shape of the enclosed particle if they contain a solid. They can be considered as a special form of packaging, in that the particulate matter can be individually coated for protection against environment and release the volatile substance from the enclosed capsule as required. This property has enabled microcapsules to serve many useful functions and find application in different fields of technology. For example, the storage life of a volatile compound can be increased markedly by microencapsulation. Although there are many effective approaches to microencapsulation in order to slow down fragrance-release, cyclodextrins are the best considering issues of human safety.

Cyclodextrins are nonreducing cyclic oligosaccharides produced by certain microorganism-cultivated starch variety, and are capable of forming inclusion compounds with molecules that fit into their cone-shaped hydrophobic cavity [11,12]. The encapsulation process is accompanied by changes in the properties of the substance within the cavity, e.g., vapor pressure of the volatile substance. They pose no skin irritation, no skin sensibility, and no mutagenic or teratogenic effect. The scents of lavender, rose, citrus, or vanilla are included into cyclodextrins to fulfill important psychological and emotional needs as well as needs of a purely physical and sensorial nature. The medical textile with functional aromatherapy can be realized in this way.

## EXPERIMENTAL

### Material

Mill desized, scoured, and bleached fabric (Poplin) was purchased from a spinning and weaving factory.  $\beta$ -Cyclodextrin was reagent grade, procured

from the market. Lavender was commercial grade product, kindly supplied by the Perfume Institute, Shanghai, China. The alcohol used was of laboratory grade.

### **Laboratory Apparatus**

The high-speed shearing emulsifier BME 1001 was from Weiyu Mechanical-electronic Co. Ltd., Shanghai. The JB90-D heavy electrical agitating machine was from Shanghai Specimen Model Factory. The TSM microsize particle analyzer was from the Shanghai University of Science and Engineering. UV-3000 reflectance spectrophotometer was from Shimadzu, Japan. FT-Raman spectrum NEXUS-670 was from an American Company called Nicolet.

### **Procedures**

#### *Preparation of Inclusion Compound*

$\beta$ -Cyclodextrins were resolute in a mixture of alcohol and distilled water (1:3). The solution was emulsified in a high-speed mixer at a speed of about 10,000 rpm for 5 min. The emulsified solution was transferred to a flask. The lavender-alcohol solution was added to the emulsified solution within 30 min, with the aid of stirring, while the temperature was maintained at 40°C for 2 h.

#### *Application of Inclusion Compound on Cotton*

The inclusion compound was fixed onto cotton with a low temperature binder by conventional pad-thermofixing method. Cotton fabric was padded twice to a wet pick up of 100% in the solution. The treated fabric was then subjected to heat treatment at 80°C for 5 min.

#### *Testing and Analysis*

The inclusion compound in the treated fabric was extracted by alcohol in 12 h. The concentration of the lavender on the fabric was measured on the UV-3000 reflectance spectrophotometer. The excitation wavelength was 276 nm. Optical microscope photograph of the crystal inclusion compounds was taken by a computer controlled UV-G image analysis system.

## RESULTS AND DISCUSSION

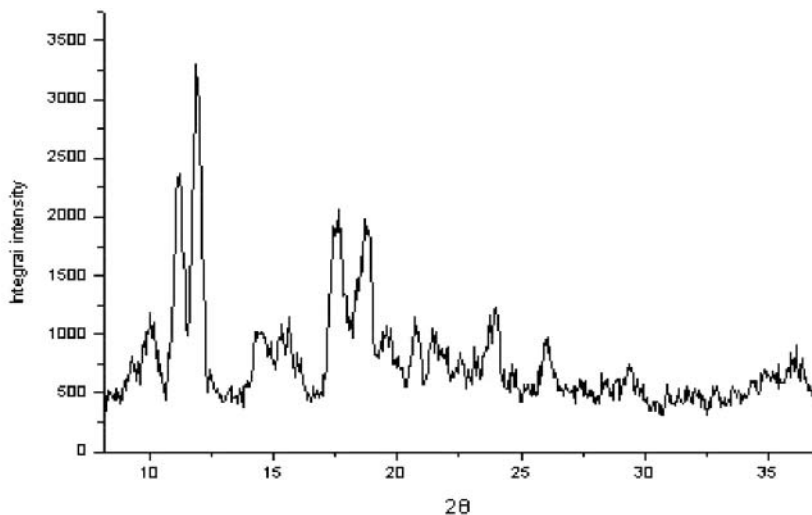
### The Formation of Inclusion Compounds

The stability of the formation of inclusion compounds between cyclodextrins and essential oils depends on the size of the hollow space in the cyclodextrins and the polarity of the environment of the essential oils.

X-ray powder diffraction spectrum is a useful tool to determine whether inclusion compounds have formed or not. As guest molecules, essential oils are liquids, which are not able to produce any diffraction. However, the inclusion compounds are of powder crystal, which can form characteristic peaks. The X-ray diffraction spectrum (Figure 1) showed that the diffraction peak at  $2\theta = 17.6^\circ$  and  $2\theta = 18.8^\circ$  was produced by the inclusion compounds of cyclodextrin and lavender oil.

### Nature of Fragrance Compounds

Fragrance compounds are volatile substances. This nature is the most important factor that influences the rate of fragrance-release of inclusion compounds. The minimum scents of different fragrance substances used are different. The detection thresholds describe this well, whose value might be influenced by the solvent. Considering that inclusion compounds will be fixed on the surface of cotton, the detection threshold in water was tested.



**FIGURE 1.** X-ray diffraction spectra of inclusion compounds of cyclodextrin and lavender oils.

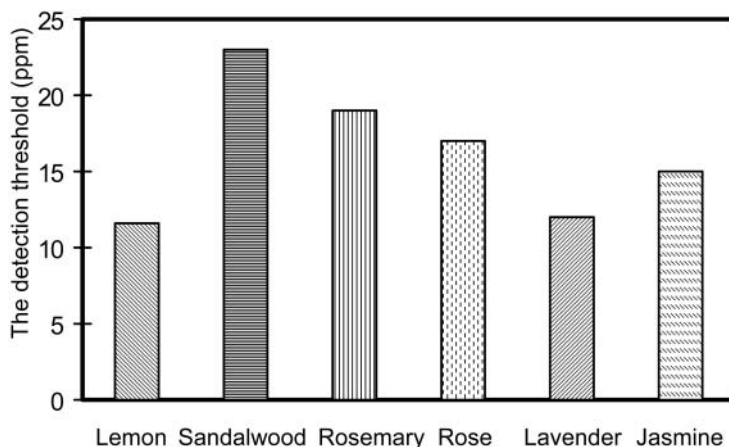


FIGURE 2. Detection threshold of fragrance compounds in water.

Fragrance substances dissolved in alcohol were added to water (1000 mL). After stirring for 10 min, the solution was diluted (1 : 1) until the scent of the solution could no more be felt by ten well-trained subjects. The results are shown in Figure 2.

Tenacity is defined as the lasting property of fragrance substances which are adhering to the surface of the fabric. The tested fabric was immersed in a water solution of fragrance substances (0.5 g/L), at room temperature for 12 h. The concentration of fragrance substances on the treated fabric was determined after 12 h by UV-3000 spectrophotometer. The results are presented in Figure 3.

Figures 2 and 3 show that the detection threshold and tenacity are quite different for the fragrance compounds used in practice. Sandalwood was different to smell even though the same concentration of fragrance compounds existed on the cotton fabric. The tenacity of lemon was the lowest among the six fragrance compounds, although it was easy to smell. For each fragrance compound, the scent could no more be felt after remaining immersed in the fragrance compound solution for 5 days.

### Fragrance-release Property

The form of the inclusion compound affects the rate of fragrance-release. The enclosed substance is totally or partially included in the cavity of the cyclodextrin. This system is not absolutely sealed. The concentration of essential oils on the fabric was measured by the UV-3000 reflectance spectrophotometer. The fragrance-release property is shown in Figure 4.

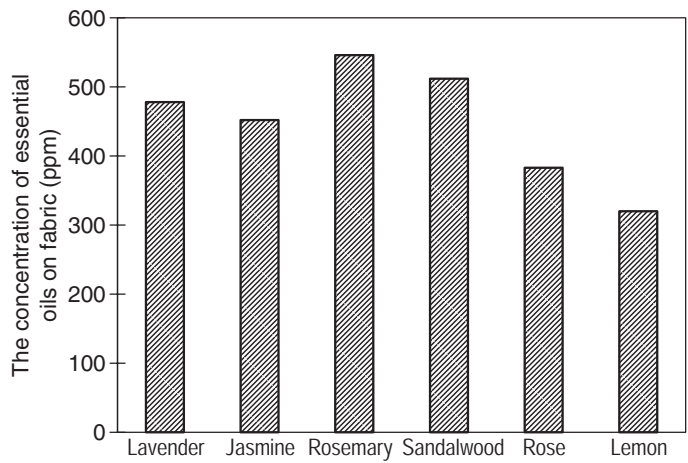


FIGURE 3. Tenacity of fragrance compounds.

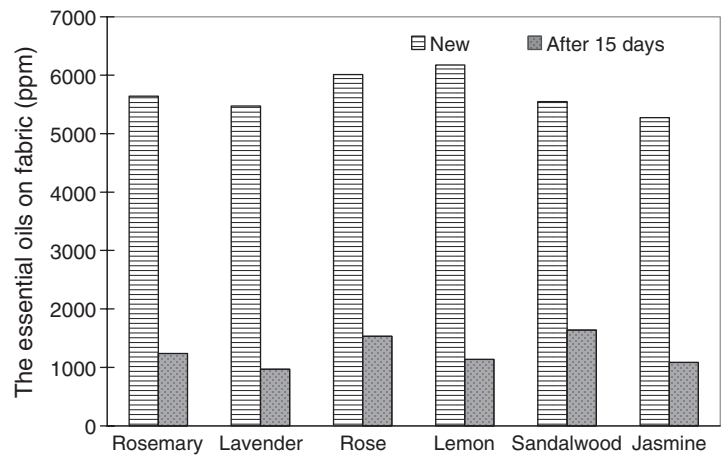


FIGURE 4. Rate of fragrance-release of treated fabrics.

A sensorial evaluation of results was also performed by a group of ten well-trained subjects, in insulated booths where fabrics kept on an open desk, at room temperature, were smelt every five days in order to feel the scents. The test panel evaluation results are presented in Table 4.

As the ‘second skin’ of the human body, all types of textiles are excellent agents to transfer fragrance compounds, and used by people according to their preference. Aromatherapeutic textiles formed of lavender, lemon,



Table 4. Sensorial evaluation of scent intensity

Fragrance substances	Scent Intensity						
	2 days	5 days	10 days	15 days	20 days	25 days	30 days
Rosemary <sup>a</sup>	+	nil	nil	nil	nil	nil	nil
Lavender <sup>a</sup>	nil	nil	nil	nil	nil	nil	nil
Jasmine <sup>a</sup>	nil	nil	nil	nil	nil	nil	nil
Lemon <sup>a</sup>	nil	nil	nil	nil	nil	nil	nil
Sandalwood <sup>a</sup>	+	nil	nil	nil	nil	nil	nil
Rosemary <sup>b</sup>	+++++	+++++	+++++	++++	+++	+++	++
Lavender <sup>b</sup>	+++++	+++++	++++	+++	++	++	+
Jasmine <sup>b</sup>	+++++	+++++	+++++	++++	+++	++	++
Lemon <sup>b</sup>	+++++	+++++	++++	+++	++	+	+
Sandalwood <sup>b</sup>	+++++	+++++	+++++	++++	+++	+++	++

+++++ express very strong; ++++ express strong; +++ express common; ++ express weak; + express very weak.

<sup>a</sup>before encapsulation; <sup>b</sup>after encapsulation.

chamomile, rose, cardamom, clove, or jasmine have a sedative effect, and are fit for bed gowns, underwear, sheets, curtains, carpets, etc. basil, chamomile, and lavender can be used for restraining the growth of bacteria in textiles. Work efficiency is shown to improve after inhaling jasmine, lavender and mint scents of an aromatherapeutic garment. Bacteria-restraining products are usually to be used on underwear, whereas outerwear such as a sweater is good for the fulfillment of other pharmaceutical effects of essential oils.

## SUMMARY

Aromatherapy, is becoming increasingly popular as an approach to healing with natural substances, and is favored by the public. It is available to people who attempt self-therapy at home. In this paper, it was shown that inclusion compounds of cyclodextrin and fragrance could be formed. As the guest substance, cyclodextrins could transfer the aroma successfully to the cotton fabric and pose no skin irritation, skin sensibility, or mutagenic or teratogenic effects. The properties of the fragrance compound, such as detection threshold and tenacity affected the scent intensity that could be smelt by a person. The rate of fragrance-release of inclusion compounds decreases with time. How long the pharmaceutical and physiological effects remain on the cotton fabrics has to be determined in a further study.

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