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Development of Scented Bow-Tie: User Experience

Razvoj odišavljenega modnega metulja: uporabniška izkušnja

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Abstract

The bow-tie is a male and female fashion accessory. It can be made in different designs and of different materials, and by connecting different research areas, it can also be given various functionalities. In the study, knowledge on textile materials, printing and microencapsulation was combined with sensory perception (senses of smell and vision), which plays an important role especially in marketing. In the process from an idea through the invention to final innovation, we were able to develop a new product, i.e. a scented bow-tie. In the research, microcapsules with a melamine formaldehyde shell, and fragranced female and male oil in the core were produced and analysed (size, size distribution and shell permeability). Microcapsules were applied with the screen printing technique to selected textile materials which were later used for designing bow-ties. Forty bow-ties were used in the continuation of the research, together with a questionnaire of bow-tie testing, distributed between male and female users, who were testing the bow-ties for three months. By means of the questionnaire, information on the characteristics, intensity and duration of the fragrance as well as the likeability of bow-ties and packaging was gathered and analysed. To obtain specific target groups for the designed bow-ties, the method of motivation groups was included into the questionnaire. The obtained results enabled the conclusion that the microcapsules with fragrance oil were just slightly permeable (male slightly less than female). Therefore, diffusion of fragrance through the shell was gentle, pleasant and discreet, which was an important characteristic of our bow-ties. After each wear, fragrance faded; the users were hence instructed to rub the bow-ties between their fingers. Consequently, microcapsules ruptured and the fragrance was again released from the core. For the bow-tie users, this was an amusing experience, since the fragrance lasted for the predicted ten wears and even longer. The added value of bow-ties was recognised in interesting decorative patterns printed on the face, in their elegant design and shape, as well as in the pleasant fragrance, which was characterised as an alpha motive for the male users and stayed unidentified by the female users.

Keywords: bow-tie, microcapsules, screen printing, user experience, fragrance

Izvleček

Modni metulj je tako moški kot tudi ženski modni dodatek. Izdelan je lahko v različnih oblikah in iz najrazličnejših materialov, pri čemer mu lahko s povezovanjem posameznih raziskovalnih področij dodamo tudi druge funkcionalnosti. V raziskavi smo znanje s področja tekstilnih materialov, tiska in mikrokapsuliranja povezali s področjem čutne zaznave (čutili za vonj in vid), ki v zadnjem desetletju, predvsem na področju marketinga, igra pomembno vlogo. V postopku od ideje do invencije in končne inovacije smo tako razvili nov izdelek, tj. dišeči modni metulj. V ta namen smo izdelali mikrokapsule z melamin formaldehidno ovojnico, v njihovo jedro pa smo ujeli dišeča olja (z moškim in ženskim vonjem). Mikrokapsule smo v nadaljevanju preskušali (porazdelitev in velikost ter prepustnost stene) ter nato z metodo sitotiska nanесли na tri izbrane tekstilne materiale, ki smo jih uporabili za izdelavo metuljev. Štirideset metuljev smo skupaj s priloženim dnevnikom o nošenju razdelili med ženske in moške uporabnike, ki so modne metulje testirali tri mesece. Na podlagi dnevnika smo pridobili in analizirali informacije o intenziteti in

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trajanju vonja, všečnosti modnih metuljev in embalaže. V dnevnik smo vključili tudi metodo motivacijskih skupin, s pomočjo katerih smo modne metulje na podlagi vonja lahko pripisali ustreznim ciljnim skupinam. Iz rezultatov testiranja mikrokapsul je bilo ugotovljeno, da so stene le-teh rahlo porozne (nekoliko bolj v primeru mikrokapsul z moškim dišečim oljem). Zaradi omenjenega je bilo prodiranje vonja skozi stene nežno, prijetno, predvsem pa diskretno, kar je pomembna lastnost izdelanega modnega metulja. Po vsakem nošenju je vonj nekoliko oslabil, zato so uporabniki, skladno z navodili, modne metulje rahlo podrgnili med prsti. Posledično je del mikrokapsul počil, olje se je sprostilo iz jedra, s tem pa tudi vonj. Za uporabnike je bila to prijetna izkušnja, saj se je na tak način vonj sproščal tekom predpisanih deset nošenj in celo več. Dodana vrednost modnega metulja je bila spoznana v njegovih zanimivih potiskih, elegantni obliki in prijetnem vonju, ki je bil v primeru moških modnih metuljev uvrščen v alfa motivacijsko skupino, v primeru ženskega vonja pa je ostal nedoločen.

Ključne besede: modni metulj, mikrokapsule, sitotisk, uporabniška izkušnja, dišava

1 Introduction

The bow-tie first appeared in the early 19th century, namely as a tie which can be tied in numerous ways. By the mid-1880s, it became a major fashion accessory in the men's wardrobe. In that time, two patents were registered, in which the bow-tie was named a "neckscarf" [1] and "necktie" [2]. In the past, the bow-tie went through numerous changes [3–6], and superseded all of its formal and traditional stereotypes. From the street style, to fashion shows and high fashion celebrities, the bow-tie was integrated into different styles and ways of wearing. The classic way of wearing a bow-tie has changed and gained new dimensions. For a long time, the bow-tie was only a male fashion accessory, however, when new subcultures appeared, even women started to wear them [7], e.g. celebrity actors Marlene Dietrich and Katharine Hepburn, who appeared in men's suits with bow-ties in a photo from the 1930s [8–10]. Today, bow-ties can be worn by both genders, at any occasion, at many subcultures, e.g. hipsters etc. They can be designed in the form of a differently sized butterfly, batwing, diamond point and rounded club [10, 11], and tied as a "self-tie", "pre-tied" or with a "clip" located on the bow-tie [10, 12]. Generally, they are made of textile materials (most commonly silk, cotton, polyester etc), although other materials have become popular as well but are still rarely used, e.g. wood, Plexiglas, plastics, metal etc.

The aim of our research was to design and upgrade a bow-tie with added value. At the beginning, requirements for such bow-ties were set up as follows:

- bow-ties need to be designed from textile material;
- they need to be created in conventional manner (folding the material into appropriate shape and later sewn);

- production costs of newly developed bow-ties should not exceed the classical production costs by more than 10%;

- and finally, the bow-tie should have a "personal note" the users could identify themselves with.

According to the requirements, several ideas were presented but we have focused only on one, i.e. the scented bow-tie. Scented bow-ties can easily be personalised with specific fragrance and aesthetic appearance. Keeping that in mind, we started exploring the possibility of its creation by setting the main process activities:

1. scented bow-tie should be designed from the textile material on which fragrance oil will be applied;
2. due to fragrance oils quickly losing their scent, the microencapsulation process should be introduced into the research with which fragranced male (in the continuation MC-MF) and female (in the continuation MC-FF) oils should be entrapped inside the core and thus protected against premature evaporation;
3. microcapsules should have a melamine formaldehyde shell, which is slightly permeable and ruptures under shear forces;
4. microcapsules should be applied to textile materials with the conventional screen printing procedure;
5. bow-tie should be designed with a classical process from selected material;
6. according to the planned process of bow-tie design, its production costs will slightly increase (depending on the market price of microcapsules and costs of added printing phase).

In accordance with the predicted process activities, the development and designing of scented bow-ties started.

2 Materials and methods

Microcapsules with a melamine formaldehyde shell and fragrance oil in the core were produced, analysed and applied to a selected textile material from which bow-ties were designed and tested by the participants in the research. The materials and methods are described in the continuation.

2.1 Materials

Microcapsules with a melamine formaldehyde shell and single core, in which fragrance oil was entrapped, were synthesized by modified *in situ* polymerisation through the following stages: 1) preparation of an aqueous solution of modifying agent; 2) emulsification of core material; 3) addition of partly methylated trimethylolmelamine (Melamin, Slovenia) amino-aldehyde prepolymer for shell formation; 4) induction of polycondensation reaction; 5) polycondensation process (for about 1 hour) – formation of microcapsules; 6) termination of polycondensation; 7) removal of the released formaldehyde by adding ammonia scavenger; and 8) cooling to the room temperature. The final form of microcapsules was suspension. Microcapsules consisted of approximately 80–85% core material, while the rest belonged to the shell. For the *core material*, two commercial male and female fragrance oils were used (Tovarna Organika, Slovenia). The male fragrance oil consisted of a mixture of soft bergamot oil on the basis of amberggris, orange blossom, vanilla, sandalwood and sweet musk. The female fragrance oil was an aquatic floral substance that opens with top notes of lotus, freesia and cyclamen. The heart of the female fragrance oil was composed of the elements of peonies, lilies and carnations.

For the bow-tie design, three types of textile materials were used, i.e. soft 100% polyester satin fabric with glossy surface (thread density: weft 33 cm⁻¹, warp 42 cm⁻¹), adhesive nonwoven interlining (73% viscose, 27% polyester) and light-weighted taffeta weaved cotton batiste fabric (thread density: weft 37 cm⁻¹, warp 45 cm⁻¹) as the carrier of microcapsules.

Bow-tie design: Satin was reinforced with an adhesive nonwoven interlining and later cut into rectangular 25.5 × 14.5 cm shapes. On the front side of each rectangle, decorative patterns were printed. Microcapsules in 20% mass conc. (according to previous testing) were mixed with printing ink (Elastil

Comprente, Minerva, Italy) and applied with screen printing to the surface of batiste material. The screen printing technique was performed manually. The screen was made of an aluminium frame and PET mesh with the thread density of 43 cm⁻¹, monofilament diameter 80 μm, thread angle 0° and load tension 15 N. All prints were made with two passages of the squeegee, air-dried and cured by ironing at 150 °C temperature. The batiste material with microcapsules was lodged to the inner side of the composed satin-interlined material composition. The long sided edges of rectangles were folded backwards, up to the middle; furthermore, the same was performed with short sided edges, giving us a smaller rectangle, which was sewed and folded into the final design of the bow-tie (Figure 1).



Figure 1: Bow-tie final design

Bow-ties were stored in specially designed paperboard boxes (Figure 2), the purpose of which was not only to protect the product against external influences (dust, dirt etc), but also to retain the fragrance inside the box. The box was constructed in EngViewSystems (EngView Systems Sofia JSC, Bulgaria), cut out on a cutter plotter Pirina 700 (Pirina Technologies, Bulgaria) and creased with head pressure 0.50 MPa.

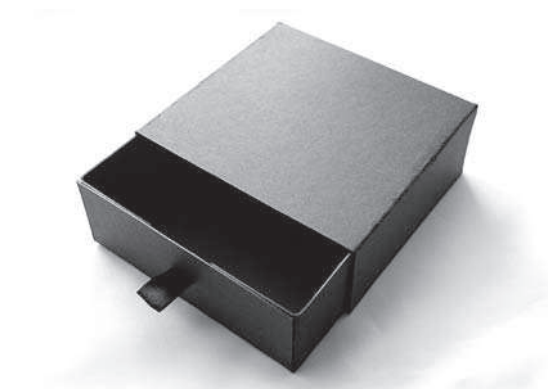


Figure 2: Packaging final design

2.2 Methods

The morphological properties of microcapsules (MC-MF and MC-FF) and printed materials were observed with a scanning electron microscope (SEM, JSM 6060 LV, Jeol). The samples were fixed on the SEM specimen stub and covered with an ultra-thin coating of gold (with high vacuum evaporation).

The size of microcapsules was determined from the SEM images with the use of ImageJ software and size distribution curves were drawn from the results of size measurements.

The release behaviour of microcapsules was tested according to Hwang *et al* [13]. The aqueous suspension of microcapsules was added into an aluminium cup (5 × 7 cm in size); the sample was then placed into a drying oven at 25 °C for 5 days. Each day at the same time, the samples were weighted and placed back into the oven. Each time, mass loss was calculated according to the following Equation (1):

$$\text{mass loss [\%]} = \frac{A_0 - A_n}{A_0} \cdot 100 \quad (1)$$

where A_0 presents the weight (g) of the microcapsule suspension before the release test and A_n presents the weight (g) of microcapsules after n days of release test ($n = 1-5$). The first calculated mass loss after 1 day corresponded to water evaporation and the residual material corresponded to *dry mass/share of microcapsules in the suspension*. Further drying in the following four days corresponded to the weight loss caused by the *porosity of shell*.

On textile materials, the following parameters were determined: mass per unit area according to EN 12127 [14], thickness according to ISO 5084 [15] and crease recovery angle according to ISO 2313 [16]. The mean value of the recovery angle was calculated from the mean values of measurements in warp and weft directions as follows (Equation 2):

$$\text{crease recovery angle [}^\circ\text{]} = \frac{\alpha_{5(\text{warp})} + \alpha_{5(\text{weft})}}{2} \quad (2)$$

where $\alpha_{5(\text{warp})}$ and $\alpha_{5(\text{weft})}$ present the mean values of the crease recovery angles obtained in warp and weft directions, respectively.

The bow-tie testing was performed with a subjective user experience wear test by 15 male and 16 female differently aged participants. They wore bow-ties at different occasions (e.g. concerts, parties, every day at work etc) from November 2015 to January 2016, meaning that the surrounding factors (open/close

area, with less or more different surrounding smells) could have influence on the results. The test was performed as follows: the packaging with a bow-tie and wear instructions was given to each participant, who had to wear the bow-tie for at least 10 times. During the wear test, they had to fill in a questionnaire relating to the bow-tie and the packaging properties, the characteristics as well as the duration and intensity of the released fragrance.

Within this test, the participants evaluated the fragrance also according to the motivation groups which are commonly used by companies for identifying target customer groups according to their tastes, life views, interests and opinions. For this purpose, 20 motivation images, representing four basic motivational groups, were used (Figure 3): *alpha group* is motivated on the basis of their status in society, status symbols, self-esteem, prestige, luxury etc; *discovery (adventure) group* is motivated by challenges, discovering new things, exploring, sport, adventure and other experiences; *security group* represents the type of people for which the most important value is security, home, family, stability and predictability; *social group* highlights features such as companionship, society, entertainment, leisure, spontaneity and humour. Among 20 pictures, representing four different motivation groups, participants had to choose 5 of them. The results were then analysed in Microsoft Excel.



Figure 3: Representative images of motivation groups

The results of the wear test were analysed and are presented in the continuation as: 1) evaluation of bow-ties, packaging and fragrance before wear test, 2) evaluation of presence, intensity and fading of fragrance during test, and 3) evaluation of bow-ties fragrance and appearance/damages after the test.

3 Results and discussion

3.1 Properties of microcapsules

SEM analyses showed (Figure 4) that both types of microcapsules (MC-MF and MC-FF) were undamaged and spherical. The size distribution curve of the MC-MF microcapsules was bimodal, with two distinctive size ranges: from 3 μm to 15 μm , in which 14.2% of MC-MF microcapsules were presented, and from 15 μm to 36 μm with 83.1% of microcapsules. The remained 2.8% of the MC-MF microcapsules were larger than 36 μm and their average size was 23.5 μm ($\sigma = 8.42 \mu\text{m}$). MC-FF microcapsules were smaller, on average 15.5 μm in size ($\sigma = 5.10 \mu\text{m}$), while the size distribution curve was just slightly bimodal, with two ranges of sizes, i.e. 24% of MC-FF microcapsules was in the range from 2.8 μm to 12.0 μm , while 74.4% of microcapsules was presented in the second range from 12 μm to 26.4 μm . The remained 1.6% belonged to the microcapsules larger than 26.4 μm .

The size of microcapsules is one of the factors, which influences the release properties: when microcapsules are small (below 10 μm [17]), they cannot be easily broken (especially under shear forces) and thus the yield of the released fragrance is limited. In contrast, when microcapsules are large (more than 30–40 μm [17]), they can easily be ruptured, the release of the core material is instant and the smell of the sample is ephemeral. According to Bône *et al* [17], the microcapsules with sizes between 10–40 μm are the best compromise.

The release behaviour/shell porosity of microcapsules after 5 days at 25 $^{\circ}\text{C}$ is presented in Figure 5. After the first day, the decrease in the microcapsule suspension weight corresponded to water evaporation, while the residue corresponded to the dry mass/share of microcapsules in the aqueous suspension which was 53.6%/50.3% for MC-MF/MC-FF. In the following four days, the decrease in microcapsule suspension weight corresponded to the diffusion of fragrance oil through the microcapsule shell. The diffusion was 0.11% for MC-MF and 0.23% for MC-FF, respectively. The low percentage of the release of core materials at lower temperature implies that the microcapsule shells are fairly nonporous and that the fragrance will be released by the destruction (i.e. rupture) of the shell rather than by the diffusion through the shell at room temperature.

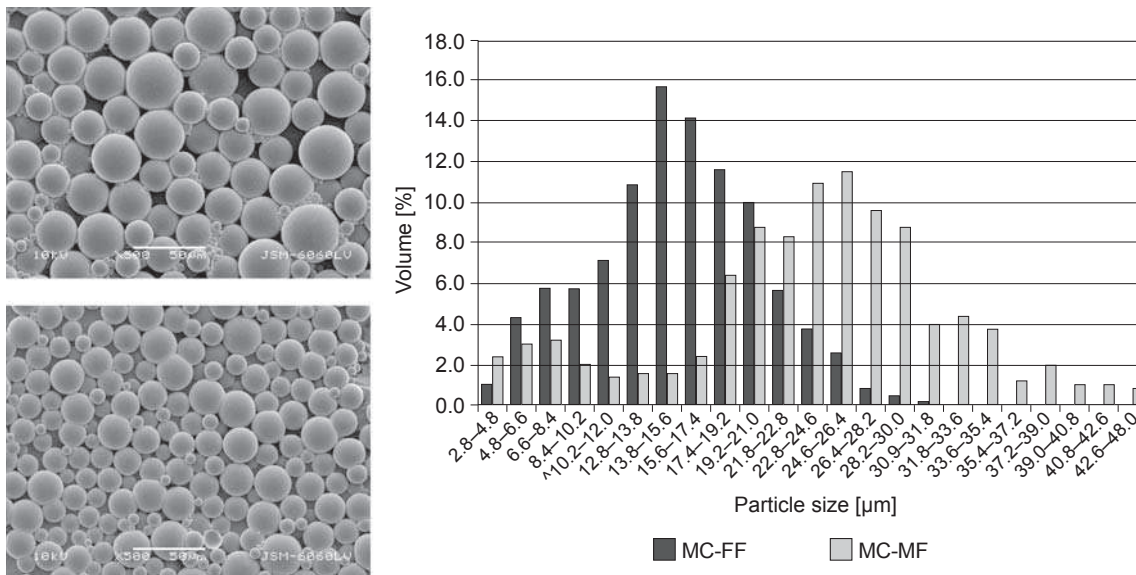


Figure 4: Images of MC-MF (left, above) and MC-FF (left, below), and their size distribution (right) (SEM; 500 \times magnification)

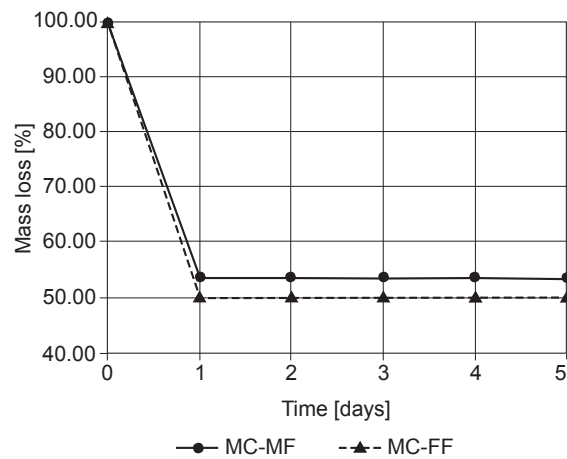


Figure 5: Proportion of released core material through microcapsule shells after 5 days at 25 °C for MC-MF and MC-FF

3.2 Properties of non-printed and printed material

The properties of bow-tie materials are shown in Table 1. The results showed that satin material became

stiffer when interlining was adhered to its inner side; nevertheless, a soft folding of the material into a bow-tie was still possible. Microcapsules were printed onto the batiste material (Figure 6), which was lodged to the inner side of satin-interlined composition. After the printing, the batiste material became stiffer and more sensitive to creasing (higher crease recovery angle in Table 1). Since this material was integrated inside the bow-tie, creasing was not an intrusive factor, influencing the required soft folding of the material during the bow-tie designing.

3.3 User experience analysis

Before the wear test, the participants evaluated the material, the construction, the appearance and the first impression of bow-ties (Figure 7) and the packaging (Figure 8).

As it can be seen from Figure 7, the participants' first impression of bow-ties was positive. They were mostly impressed by the idea of integrated fragrance and they commented the whole concept. The material the bow-ties were made of was marked as pleasant to touch, soft and non-irritating to the skin. Ad-

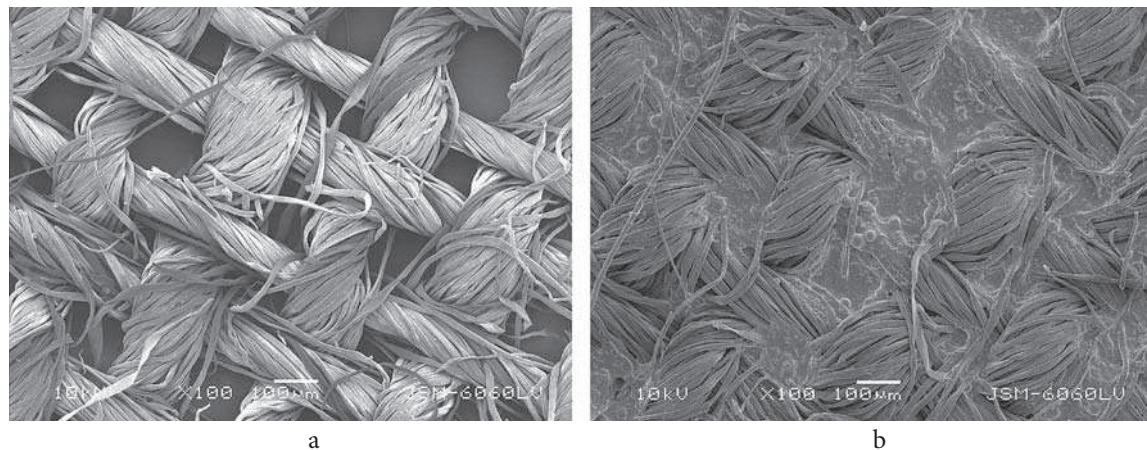


Figure 6: Surface of non-printed (a) and printed (b) batiste with microcapsules (SEM; 100× magnification)

Table 1: Properties of non-printed and printed textile materials with MC-MF and MC-FF microcapsules

Material	Thickness [mm]	Mass per unit area [g/m ²]	Crease recovery angle [°]
Non-printed satin	0.269	143.17	177.6
Non-printed satin + interlining	0.468	170.00	161.9
Non-printed batiste	0.144	58.80	42.1
Printed batiste with:			
MC-MF	0.212	121.58	64.3
MC-FF	0.205	118.00	56.9

ditionally, the appearance of bow-ties was rated as very attractive, mainly due to different colours of the used material and printed patterns. The appearance of bow-ties was also recognised as elegant (especially black bow-ties), and (in the case of the bow-ties printed with MC-FF) suitable for gala events and also for casual occasions. The participants also remarked upon the design of individual bow-ties, where they commented the appearance of seams.

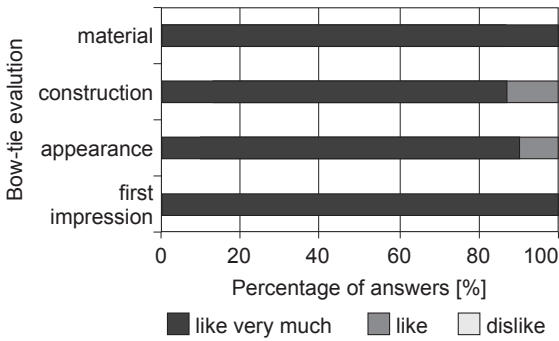


Figure 7: Evaluation of bow-ties before testing

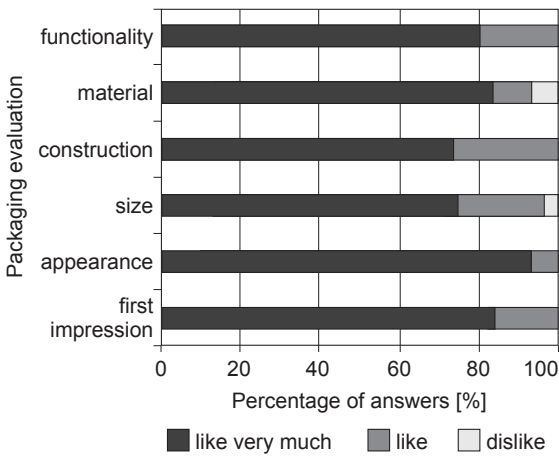


Figure 8: Evaluation of packaging

The participants' responses on the packaging are presented in Figure 8. Their first impression was that the paperboard box is stylish, likable and that it is of appropriate colour. Most of the users (80.6%) commented the functionality. The participants were impressed by the appearance of the box, in particular with a pull-out drawer and its textile strap holder. Although the packaging was made of paperboard, several participants (16.7%) suggested that it could be made of thicker, higher grammage material. For some participants (21.9%), the size of the box was too big (e.g. in the case of travelling). A quarter

of participants (25.8%) also criticised the construction of the packaging, which was in some cases not precise enough.

With the selection of five out of twenty representative images of motivation groups, the participants classified male and female bow-ties into different motivation groups (Figure 9). The obtained results were compared with the recommended market price of fragranced bow-ties, which was given by the participants at the end of the test (Figure 10).

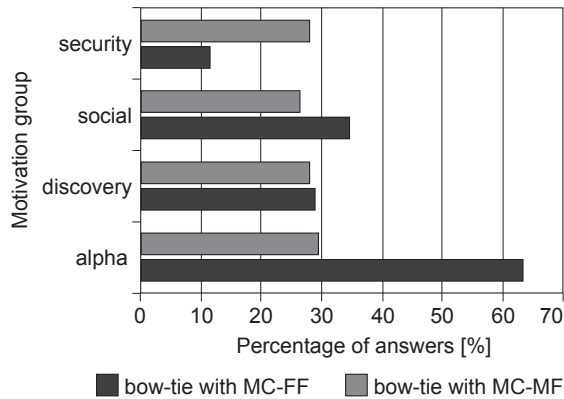


Figure 9: Motivation group classification of fragranced male and female bow-ties

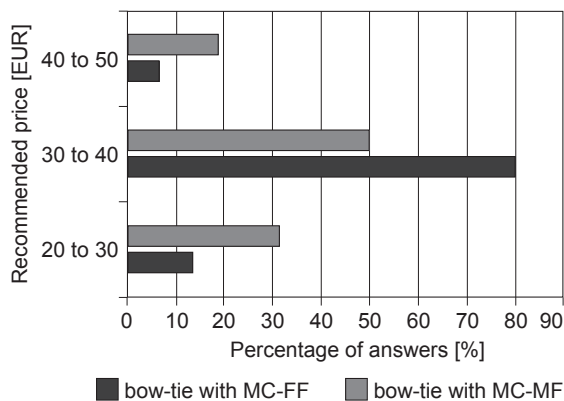


Figure 10: Recommended market price of fragranced male and female bow-ties

Male participants attributed their fragrance bow-ties (MC-MF) to the alpha group, which is mainly motivated by the status in the society. Since bow-ties already present a status symbol, the added fragrance expectedly raised their market price to the average 34.4 EUR per piece (Figure 10; regular market price for an ordinary bow-tie is approximately 20 to 30 EUR). In contrast, female participants did not allocate their bow-ties (MC-FF) to a specific

motivation group, but they equally distributed them into all four groups (Figure 9). Such a classification was possibly a result of the fact that firstly the female fragrance oil (MC-FF) was more “universal”, and therefore suitable for all four motivation groups (this statement was also confirmed by female participants after the test) and secondly, that females generally rarely wear bow-ties, due to which this test represented a new, unfamiliar experience to them. The female fragranced bow-tie (MC-FF) was assigned with a slightly lower market value than the male’s, i.e. 33.8 EUR per piece (Figure 10), proving that the addition of the fragrance contributes to the added value of bow-ties.

Before each wear, the participants took the bow-ties out of the packaging and described the presence and intensity of the fragrance. As it can be seen from Figure 11, before each wear the female fragrance (MC-FF) was slightly less sensed as the male fragrance (MC-MF); nevertheless, in both cases, most of the users (90.9%) sensed the fragrance as very gentle.

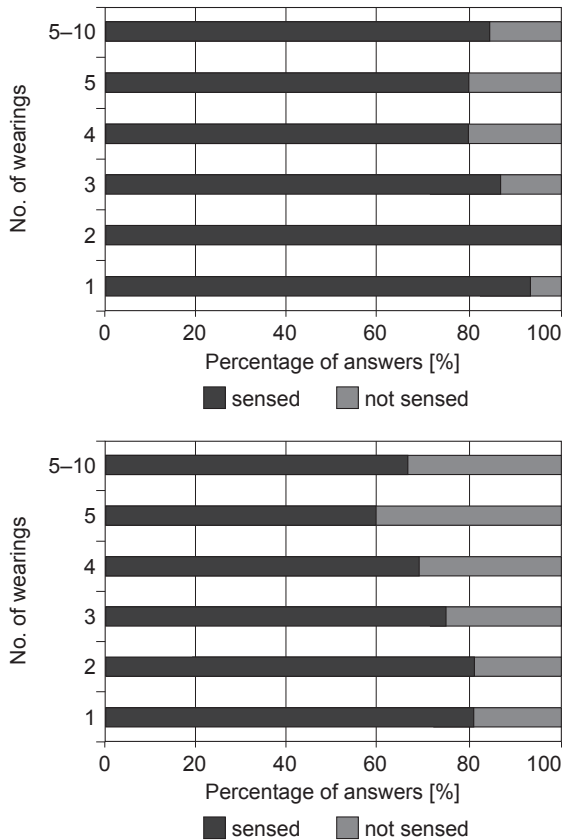


Figure 11: Sensing fragrance of bow-ties with MC-MF (above) and MC-FF (below) after they were taken out of the packaging

During the wear, the fragrance was again experienced by the users as gentle, pleasant and not annoying. As it can be seen in Figure 12, the percentage of users sensing the fragrance during the wear decreased after each wear, which implies that the bow-ties were slowly losing their fragrance (fading).

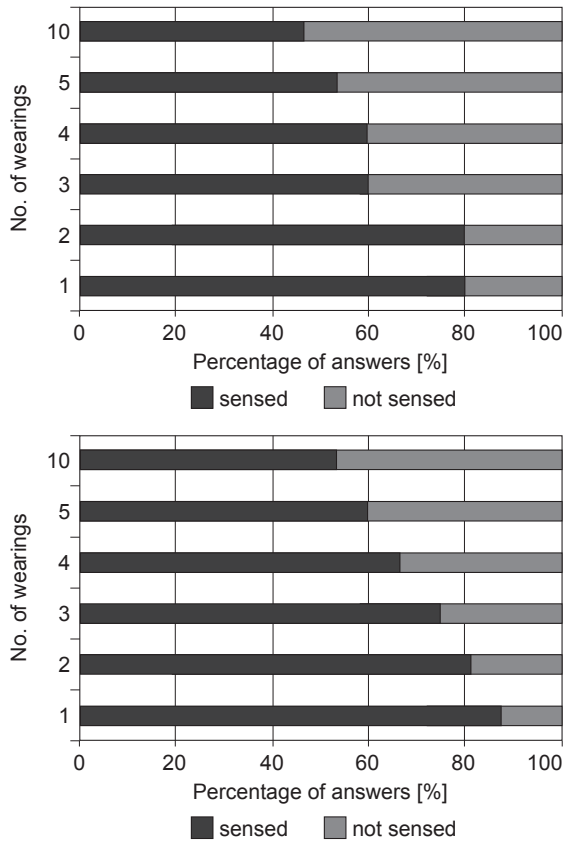


Figure 12: Sensing fragrance of bow-ties with MC-MF (above) and MC-FF (below) during wear

The results showed (Figure 12) that the fragrance was just slightly less sensed for the bow-ties with MC-MF compared to the bow-ties with MC-FF. The participants also noticed that the fragrance faded during each wear (Figure 13).

The fading was more intense in the case of bow-ties with MC-FF (Figure 13). Microcapsules MC-MF were larger and their rupturing was easier compared to smaller MC-FF microcapsules. The release of the male fragrance oil was thus possibly more efficient, yet it would probably last for a shorter period of time. In contrast, the microcapsules with female oil were smaller, more resistant to mechanical forces, hence the fragrance was released slowly in smaller quantities and for a longer period of time.

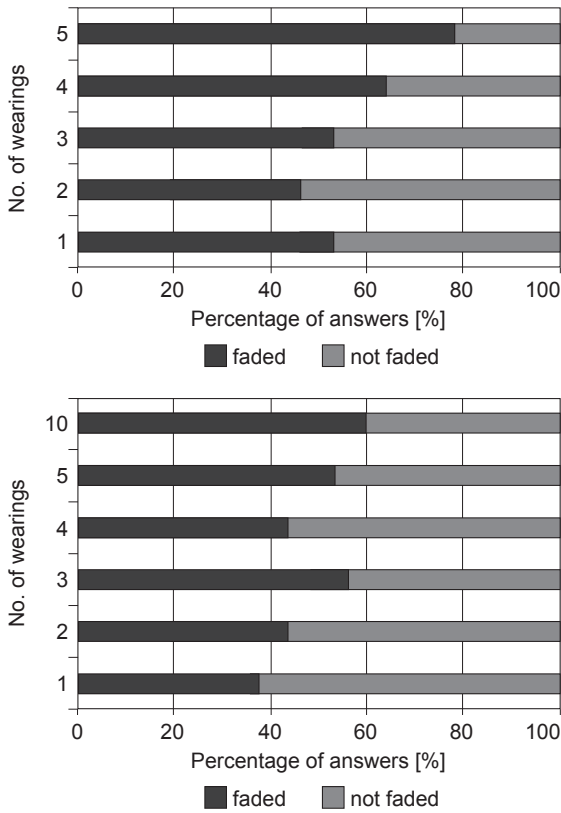


Figure 13: Fading fragrance of bow-ties with MC-MF (above) and MC-FF (below) during wear

During each wear, the participants were asked to rub their bow-tie between fingers if the fragrance was not sensed. By rubbing, the microcapsules with fragrance oil ruptured and the fragrance was released from the core. In Figure 14, the presence of the fragrance immediately and 10 minutes after the rupture of the microcapsules before the tenth wear is shown.

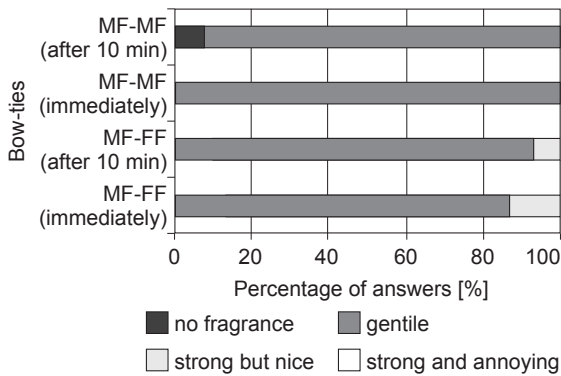


Figure 14: Sensing released fragrance immediately and 10 minutes after rupture of microcapsules before tenth wear

As it can be seen from Figure 14, the participants sensed the released fragrance immediately after the rupture of microcapsules as well as after 10 minutes. The fragrance was in both cases gentle.

After the test, the bow-ties were collected, examined and again evaluated. Most (83.9%) bow-ties still released a gentle and discreet fragrance, which became more pronounced when the bow-ties were rubbed between fingers. The analysis showed that the prints were undamaged, although participants rubbed bow-ties quite often, especially since they found this function very amusing. All users (100%) liked the idea of scented bow-ties and as it was already mentioned, they were prepared to pay for them a slightly higher price. According to their responses, they would like to wear the bow-ties also with some other fragrances (93.5%) and they would like to give them away as a gift (96.8%).

4 Conclusion

From the results of MC-MF and MC-FF microcapsule testing, it was concluded that:

- shell of microcapsules was only slightly porous, but just enough to gently release during the wear the fragrance of oil from the core;
- fragrance faded during wear; however, the rupturing of the shell by rubbing the bow-tie between fingers, enabled a prolonged release of the fragrance;
- discrete fragrance of bow-ties was pleasant for the participants; if the fragrance had been too strong, it would have been annoying for the participants;
- male participants allocated MC-MF fragrance of bow-ties to the alpha group, while the female MC-FF fragrance oil was more “universal” and consequently suitable for all four motivation groups.

The aim of the research was to develop/upgrade a bow-tie with added value. The main idea was to design a bow-tie with a “personal note”, which was in the research achieved by adding a fragrance, aesthetic appearance and decorative prints. Scented bow-ties were designed with a classical production process with only slightly higher costs.

Acknowledgments

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