UDC 655.3.066.53+681.625.234

AROMA PRINTING AS A MODERN TECHNOLOGY OF PACKAGING DESIGN

S. F. Havenko[1], S. E. Khadzhynova[1], O. G. Kotmaljova[2], M. T. Labetska[2]

[1] Lodz University of Technology, Institute of Papermaking and Printing, 10/12 Skorupki St., 90–924, Lodz, Poland

[2]Ukrainian Academy of Printing, Lviv, Ukraine 19, Pid Holoskom St., Lviv, 79020, Ukraine

Aroma printing has occupied a considerable place among the modern technology of product packaging design, which improves not only the design, but also, in consequence of using aroma ink or aroma varnish, but enhances the perception of information about products. Aroma images with a closed presentation of fragrances created by offset and screen printing on cardboard have been presented. The influence of time and frequency of use, impact factors (cooling, heating and UV-light) on the change of stability and fragrance intensity of printed aroma images has been studied.

Electron microscopy shows the interaction of aroma varnish and cardboard-base when printing in different ways, the structure changing of the aroma covers after use. It has been found out, that microencapsulation methods, the structure of microcapsules, the ratio of the diameter and the thickness of the capsule membrane influence the fragranced image quality. As a result of comparison of fragranced images printing technologies, we have set the requirements for substances for microencapsulation of aroma composition.

It has been confirmed that aroma varnish can be used successfully in offset and screen printing for the design and labeling the packaging according to their destination.

Keywords: *aroma printing, UV-varnish, aroma capsule, microstructure, electron microscopy*

Introduction

The conducted marketing studies show that odors are remembered better and longer than any visual images. Therefore, manufacturers of luxury packaging are seeking not only to improve their construction, design, but also attract buyer's attention to their products by modern printing technologies. Among these technologies, aroma printing develops intensively, that uses aroma inks and aroma varnishes, which covers printed images for open or close fragrances presentation. Aroma inks and varnishes can be successfully used to design the packaging, depending on their destination, by different printing methods – offset, screen, gravure and flexographic printing [1].

The best way for fragrances of small print runs is digital inkjet printing, which can be done by using aroma printers and aroma cartridges, ensuring the continued presentation of fragrances. Aroma printing is a promising area not only for the design of promotional

and packaging products. To strengthen the effects of tactile perception of information about objects by blind and visually impaired people we can successfully apply the aroma varnish or ink when applying relief-dot images in Braille on pharmaceuticals, foods or any other packaging [2]. Psychologists studying the effects of odors on the subconscious feelings, thoughts and behavior, confirmed the findings of Alan Hirsch, a noted researcher of odors, the founder of the research of odors and tastes, that fragrance is the factor that controls the behavior of the consumer at the time of selection, purchase or use of goods. Therefore, the use of aroma printing is an urgent problem nowadays and requires deep fundamental-applied and scientific research.

Problem statement

The application of aroma printing for continuous, selective or fragmentized decoration of printed promotional and packaging products is implemented by continuous outdoor, indoor and temporary presentations of fragrances. Fragranced offset and screen inks are water-based dispersion (this group is characterized by reduced viscosity and thixotropic and introduced damping and adhesion additives to let us use them for fragrances images with non-absorbent surfaces, they have a high fixing rate, improving adhesion occurs through priming the surface by UV primers or additive to aroma varnish of 10% UV varnish, while applying UV dryers with minimal power). Alcohol aroma varnishes are a mixture of aroma capsules uniformly distributed in the dispersion of polymer film, creators and alcohol solvents; this group of varnishes is suitable for coating all types of surfaces. But because of the high drying speed and solvency through the reactivity of microcapsules and their own substantial odor, they have not found a widespread use. UV aroma varnish is a mixture of aroma capsules in PP compositions suitable for all surfaces. However, these varnishes have some problems with the stabilization of the mixture for a long time [3].

The use of varnishes and inks based on aromatic microcapsules provides a predictive and stable result. The main advantage of this fragrances method is that the fragrance is released only when it is necessary, and in the absence of exposure, the smell can be stored for 2 to 3 years. Aromatic capsule can be added to inks, varnishes and adhesives. Each of these approaches has its advantages and disadvantages. For creating the fragranced effect, the microcapsules are added directly to the triad or additional inks [4].

As you know, the production of aroma varnishes are based on encapsulation, i.e. the placement of liquid or pasty substances in closed solid membrane size from 2 to 50 microns. The size of capsules in varnish for offset printing is 2.5 microns, screen printing — 10–50 microns. The membrane of microcapsules is used for its mechanical protection and long-term storage of odors.

It should be noted that the capsules in size 6 microns have a small volume (about 0.113 mkm^2), but the great strength of membrane, and capsules in size 10 microns have in opposite: greater volume (about 0.524 mkm^2), but less strength of membrane.

The structure of the microcapsules' membrane may contain a natural substance (wax, gelatin, starch) or synthetic one (acrylates, synthetic cellulose, modified starch and other polymers).

This set of components is specifically designed to serve as a reliable mechanical protection and for controlled (with a possible delay in time) release of fragrance.

Fragrance's researchers warn that the substance intended for microencapsulation, can not consist of substances that are soluble in water. Their boiling temperature should not exceed 100 °C. In addition, there are serious limitations, since it is impossible to introduce products containing alcohol in microcapsules.

To protect the microcapsules from premature destruction we use the so-called gap constraints. They are round, hard balls made of artificial resin, slightly more microcapsules' size, whose number in the finished print mass is 2–7%. They are placed in designed for processing product with microcapsules. Microcapsules should be evenly distributed in the substrate. The main task of specialists is not to destroy them with stirring in any case. It is generally accepted that a decrease in the radius leads to the membrane thickness and the mechanical strength increases, and conversely. This is extremely important because the mechanical destruction and release of capsule contents need some pressure [5].

The aim of the research was to find the interaction features of aroma varnishes and substrate of paperboard packages, changing the structure of the surface and the intensity of the smell of fragranced images printed by offset and screen printing under the influence of external factors.

Experiment equipment and method

The printing cardboard Alaska GC-2 with basis weight 250 g/m² has been chosen as the object of the research. The printing was conducted at the offset sheet machine HEIDELBERG Speedmaster SM 74-5 with ink Corona GA 5015 (Huber Group), and at the screen printing machine TX-2530 using the stencil mesh with resolution 70 lines/cm. UV-fixing aroma varnish Incandensess with floral smell was used for printing images [6].

To detect changes in the intensity of release and storage odors from aroma prints, such factors were taken into account as cooling to a temperature of -10 °C, heated to 100 °C in an incubator, and exposed to direct ultraviolet light (sunshine). For the experiment, a group of people with 9 persons was handed out with cardboard strips pre-coated with aroma varnish that proposed the change rate of odor intensity on a 10-point scale at regular intervals (every 6 hours).

Thin slices of fragranced images were examined in the light microscope Biolam with lens's magnification x90, the photographs were taken using a special set-top box for SLR digital camera Olympus E520 with the image resolution of 10 megapixels with next image framing to the size 800x600 pixels to separate microcapsules with fragrances for some shots. The study of the structural changes of cardboard flavored with aroma printed lacquer was performed in the transmission electron microscope SELMI PEM-100-01 using ultrathin sections and in the scanning electron microscope JEOL T220A (Japan). Image surface samples were obtained at magnifications x2000 [7,8].

Results and discussion

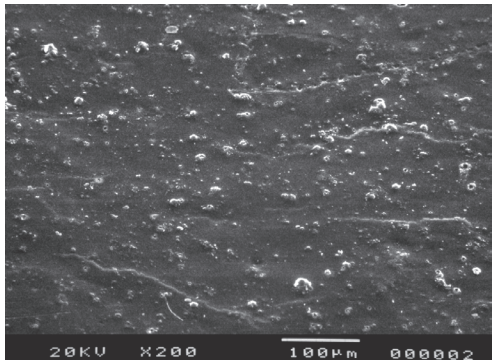
Results of analysis of the impact of cooling, heating and UV light on the change of images' fragrances, conducted with the assistance of experts, are given in Table 1.

Table 1

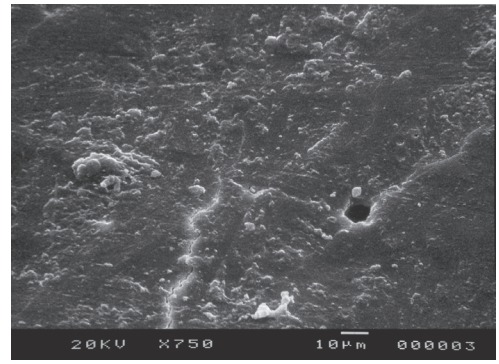
The influence of external factors on the change in intensity of flavored image odor

Recipients	External Factors								
	Heating			Cooling			UV light		
	Duration (h)			Duration (h)			Duration (h)		
1	2	4	6	2	4	6	2	4	6
2	9	10	9	8	7	9	10	10	9
3	8	10	9	9	7	8	10	10	10
4	9	9	9	9	8	9	9	9	10
5	8	10	9	8	7	8	10	9	9
6	10	10	10	8	8	8	10	9	9
7	8	9	8	10	8	9	9	10	9
8	8	10	8	8	7	8	10	9	9
9	8	10	9	9	8	8	10	10	10

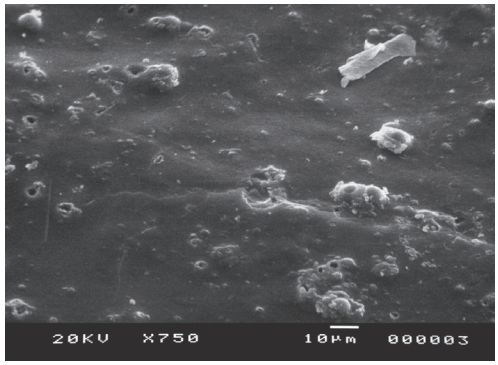
Electron — microscopic researches of fragranced images formed by offset printing, after conducting experiments (Fig.1b), showed significant changes in the structure of aroma layer comparing to the standard printed image (Fig. 1).



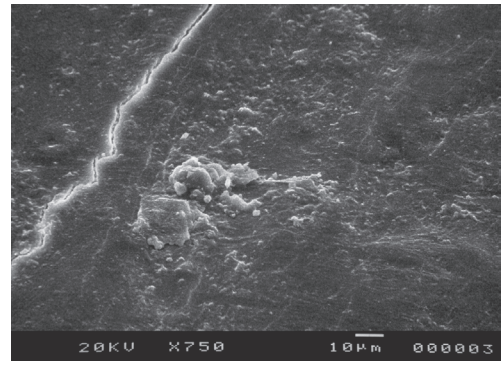
a)



b)



c)



d)

Fig.1 Microstructure of fragranced images formed by offset printing
standard printed image, b) image after exploitation,
b) image after 6 months, d) image after 1.5 years

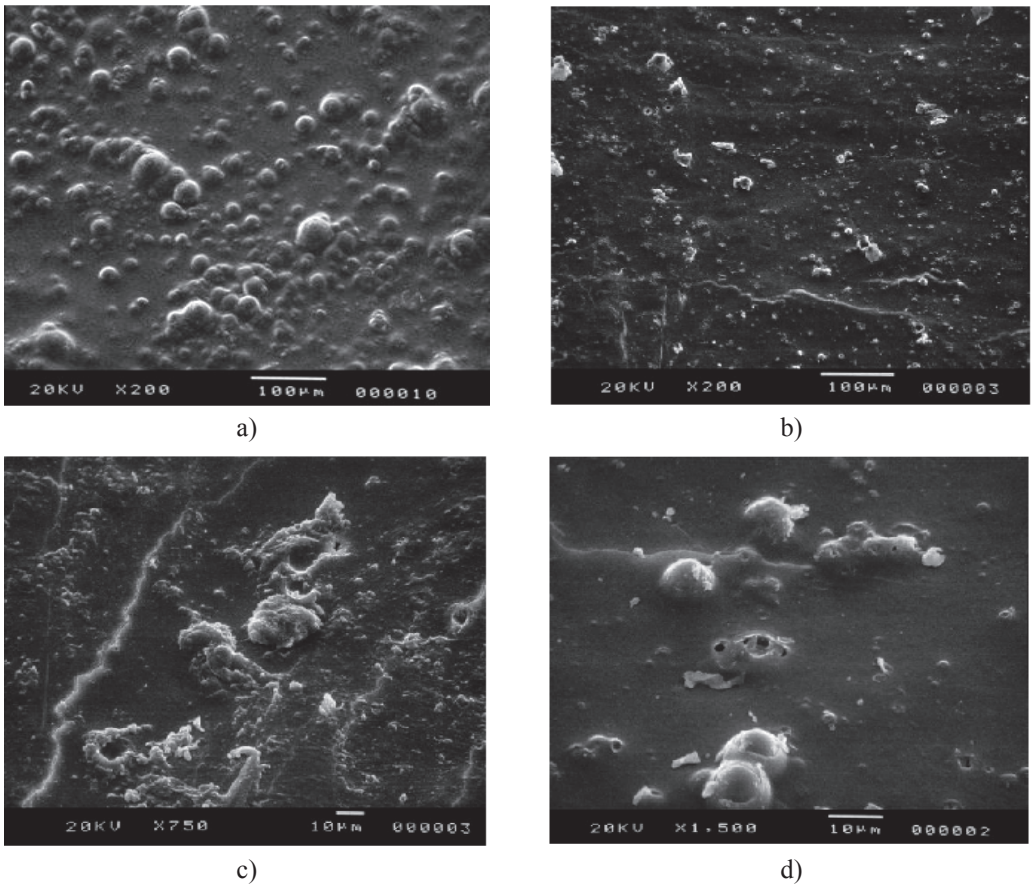
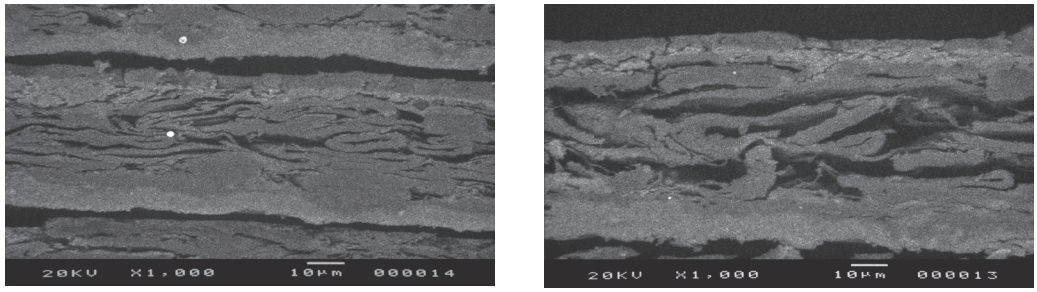


Fig.2 Microstructure of fragranced images formed by screen printing
a) standard printed image, b) image after exploitation,
c) image after 6 months, d) image after 1.5 years

Conducting the repeated experiments after 6 months (Fig.1c, 2c) showed no significant changes in the intensity of sample odor. However, analysis of the micrographs showed a considerable damage of microcapsules in the structure of fragranced images, including the ones printed by screen printing with greater thickness of the varnish layer.

Expert studies of the mentioned above samples after 1.5 years (Fig.1d, 2d) showed a significant reduction in the intensity of fragrance. This fact can obviously be explained due to the release of fragrance by "Rub and Smell" held microcapsules destruction that resulted unauthorized weathering smell for a long period. This is confirmed by the microphotographs shown in Fig.1 and Fig.2.

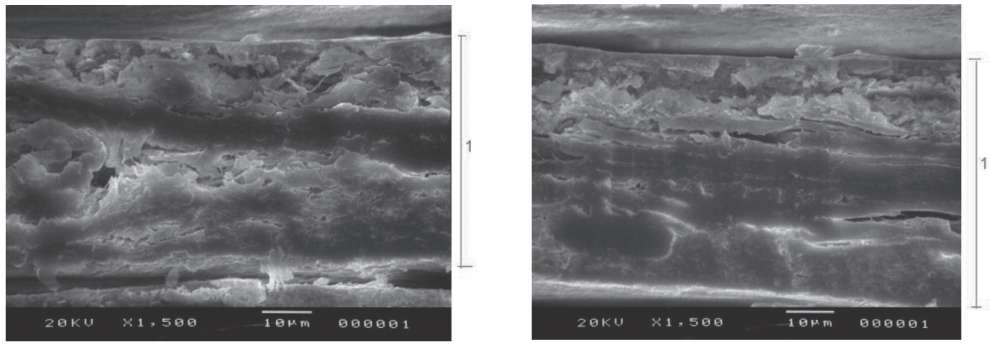
Using scanning electron microscopy has confirmed the penetration of UV varnishes in the structure of the test board (Fig. 3 and Fig.4). When using varnishes of high viscosity (up to 15–20 percent of aroma capsule), there is no significant penetration to the structure of cardboard as in offset and screen-printing method (Fig. 3 a, b)



a) b)

Fig. 3 Microstructure of cardboard surface with UV aroma varnish with high-viscosity: a) offset printing, b) screen printing

The reduced viscosity of varnish (and corresponding decrease to 5–10 percent of aroma capsule within it) leads to its deep penetration into the structure of the board, which is a negative point, clearly shown in micrographs (Fig. 4)



a) b)

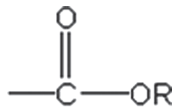
Fig. 4. Microstructure of cardboard coated with UV aroma varnish with low viscosity: a) offset printing b) screen printing

It is known that anti penetration varnish coatings cover or fill the surface pores of cardboard, in particular the Cretaceous layer. The studies confirmed that paperboard coating is ideal for use in aroma printing using UV varnishes, especially with high viscosity. UV-aroma varnish after the complete formation of polymer networks "links macromolecules polish" for aesthetic effect and provides good operating conditions.

The cooling, heating and UV-light have no effect on the change of fragrance saturation, because it destroys the structure of microcapsules with aromatic substances that are part of offset printing with varnish. However, a significant impact on the change of intensity of fragrance is the image efficiency, the total number of consumers who use these products and shelf life.

Unfortunately, the only theory that could explain the stability of fragrances at those or any other conditions of use, currently does not exist. There is a famous hypothesis by Dyson (1937), in which he explains the percentage of fragrance release based on vibration hypothesis perception of smell by life organisms. The noteworthy method is

based on quantum theory, known in the literature as Raman-effect that studied molecular vibrations of odorous substances. In addition, references present other approaches to the evaluation of fragrance [3]. Any distribution of substances by smell is based on our subjective feelings, often we like one, but we do not like the other. It is not possible to evaluate and express the odor substances objectively yet. It is usually compared with anything, for example with the smell of violets, orange, roses. Science has gathered a lot of empirical data that associates the odor with the structure of molecules. Some sources cite examples to 50 or more such combinations between structure and odor. Indisputable is the fact that the aromatic substances usually contain one of the so-called functional groups:

carbine -C-OH, carbonyl> C = O, ester and  others.

At first glance, it might seem that the more functional groups in the molecule lead to the better or more intensive smells. Often it is the opposite. Fatty connections (they contain chains of carbon atoms) layers of different groups reduce the odor. Increasing number of identical groups eliminates the odor in aromatic substances of all classes.

Great influence on the odor has a molecule size. Typically, such compounds, that belong to the same homologous series, smell the same, but the strength of smell decreases with the increasing number of atoms; connections with 17–18 carbon atoms are usually odorless. Fragrance of cyclic compounds depends on the number of rings. If they are 5–6, the substance smells bitter almonds or menthol, 6–9 — provides transitional smell, 9–12 – the smell of camphor or mint, 13 – the smell of resin or cedar, 14–16 — the smell of musk or peach, 17–18 — smell of onions, connection with 18 members and more do not smell at all, or smell very little. The intensity of the fragrance depends also on the structure of the carbon chain. For example, branched-chain aldehydes smell more strongly and pleasantly, then isomeric aldehydes of standard structure.

Great influence on the odor has the substituents position in the molecule. The position of the double bond in the molecule also effects the smell. Often unpleasant odor is caused by triple bond. Obviously, cycles, especially with 15–18 units, have more influence on the odor.

Because of this, such kinds of research deserve the attention, they are relevant and promising, since they present new approaches in the theory of explaining mechanism of fragrance's release from different environments.

REFERENCES

1. Havenko, S. & Kotmalova, O. (2010). Modern technology of production aromatisation by printing technology. Book kvalilogy, 1 (17), 22–33 (in Ukrainian).
2. Vakulich, D., Motyka, M. & Tsutsa, O. (2010). Labeling for the blind on packaging for pharmaceuticals. Packing, 1, 44–46 (in Ukrainian).
3. Solodovnik, V. (1980). Microcapsulation. Moskwa: Chemistry (in Russian).

4. Zymon, A. (1974). Adhesion and fluid. Moskwa: Chemistry (in Russian).
5. Havenko, S., Kotmalova, O., Netak, V. & Khadzhynova, S. Pat. № 77304. Ukraine. Aroma ink for piezo inkjet. Patent Ukrainian Academy of Printing. Appl. 07/12/2012, publ. 11.02.2013. Bull. № 3 (in Ukrainian).
6. Guide for full color screen printing (2000). Trans. IPS Limited (Ukraine). Sericol International Limited (in Ukrainian).
7. Thomas, G. & Horynfy, M. (1983). Transmission electron microscopy of materials.Moskwa: Nauka (in Russian).
8. Dembovskaya, Y. (1978). Summary microscopy in printing technology. Moskwa: Knyga (in Russian).
9. Havenko, S., Kotmalova, O. & Petryk, P. (2013). Technologia produkcji opakowan z zastosowaniem farb i lakierow zapachowych. Opakowanie, 7, 57–61 (in Polish).
10. Havenko, S., Petryk, P., Labetska, M. & Rybka, R. (2015). Investigation of the fixing mechanism of aroma varnish coating in web offset printing. Technologija i тechnika drukarstwa, 3 (49), 66–71 (in Ukrainian).

АРОМОПОЛІГРАФІЯ — СУЧАСНА ТЕХНОЛОГІЯ ОЗДОБЛЕННЯ ПАКОВАНЬ

С. Ф. Гавенко[1], С. Є. Хаджинова[1],
О. Г. Котмальова[2], М. Т. Лабецька[2]

[1]Лодзинський технічний університет, Інститут папірництва і поліграфії, Скорупки 10/12, 90–924 Лодзь, Польща

[2]Українська академія друкарства, вул. Під Голоском, 19, Львів, 79020, Україна
svitlana.khadzhynowa@p.lodz.pl

Аромополіграфія займає значне місце серед сучасних технологій оздоблення паковань, не тільки поліпшує їх дизайн, але також, внаслідок використання ароматичних фарб або ароматичних лаків, покращує сприйняття інформації про запаковані товари чи продукти. Розглядаються ароматичні зображення, утворені на картоні в процесі офсетного та цифрового струминного друку з використанням ароматизаторів для закритої презентації ароматів. Досліджується вплив зовнішніх факторів (охолодження, нагрівання та УФ-опромінення), часу і частоти використання ароматичних зображень на зміну стабільності та інтенсивність вивільнення ароматів.

За допомогою електронної мікроскопії показано взаємодію ароматичного лаку з картоном при друкуванні різними способами, зміну структури ароматичних покриттів після їх використання. Встановлено, що методи мікрокапсулювання, структура мікрокапсул, співвідношення діаметра та товщини капсульної мембрани впливають на якість аромату зображення. В результаті порівняння

технологій друкування для утворення ароматничних зображень встановлені вимоги до вибору методу ароматизації та складу ароморечовин.

Підтверджується, що ароматичний лак можна успішно застосовувати в офсетному та трафаретному друці для оформлення та маркування упаковки відповідно до місця призначення.

Ключові слова: *аромополіграфія, УФ-лак, ароматична капсула, мікроструктура, електронна мікроскопія*

Стаття надійшла до редакції 16.02.2017.
Received 16.02.2017.