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Quantitative Fragrance Durability Evaluation Depending on Keeping Condition of Knitted Fabric Treated by Microcapsules Containing Star Anise Essential Oil

***Chu Dieu Huong**, Nguyen Thi Tu Trinh**
Hanoi University of Science and Technology, Hanoi, Vietnam
**Email: huong.chudieu@hust.edu.vn*

Abstract

Fabric treated by fragrance was one of textile applications. The evaluation of fragrance durability of fabric treated by the fragrance was always the subject of many researches, though quantitatively determining fragrance intensity was difficult and there will not always be agreement on odor characteristics by different testers. In this paper, we built a simple and quantitative method to evaluate the fragrance intensity, which could be considered as the remained oil quantity on fabric treated by microcapsule loaded with star anise essential oil. The evaluation was based on the combination of the expert method and diluted solution method. This method was used to evaluate the influence of the knitted fabric's keeping conditions on fragrance duration of the fabric. Two groups of single jersey fabric have been prepared: one was knitted from the Ne 40/1 Chief Value Cotton (CVC) yarn (60% cotton and 40% polyester). The second group was also single jersey fabric knitted from the Ne 46/1 100% cotton. The knitted fabrics were treated with microcapsules containing star anise essential oil and then have been kept in ambient conditions (temperature was about 25 °C ±2, relative humidity was 75% ±2) and in the cold dried condition (temperature was about 2 °C, relative humidity was 20%). The results showed that the developing method in the research can be used to effectively quantitatively evaluate the fragrance intensity of fabric treated by fragrance. The fabrics treated by microcapsules containing star anise oil essential remained their fragrance longer than 7 days in the cool dried condition while which ones in the ambient condition finished their fragrance after 5 days.

Keywords: Fragrance fabric, fragrance duration, aromatherapy, knitted fabric, single jersey fabric.

I. Introduction

Nowadays demands for sustainable development processing in textile production and an increase in environment protection have led to the development of many new cleaner and greener technologies. Recent researches have proposed many technologies for the eco processing of textiles, which include, finishing by natural products such as enzymatic finishing of textiles, plasma technology, and microencapsulation. Microcapsules are small particles that contain an active agent in a polymer material surrounded. The active agent inside the microcapsule is called a core material whereas the material surrounded is called a shell or membrane. Usually, microcapsule's diameters may be between a few micrometres and a few millimetres. The active agent inside the microcapsule could be delivered through the membrane. The deliverance is influenced by the different factors such as pore membrane dimension, the temperature, pH, extern force. The microencapsulation technique is now widely used in textile finishing [1]. Fragrance garments and even odour garments were always the subjects of rank in recent researches. Garment fabrics can retain and emit odour during wear and even after removal from the human body. Rachel H, McQueen *et al.* have studied the remaining axillary malodorous durability after removal from wearing of interlock fabrics knitted from three kinds of yarn: cotton, wool, and polyester [2]. The result showed that odour intensity is affected by the fiber type from which the garment is made. The authors reported that the intensity of axillary odour emanating from fabrics was inversely influenced by hydroscopic fibre ratio: the compounds likely to be associated with axillary malodour were found to increase over seven days in interlock polyester fabrics, but it was not clear for either the wool or cotton interlock fabrics with the same time. The differences in the chemical structure and physical morphology of the investigated fibres were the reason. The availability of reactive sites for absorption of volatile compounds may be a reason for differences in odour retention. Both cotton and wool have many hydroxyl groups which can make hydrogen bonds with polar molecules. Moreover, wool fibers have many reactive amino acid groups to which volatile molecule odour can bind within the fibre. Polyester, on the other hand, has no reactive groups so the hydrophobic tendency of polyester makes it likely to attract oily compounds present in sebaceous secretions from sweat humans. As bacterial numbers

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are not a reason for odour intensity emanating from fabrics that differ in fibre content, the difference among the studied fabrics may be a result of metabolic versatility of some resident microbial strains.

Obtaining a durable aroma finish on textiles has been a long-time dream for textile production. As fragrances are volatile so they evaporate away and do not stay for long periods and are not resistant to wash. Therefore, microencapsulation was found to be a solution to this problem. Microencapsulation can effectively control the release rate of fragrance compounds and essential oils as required which ensures the storage life of volatile substances. BHATT *et al.* have studied the durable aroma finish on cotton using microencapsulation technology [3]. They have coated a thin layer of gel with microcapsules containing a fragrance on cotton fabric and have verified the durability of fragrance after washing cycles. The results showed that the microcapsule shell clearly effects on keeping the volatile fragrance agent from the surrounding influence and has controlled the fragrance release. The fabrics have kept the fragrance after 30 washing cycles. The intensive fragrance has reduced while the number of washing cycles was increased. Rumeysa Tekin *et al.* have investigated the durability of the fabric treated by polyurethane-urea microcapsules containing the TeddysoftTM fragrance [4]. The microcapsules have been produced by interfacial polymerisation method. The fabric has been washed by domestic washing machine. The fragrance durability has been qualitatively evaluated by nine perfumers and by headspace-GC analysis. The quantitative evaluation given by the nine perfumers showed that the fabrics which have been washed with softener mixed with the microcapsules containing the TeddysoftTM fragrance keeping the fragrance one week longer than these ones washed with the softener containing only TeddysoftTM fragrance. Headspace-GC quantitative analysis showed also that the fragrance durability was longer in the first case than the ones in the second case. The results showed that the quantitative evaluation of the perfumers has met the ones evaluated by the GCMS but no detail describing has been provided for the quantitative evaluation of the perfumers. The fabrics treated with essential oil can reduce malodour in the garment by eliminating bacteria because the malodour has been caused by the metabolic bacteria in the human sweat. The application of chemical fragrances to garments has been carried out for decades year as fabric conditioners in the wash and tumble drying process but the effect was not for a long time and the direct contact with the skin of chemical fragrance may cause the worries for users. Application of microcapsules content essential oil showed advantages for fragrance fabric. The evaluation of the fabric fragrance duration treated by microcapsule with an active agent as essential oil stays an interesting solution.

Among the five human senses, smell is considered as the most complex and unique in structure and human organization. Odor is a psychophysical phenomenon. Four measurable parameters of perceived odor are odor concentration, odor intensity, odor persistence, and odor character descriptors. The parameters were closely related to each other. The odor intensity decreases with dilution at a different rate. Fig. 1 illustrates how the odor intensity of n-Butanol decreases as the odor is diluted [5].

So, in every case odor intensity is related to the odor concentration (dilution ratio).

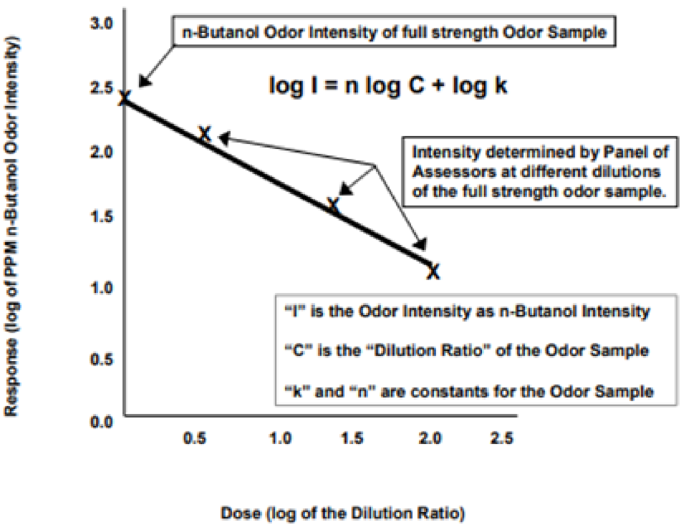

Fig. 1. "Dose-Reponse" plot of an odor sample.

Sensory evaluation in the laboratory came into practice to quantify the strength of odorous air emissions. Laboratory olfactometry involves diluting the odorous air sample at varying concentrations then presenting the diluted odor to human assessors to determine the threshold of the odorous emission. The laboratory dilution process simulates the dilution of the odor in the ambient air [5]. Although the measurement of a fragrance fabrics was not compliant to the laboratory olfactometry that lead to find one method to qualitatively evaluated the fabric samples. Among four parameters of perceived odor the odor intensity may be measured for evaluation of the duration of fragrance fabric samples. Odor intensity is measured using several methods including descriptive word category scales (for example the 5-point scale: no odor, slight, moderate, strong, very strong), magnitude estimation, and referencing scales. The magnitude estimation is qualitative and suitable for the evaluation of the same and similar odors. The procedure is comparing the intensity of one odor sample to another sample odor. The perfumer would be sniffed odor sample A and may give the intensity of this odor sample a value of “10”. After the perfumer would be presented odor sample B and they would provide a rating based on sample A: if sample B was perceived as half as intensity as sample A, the perfumer would give sample B an intensity of “5” [5]. This procedure is suitable for measuring the fragrance fabric so we adopted it for our experiments

So, this research studied the influence of ambient conditions on knitted fabrics treated by microcapsule with essential oil in their core. Moreover, developing a simple and quantitative method to evaluate the fragrance durability of fabric treated by microcapsule containing essential oil was our aim in this study.

2. Materials and Methods

2.1. Materials

2.1.1. Knitted fabrics

In order to study the influence of yarn material and the fabric parameters on the fragrance durability, the research had used the single jersey fabrics which knitted with the 100% cotton yarn and the CVC yarn (60% cotton and 40% polyester) with the different loop length (Table 1).

2.1.2. Microcapsules

The research used microcapsules (Fig. 2) that were kindly provided by the project 05/2012/HĐ-NĐT (Vietnam). The anise essential oil-loaded microcapsules were prepared by the solvent evaporation method. Eudragit RSPO supplied by Merk (Germany), was used as a polymer for membrane of microcapsules. Quillaja saponin bought from Sigma Aldrich (Germany) was used as a natural surfactant. The dispersed phase and dispersant phase were water and ethyl acetate, a non-halogenated solvent during microencapsulation process, respectively. All the materials were used as provided without any purification. The dispersed phase with the surfactant (0.2% w/w) was added to dispersant phase with polymer for membrane followed by mechanical stirring (700 tpm) to form the emulsion. The emulsion then let to evaporate the solvent to form the microcapsules which had been washed with distilled water to obtain the finished microcapsules. The size and size distribution of formed microcapsules were measured by the Laser Light Scattering. The microcapsules had nearly spherical shapes with the mean diameter of around 25-30 µm.

Table 1. Technical parameters of investigated knitted fabrics

Fabric code	Fabric material	Yarn	Yarn count	Loop length (mm)
CVC1	CVC	60% Cotton 40% PET	Ne 40/1	2,82
CVC2				2,56
CVC3				2,41
CT1	Cotton	100% Cotton	Ne 36/1	2,83
CT2				2,87
CT3				2,96

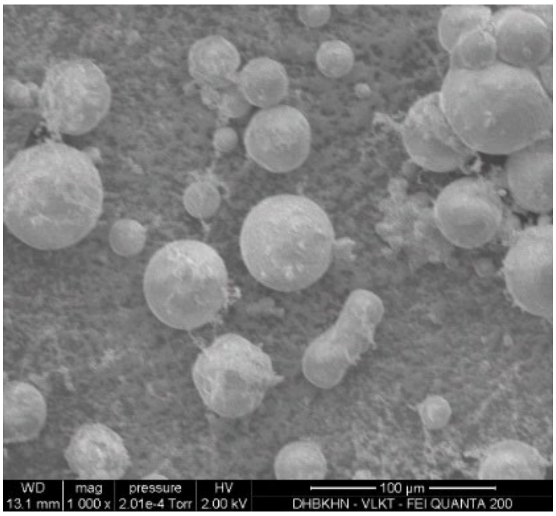

Fig. 2. SEM image of microcapsules containing star anise essential oil

2.2. Preparation of Fragrance Fabrics

An aqueous microcapsules solution (5% w/w) of microcapsules containing the star anise essential oil has been used as fabric fragrance agent solution. 2 ml of aqueous microcapsules solution had coated in square fabric sample of dimension 5 x 5 cm. Six samples have been prepared for every kind of fabric. The fragrance intensity of fabric coated by microcapsules has been investigated while the samples had kept in cold dried condition (temperature of 2 ºC and relative humidity of 20%) and in the ambient condition (temperature was about 25 ºC ±2, relative humidity was 75% ±2) for 7 days. Three samples of every kind of fabric have been prepared for each condition. The result of fragrance intensity evaluation was the mean value measurement of three samples.

2.3. Fragrance Durability Evaluation

In this research, the fragrance intensity of fabric samples treated with microcapsules containing the star anise essential oil had been evaluated by expert method in combination with the comparison of diluted sample method based on the standard ASTM D 1292-10 [5-6] to create a suitable process for evaluating the odor fabric samples. The measurement of intensity by magnitude scale procedure is mentioned in section I. The aqueous solution of microcapsule had gradually diluted by distilled water and has been contained in a small bottle of 10 ml. Eleven bottles had been prepared with different ratios of microcapsule volume solution and the bottles had then well tight closed during the experiment. The bottle of total distill water is "no odor" and was considered "blank" (Fig. 3).

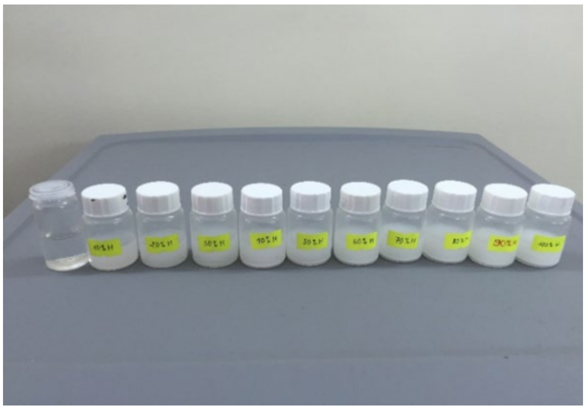

Fig. 3. Eleven main bottles with different ratios of microcapsule volume.

Their fragrance grade Fg was calculated (1) in dependence on the ratio of microcapsule volume solution Vms (ml) to the total volume solution in the bottle (Table 2).

$$Fg = \frac{Vms}{Vms+Vw}x10 \quad (1)$$

The first investigation showed the range of odor evaluation was concentrated in the interval inferior 40 points, so the supplement bottles have been provided to assure the precision during the evaluation. Ten supplement grades have been added between successive grades bottled such as 0 point - 10 points, 20 points – 30 points and 30 points - 40 points. Their Fg was also calculated as formula (1). For example the point of 11 given by the supplement bottle grade with Vms = 1,1 ml in total 10 ml. The supplement grades helped the evaluation point reach the ones number (1, 2 to 39, 40 points) and the odor measurement became more exact.

Eight perfumers have been trained to participate in the evaluation of the fragrance. They were compliant with the odor panel rules as a part of the assessor's agreement to participate in odor testing. Every perfumer has smelled the fabric sample and compared it to the sample bottles with its fragrance grade then has given out a point in a hundred grades. Before changing to evaluate another fabric sample the perfumer has been demanded to smell the bottle of zero fragrance grade. The evaluation was carried out at 9 AM every day. In order to guarantee the objectiveness of the evaluation, the perfumer obeyed strictly the above protocol and didn't have any discussion during the experiment. Moreover, they must be free of colds or physical conditions that may affect the sense of smell; must not chew gum or eat at least 30 minutes before participating in the odor panel; must not wear perfume, cologne, or after shave the day of the odor testing, must have their clothes odor-free, have their hands clean and no odor of the odor panel [7]. The result of fragrance intensity for every fabric sample was the mean value given by all eight perfumers for this fabric sample.

Table 2. Fragrance main grade of sample bottle of microcapsule solution

Order of bottle	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Volume of microcapsule solution *Vms* (ml)	0	1	2	3	4	5	6	7	8	9	10
Water volume *Vw* (ml)	10	9	8	7	6	5	4	3	2	1	0
Fragrance grade (*Fg*)	0	10	20	30	40	50	60	70	80	90	100

3. Results and Discussions

3.1. Influence of Keeping Condition to Fragrance Durability of CVC Fabric Sample

The first observation showed the important influence of keeping condition to fragrance durability of CVC fabric sample. At every moment of experiment process, the fragrance durability of all the CVC fabrics was always more important when they were in the cold dried condition.

Table 3. Mean value of fragrance grade of CVC fabric sample

Day	Ambient condition			Cold dried condition		
	CVC1	CVC2	CVC3	CVC1	CVC2	CVC3
1	7,8	6,8	7,0	32,8	34,3	31,3
2	4,5	4,2	4,8	27,8	27,7	25,4
3	3,4	3,2	3,3	24,9	25,7	24,6
4	1,7	1,4	2,0	22,0	21,7	21,7
5	0,5	0,4	0,4	15,8	16,3	19,0
6	0	0	0	10,2	13,5	15,6
7	0	0	0	9,5	10,3	10,3

However, the influence of the keeping condition on fragrance durability on CVC fabric samples with different looplength was not clear (Table 3). On the first day, the fabric CVC1 with the longest looplength of 2,82 mm had the highest fragrance durability (7,8 points) in the ambient condition while it obtained the second place with the 34,3 points in the cold dried condition. However, on the fifth day, the fabric CVC1 maintained the highest fragrance durability of 0.5 point in the ambient condition and it had the last place with 15,8 points in the cold dried condition.

The diagram (Fig. 4) showed that the keeping condition influenced the fragrance durability of CVC fabric samples: the CVC fabric samples have been kept in cold dried condition (temperature of 2 ^oC and relative humidity of 20%) remained more durable fragrance which kept in the ambient condition (temperature was about 25 ^oC ±2, relative humidity was 75% ±2). On the first day the all the CVC fabric samples kept in cold conditions have evaluated with more than 30 points of fragrance while all the CVC fabric samples kept in ambient conditions had below 10 points of fragrance grade: the fragrance intensity of 7,8; 6,8 and 7,0 were obtained for the sample CVC1, CVC2, and CVC3 respectively. After five days, all fabric samples kept at ambient condition descended to zero point of fragrance intensity while the sample fabric kept at dried cold condition still maintained their odor to the seventh day with the fragrance grade of about 10 points: the fragrance intensity given by perfumers was 9,5; 10,3 and 10,3 for the sample CVC1, CVC2, and CVC3 respectively.

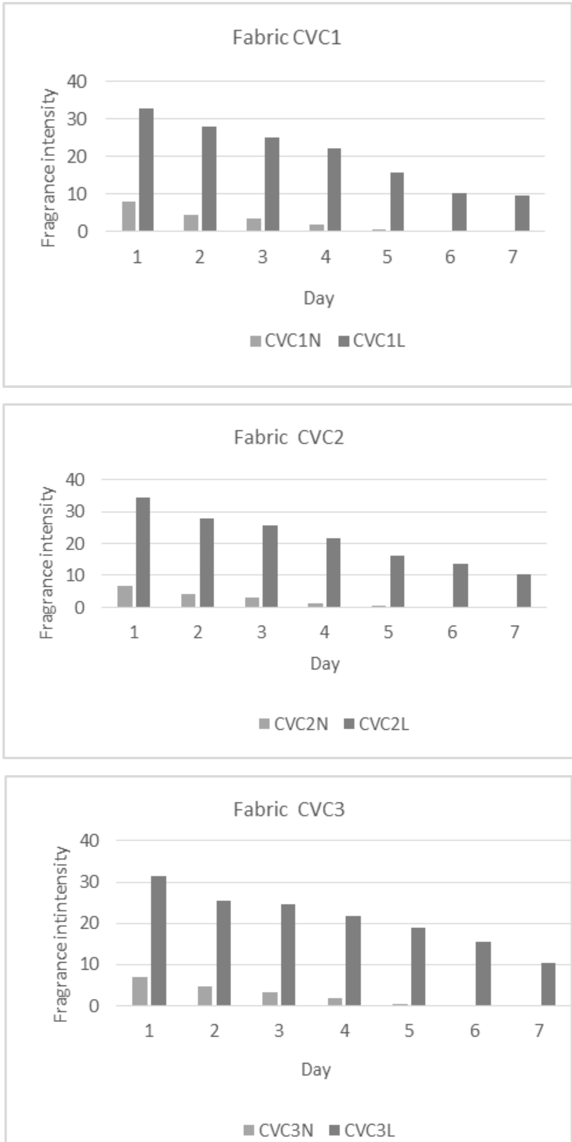

Fig. 4. Influence of fabric sample's keeping condition to fragrance intensity of CVC fabric samples (CVCN: Ambient condition with relative humidity of 70-80% and temperature of 25-27 ^oC; CVCL: cold dried condition with relative humidity of 20% and temperature of 2 ^oC).

3.2 Influence of Keeping Condition to Fragrance Durability of Cotton Fabric Sample

The influence of the keeping condition on fragrance durability on cotton fabric samples with different looplength was clearer in comparison to the CVC fabrics (Table 4). In the cold dried condition, the fabric CT1 with the shortest looplength of 2,83 mm had always the smallest fragrance durability. The fragrance durability was 35,0; 37,1; 35,7 points on the first day, and this value was 16,8; 17,3 and 18,5 points on the seventh day for the fabrics CT1, CT2, CT3, respectively. The same tendency was observed for almost the cotton fabric samples kept in the ambient condition. The fabric's structure is tighter when the fabric looplength is smaller, which help keeping more the microcapsules in the fabric and it was the reason for this tendency. The important difference was obtained when the fabric samples were kept in the cold dried condition, which caused the slower fragrant liberation from the fabric samples.

Table 4. Mean value of fragrance grade of cotton fabric sample

Day	Ambient condition			Cold dried condition		
	CT1	CT2	CT3	CT1	CT2	CT3
Day 1	7,7	8,3	8,1	35.0	37,1	35,7
Day 2	4,2	4,1	4,2	31,2	34,0	33,3
Day 3	2,9	2,6	2,8	29	30,5	32,8
Day 4	1,4	1,4	1,4	26,2	27,0	27,3
Day 5	0,2	0,2	0,4	21	22,2	22,8
Day 6	0	0	0	17,8	19,4	19,7
Day 7	0	0	0	16,8	17,3	18,5

The same tendency has been observed for the cotton fabric samples (Fig. 5): the cotton fabric samples that have been put in the cold dried condition (temperature of 2 ºC and relative humidity of 20%) were always maintained more fragrance than these ones have let in the ambient condition (temperature was about 25 ºC ±2, relative humidity was 75% ±2) with the higher temperature and humidity. For example, in the first day, the fragrance grade of the cotton fabric sample CT1, CT2, CT3 keeping at the cold dried condition were 35; 37.1 and 35.5 points while the points for the same fabrics that keeping at the ambient were 7.7; 8.3 and 8.1. On the sixth day, all fabric samples kept at ambient condition had zero point of fragrance while all the samples cold keeping still had a good fragrance of 17.8; 19.4, and 19.7 points.

The result could be explained by the difference in the temperature and humidity of the sample keeping condition. In the cold dried condition (2 ºC, RH 20%) the essential oil may be slower evaporated than that in the higher temperature condition (25-27 ºC, RH 70-80%). In consequence, all the CVC and cotton fabric samples were kept in the cold dried condition had maintained their fragrance longer. On the other hand, the low temperature was considered to solidify the microcapsule membrane and reduce the dimension holes in the membrane structure that leads to preventing the evaporation of essential oil through the microcapsule membrane. The study showed that the fragrance durability evaluation by expert method combined with diluted solution method had demonstrated the quantitative results, which reflected explainable change tendency in fragrance durability of single jersey knitted fabric coated by microcapsules containing the star anise essential oil in dependence on their keeping conditions.

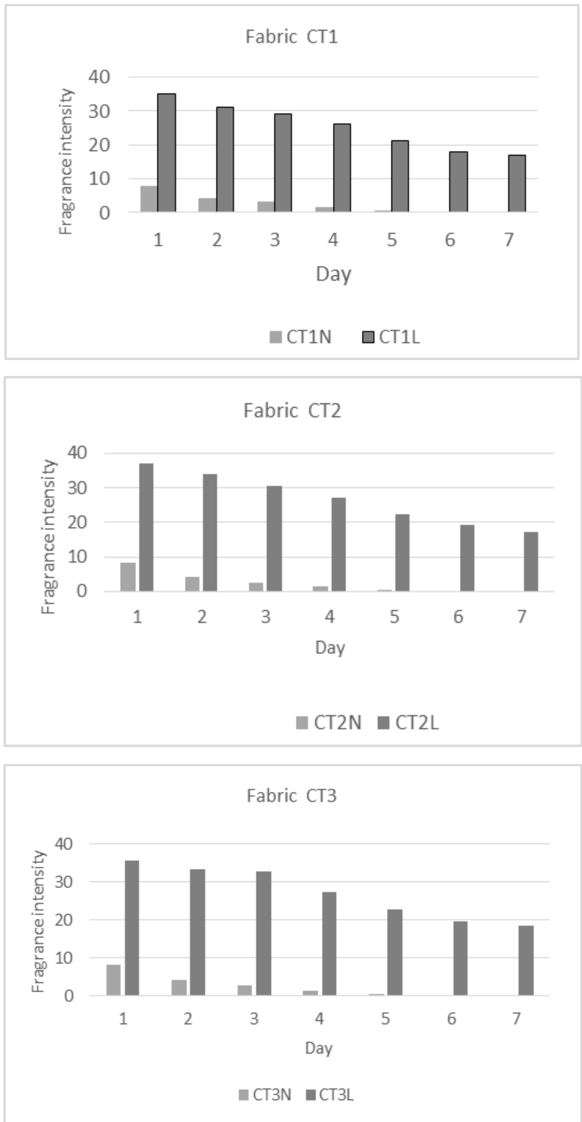

Fig. 5. Influence of fabric sample's keeping condition on fragrance intensity of cotton fabric sample (CTN: Ambient condition with a relative humidity of 70-80% and temperature of 25-27 ºC; CTL: cold dried condition with relative humidity of 20% and temperature of 2 ºC).

Table 5. Mean value of fragrance grade of cotton and CVC fabric samples

Day	Ambient condition			Cold dried condition			Ambient condition			Cold dried condition		
	CVC1	CVC2	CVC3	CVC1	CVC2	CVC3	CT1	CT2	CT3	CT1	CT2	CT3
Day 1	7,8	6,8	7,0	32,8	34,3	31,3	7,7	8,3	8,1	35	37,1	35,7
Day 2	4,5	4,2	4,8	27,8	27,7	25,4	4,2	4,1	4,2	31,2	34	33,3
Day 3	3,4	3,2	3,3	24,9	25,7	24,6	2,9	2,6	2,8	29	30,5	32,8
Day 4	1,7	1,4	2,0	22,0	21,7	21,7	1,4	1,4	1,4	26,2	27	27,3
Day 5	0,5	0,4	0,4	15,8	16,3	19,0	0,2	0,2	0,4	21	22,2	22,8
Day 6	0	0	0	10,2	13,5	15,6	0	0	0	17,8	19,4	19,7
Day 7	0	0	0	9,5	10,3	10,3	0	0	0	16,8	17,3	18,5

3.3. Influence of Yarn Material on the Fragrance Durability of Fabric Samples

The influence of yarn material on the fragrance durability of knitted fabric coated by the anise essential oil loaded microcapsule has been shown in Table 5. Two tendencies had been observed. The first tendency was for the fabric samples which were kept in the cold dried condition. All the cotton fabrics kept the fragrance much longer than the ones of the CVC fabrics at the same moment at the cold dried condition (temperature of 2ºC and relative humidity of 20%). On the first day the cotton fabric samples had got the fragrance intensity around 35-37 points while the CVC fabric samples had the point of 31-34 for the fragrance intensity. This tendency was not changed until the seven days when the cotton fabrics maintained their fragrance intensity with the point of 16-18 while the fragrance intensity of CVC fabrics decreased to 9-10 points. The CVC fabrics contain 40% polyester yarn known as the hydroscopic yarn without of reactive group. The other 60% was the cotton yarn which has many hydroxyl groups. But in our research, in the cold dried condition, the cotton fabric could maintain the fragrance longer than that of CVC while in the other research [2] the intensity of axillary odour from the fabric has evaluated was inversely related to fibre hydroscope. The difference may be from the structure membrane of microcapsules used in our research. In our study, the anise essential oil hydrophobic was not directly contacted to the CVC fabric but their membrane one. The eudragit RSPO membrane (Fig. 6) has the reactive groups that could make the physic liaison to the cotton fabric and help it to keep more microcapsules in their structure during the experiment.

In consequence, the cotton fabric could maintain the fragrance longer than the one of the CVC fabric samples.

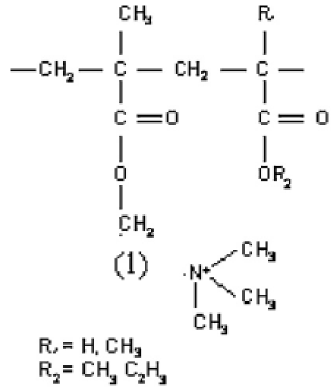

Fig. 6. Chemical structure of eudragit RSPO

The second tendency was observed for the fabrics sample which has been kept at the ambient condition. The inverse tendency was obtained that the CVC fabric samples kept the fragrance longer than theses ones of the cotton fabric samples at the ambient condition (temperature was about 25ºC ±2, relative humidity was 75% ±2) but the difference was not clear. On the first day, the CVC fabric samples had the fragrance intensity of 7,0 -7,8 points while the point of the cotton fabric samples was around 7,7-8,1. All the CVC and cotton fabric samples reached zero point on the fifth day. The facile volatile anise essential oil inside the microcapsules was evaporated through their membrane, which may be the reason for these results. At the ambient condition, the higher temperature had facilitated the evaporation of anise essential oil so all fabric samples that have been kept at ambient condition had maintained their fragrance less than the samples kept in cool dried condition. However, on the third and fourth day, the CVC samples got the point of 3,2-3,4 and 0,4-0,5, respectively while the cotton fabric samples had the point around 2,6-2,9 and 0,2-0,4, slightly less than that one of CVC samples. There the hydrophobic tendency of the polyester fibre in CVC fabric makes it easier to attract anise essential oil that just liberated out from the microcapsules through their membrane and kept it longer on the surface of the fabric. As the consequence, the CVC fabric samples had the fragrance rather longer than the cotton sample ones.

3.4. Evaluation of the Developing Method for Fabric Fragrance Quantitative Measurement

The developing method was based on the combination of the expert method and diluted solution method. This evaluation showed believable quantitative results. As presented above in the introduction and the method part, odor is a psychophysical phenomenon. A person olfactory sense gives the ability to detect the presence of some chemicals in the ambient air. But it is a person's sense of smell that can lead to a compliant which became not easy. The odor evaluation by the human olfactory sense is considered most exact and most believable. It had been assured the objectiveness of the measurement. The Table 6 showed the fragrance evaluation results caried out by development method for four fabric samples. There are 8 participating perfumers. However, their threshold olfactory sense may be different between them. For example, the first perfumer give marks of 40, 30, 20 and 20 for samples 1, 2, 3, 4 respectively while the second one recorded the mark of 50, 30, 20 and 10 for the same samples, respectively and the perfumer 5 seem to have highest threshold olfactory sense with the mark of 70, 40 for the two first samples and rather low mark 10 and 20 for sample 3 and 4. The perfumer 8 had the lowest threshold olfactory sense with the mark of 30, 30, 20 and 10 for the sample 1, 2, 3, and 4. The results demonstrated that though the personal threshold olfactory sense is quite different between the perfumers but they obtained generally the same odor tendency for 4 samples: the first sample has the highest odor intensity, follow by the samples 2 and 3, the sample 4 has the lowest odor intensity in almost evaluation of perfumers. The mean value of 8 marks given by the 8 perfumers so considered objective and show the correct tendency of the change of sample odor intensity and the results were quantitative.

In comparison, some evaluations of the fragrance intensity from the fabric treated by the microcapsules with the natural oil essential have been carried out using the aid of equipment as GCMS [4]. To evaluate the fragrance of hand towels after laundering, the authors used headspace-GCMS analysis. The hand towels were kept separately in a plastic bag and waited for 7 days for the release of the fragrance. The accepted gas phase was collected and injected into GCMC to detect the fragrance quantity. The results were not totally quantitative because the higher concentration at fragrance peaks was considered as proof of the higher odor intensity. Based on these results the authors concluded the positive effect of microcapsules for extended release of fragrance. The value of odor has not been given so the method was not quantitative.

Table 6. Odor evaluation by the perfumers

Perfumer	Sample 1	Sample 2	Sample 3	Sample 4
Perfumer 1	40	30	20	20
Perfumer 2	50	30	20	10
Perfumer 3	50	30	30	20
Perfumer 4	45	30	25	20
Perfumer 5	70	40	10	20
Perfumer 6	40	30	10	20
Perfumer 7	50	40	60	30
Perfumer 8	30	30	20	10

Moreover, the fabric samples were not considered conventional as liquid or air products which could be odor measured by some current standards [5-7]. Besides, the fabric samples were always not pure because of the diver supplement products during manufacture that made them difficult to be analysed by the conventional chemical instruments. So, the developing method in this study could be used for fabric fragrance quantitative measurement and could provide the detail value of odor intensity of sample in respecting the different personal threshold olfactory sense. The fabric odor intensities then could be comparable between the investigated fabric samples.

4. Conclusion

The research has evaluated the fragrance durability in dependence on the keeping condition of the knitted fabrics coated by microcapsules containing the star anise essential oil. The expert method combined the dilute solution with fragrance grade has been built. The results showed that the method has provided qualitative values, reliable and suitable to the tendency of fragrance durability of fabric treated by the microcapsule kept in the different conditions. Both kinds of CVC and cotton knitted fabrics shown the same tendency that the samples maintained their fragrance longer at cold dried conditions in comparison to ones kept in ambient conditions. The cotton knitted fabrics maintained their fragrance longer than the CVC fabrics in the cold dried condition while the inverse tendency was observed when the samples have been in the cold dried condition. The results were similar to the tendency reported in the recent researches [8, 9] and had confirmed that the expert method combined the dilute solution with fragrance grade which was established in our research can be applied to quantitatively evaluate the fragrance durability of the fabric treated by the fragrance agent such as microcapsules loaded by anise essential oil. Besides, the research to find a more quantitative method which can verify the convention of the developed method in this paper has been planned to carry out and would be reported in the near future.

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